FUTURENERGY

AirForce® 1

1kW MICRO-WIND TURBINE SYSTEM

SITE ASSESSMENT

TURBINE AND TOWER KIT INSTALLATION GUIDE

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REFERENCE DOCUMENTS

Ref	Reference	Title
1	13108E 19th Nov 2018 Issue 5.0	Unpacking & assembly instructions ***AirForce® 1*** 1kW wind turbine 24V or 48V battery charge application
2		
3		
4		
5		
6		

PROPOSAL DEFINITIONS

Terminology	**Description**
A	Amps
AC	Alternating Current
DC	Direct Current
LAeq	Equivalent Continuous Level (noise)
m/s	Meters per second
NM	Newton Meters
PMG	Permanent Magnet Generator
RoHS	Restriction of Hazardous Substances Directive
V	Volts
W	Watts

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Icon conventions used in this document

This is a warning

This is a caution

This is a hint

This is a note

1. INTRODUCTION

This document provides information that should allow a potential user of a wind turbine to evaluate whether their site is suitable for a wind turbine, and once that is established, to site and install the turbine.

The first section provides generic evaluation information.

The remainder of the document is based on the details of the FUTURENERGY ***AirForce*® *1*** 1kW wind turbine including the ***AirForce*® *control*** module.

The information and diagrams in this generic section are primarily sourced from Rob Beckers, (Solacity Inc), and FUTURENERGY is grateful for permission to use the data.

2. SELECTING A SMALL WIND TURBINE SITE – GENERIC INFORMATION

Wind is the fuel that drives a wind turbine. A wind turbine needs to be placed where the wind provides sufficient power and where it can be harnessed economically. This section will help to decide what tower height and location gives the best value for money.

2.1. What is good wind?

Not just any wind will do. For a wind turbine to operate efficiently it needs air that moves uniformly in the same direction and is strong enough to provide sufficient energy to turn the turbine. In general, the higher the turbine is above the local environment, the stronger and more stable the wind will be.

Eddies and swirls, or turbulence, disrupts the air and introduces rapidly changing loads that does not make good fuel for a wind turbine. The rotor cannot efficiently extract energy from turbulent wind and the constantly changing wind direction can cause excessive wear and can lead to premature failure.

Wind turbines are not designed to be installed in turbulent locations as they do not operate well and will not perform to specification.

2.2. Is the wind strong enough in my area?

A good starting point is to access the NOABL wind speed database. Entering your location post code or grid reference into any of the various on-line sources that use the data base will provide an initial estimate of the wind strength and prevailing direction in your area. The figures are very granular and do not take local topography into account, so use local knowledge and some judgement when interpreting the numbers.

2.3. The effect of obstacles

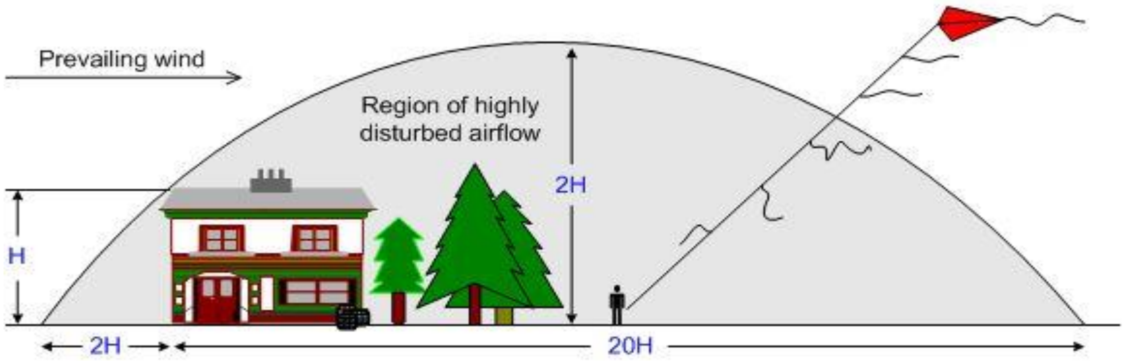
The airflow over any obstruction, including trees and shrubs, tends to create a "bubble" of turbulent air around twice the height of the obstacle that extends 20 times the height of the obstacle downwind from it.

A 10m high house disturbs the air up to 200m away, a distance that will shrink and grow with the windspeed.

A tree line of 30m trees disturbs the air up to 60m high, the effects of which are felt up to 600m away!

The figure below illustrates the potential effects. Locate your wind turbine either upwind of the obstructions, or far enough downwind so that the effect has decayed.

Notice from the figure that preference should be given to a site upwind of obstructions*, but keep in mind that tall features downwind of the turbine can also influence the quality of the wind going through the blades due to a back-pressure effect.*



Turbine height & clearance requirements

Upwind and downwind are relative to the prevailing wind direction; where the wind blows from most of the time. A wind atlas will sometimes indicate the prevailing wind direction in the local area, and if there is one at all. Some sites have winds that are equally likely to blow from more than one direction.

Ideally you need to place your wind turbine high enough to catch strong winds and above turbulent air. Since the tower price goes up with height there is a limit to what is practical and affordable.

2.4. Wind blowing over hills and cliffs

The bottom of a hill, valley, or ravine makes for a poor place to site a wind turbine. The wind tends to drop in speed at the bottom of a smooth hill, then speed up as it goes up the hill, reaching around twice the wind speed at the top of the hill as shown in the figure over the page.

Try to use this effect to your advantage if there are hills on the property or in the vicinity.

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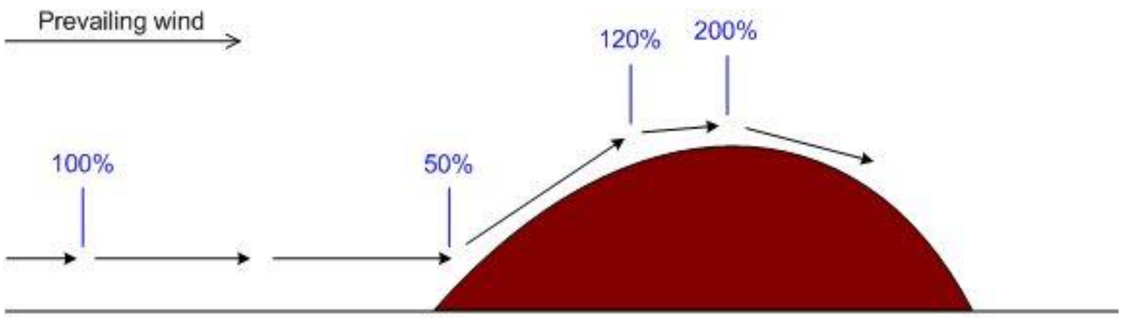
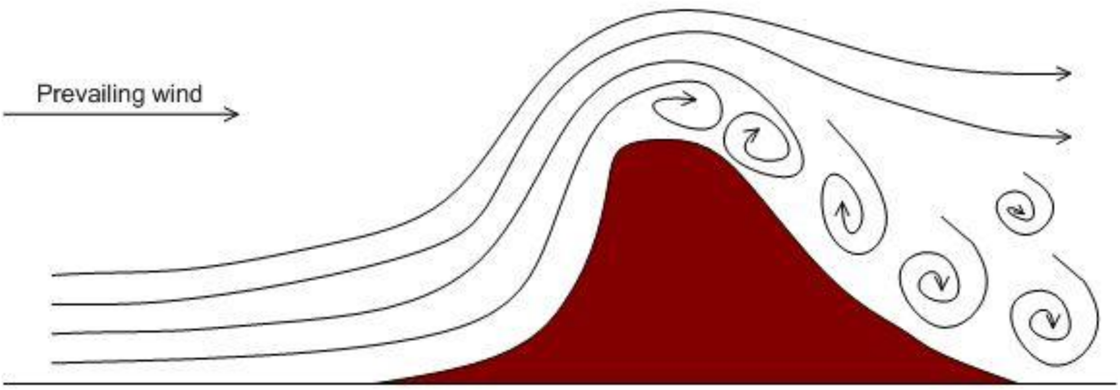


Wind speed over a ridge

For obstructions that are not smooth, such as a cliff (i.e. a sudden rise in the landscape), it gets much more difficult.

Sharp edges create turbulence, as illustrated in the figure below. The airflow at the top of the cliff can be stronger than the average wind speed in the area, but close to the cliff's edge it will also be very turbulent, making it a poor site for a turbine.



Turbulence on the lee side of a cliff

If it is necessary to site the turbine close to a cliff edge, use a higher tower or set it far enough back from the cliff edge to get above the inevitably turbulent air.

The lee side, (downwind of the prevailing winds), of a bluff object makes for a very poor wind turbine site. The bluff object will create large turbulence on its downwind side, and the average wind speed will drop off precipitously. This leaves no energy for the wind turbine to harvest.

2.5. Go fly a kite

An inexpensive and visually productive way to find out at what height turbulent air ends, and smooth, laminar airflow begins, is to fly a kite at the proposed wind turbine location on a windy day, preferably when the wind is coming from the prevailing direction. To visualize airflow, use tape-streamers tied to the kite's string every 5m or so, (DIY stores sell plastic marking tape in fluorescent colours).

Wildly fluttering tape indicates turbulence, smoothly extended tape means smooth air. Be sure to take the angle of the kite's string into account when calculating height.

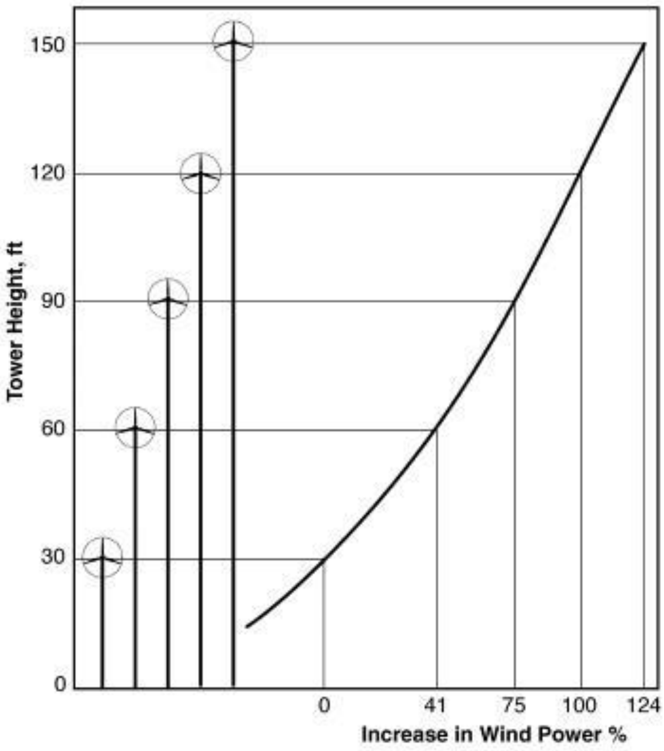
2.6. Wind power versus tower height

The energy in the wind increases with the cube of the wind speed ($P \sim v^3$), and wind speed increases with height. An increase of just 26% in wind speed means twice as much power is available in the wind, and the wind turbine will produce almost twice as much.

Double the wind speed and there is almost eight times as much power available. A small additional investment in tower height may therefore be well worth the cost due to the increased energy production.

If the annual average wind speed at the site is known, (from weather data, a wind atlas, local weather station etc.), use the manufacturer's data to gain an idea of the energy that the wind turbine will produce if placed in smooth, laminar airflow.

Weather data usually reports wind speeds at 10 meters above ground level and need to be related to a wind speed at turbine hub height. The figure below indicates how changes in tower height affect the power in the wind for an unobstructed site.



Wind turbine height vs. power

Danish companies have invested heavily in wind power and have published large amounts of information and calculators on the Danish Wind Industry Association website, a valuable and very usable resource.

An excellent interactive calculator allows the user to introduce various obstacles, (for example, a row of trees), set their height and distance to the wind turbine, and visually show what effect this will have on wind speed and energy. The calculator also shows the percentage of the wind speed at various distances and heights behind the obstacle.

Note that the effect of obstacles is not just to diminish wind speeds, but also make the air swirl, creating turbulence, the arch-enemy of all wind turbines.

2.7. Tower type

If there is sufficient space for guy wires use of a tilt-up tower for your wind turbine is advised. They are economical, costing only a little bit more than the cheapest type of tower (a fixed guyed tower), and allow the turbine to be installed to the tower on the ground.

By tilting the tower down maintenance can also be done with the turbine on the ground. This saves in crane expenses and makes installation and maintenance much safer because the work is not done at height.

2.8. Wind turbine noise and occupied buildings

Another aspect of wind turbine siting is the distance from occupied buildings. All wind turbines produce some sound. Some wind turbines are quieter than others.

In particular, the frequency content of the sound and therefore the tone of the sound they produce varies, but even a quiet turbine produces sound that will vary with turbine rpm and wind speed. Therefore, it is a good idea to place the wind turbine some distance away from any occupied building, 30 metres should be considered the minimum separation.

It is possible to install turbines closer, but the user will have to honestly assess how the turbine's sound will affect them. Once installed it is difficult to relocate a turbine.

Generally, a wind turbine that is placed in smooth air will be quieter versus the same turbine in turbulent air, unless the wind starts blowing hard. In high winds, the wind noise itself is likely to be louder than any noise from the turbine.

There also is such a thing as too much distance since the length and gauge of the wiring that is needed will increase. With the ever-increasing price of copper this makes it more expensive to install the turbine. For large distances 3 phase output and the option of higher voltage generators are alternatives.

2.9. Building mounted turbines

It is generally a very bad idea to mount a wind turbine, (any turbine), directly onto a building. The airflow that close to the building is generally very turbulent, leading to the possibility of premature failure and poor power production and is usually noisy.

Every wind turbine has some amount of vibration associated with it, and this too will be transmitted inside the house and can be amplified as a result through resonance. Structural damage can also occur.

The thought of installing a little turbine to the house, just over the roof line, to offset electricity use is very appealing, but the harsh reality is that this does not work. Several studies have been carried out involving dozens of roof-top-turbines that all concluded that those turbines do not work. Their energy production is negligible.

2.10. Vertical axis versus horizontal axis turbines

The same siting rules also apply to Vertical Axis Wind Turbines (or VAWTs). The regular "propeller" type turbines are Horizontal Axis Wind Turbines (or HAWTs).

It is a myth that vertical axis wind turbines "work in turbulent air", and "they do not need a tall tower". They need fuel just like any other wind turbine, and that fuel is the wind. They also need nice, clean, laminar airflow to do their job. Since they are omni-directional they are a little less sensitive to rapidly changing wind directions, though a properly designed HAWT will just as readily follow the wind direction by yawing.

If the wind at the site changes direction continuously it usually means there is lots of turbulence, and no wind turbine, (a VAWT included), will do well at such a site.

2.11. *AirForce® 1* wind turbine

The remainder of this document assumes that the user has made the wise choice of selecting the FUTURENERGY ***AirForce® 1*** 1kW Horizontal Axis Wind Turbine for their site.

All further information relates directly to that turbine and installation options.

A certain amount of information is repeated from that above and relates specifically to the ***AirForce® 1*** installation.

3. *AirForce® 1* SYSTEM INTRODUCTION

The FUTURENERGY ***AirForce® 1*** wind turbine system, now incorporating the ***AirForce® control*** as standard, has been developed in response to the increasing interest in the local generation of renewable energy by individual users on their own property and overcoming the dependence on grid connection and external supply of electrical energy.

This guide, that has the intent of being both useful and informative, will help purchasers and potential purchasers of the ***AirForce® 1*** to enjoy the benefits of generating their own renewable energy.

The ***AirForce® 1*** turbine is tower-top ready, weighs only 19kg, and is designed to slide over and be secured onto a standard 48mm steel tube pole. FUTURENERGY does not advise 'building-mounted' installations, other than on steel-framed buildings. The neatest and simplest solution is a guyed tower that can be lowered easily by tilting using a gin-pole arrangement for installation and maintenance purposes.

This document covers all aspects of installing a FUTURENERGY ***AirForce® 1*** micro-wind turbine, capable of producing more than 1000W in 12.5m/s wind speeds. It assumes the user has a reasonable level of DIY competency. Details are provided of how to assemble and install all parts necessary to build your turbine tower and assumes that the DIY builder has access to a range of standard hand tools.

This document does not provide instructions on assembly of the turbine itself that are provided separately with each turbine kit.

Although a wide variety of products are available that will enable a complete working system, FUTURENERGY recommends that items listed within this document are used. The operational features and performance of these items has been validated and will provide trouble-free installation and generation performance.

Experience has shown that, despite taking all care and consideration, installation and configuration with alternative items is not always fully successful.

By following these advisory instructions, the user should be able to commission the FUTURENERGY turbine in less than two days.

All FUTURENERGY turbines now supplied use an in-house designed and manufactured Permanent Magnet Generator (PMG) and provide exceptional performance.

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 FUTURENERGY could improve this advice for future installations, please contact technical@futurenergy.co.uk.

4. WARNINGS AND SAFETY NOTICES

Wind turbines are large, heavy items of rotating machinery with exposed blades and sharp surfaces and should be treated with extreme care and respect in all aspects of construction, installation, maintenance and operation.

The turbine blades are sharp, flexible and generally unbreakable that can cause serious personal injury.

The electrical power generated by wind turbines can inflict electric shock, burning and serious personal injury. All electrical parts must be considered as potentially lethal.

Children should not be allowed to 'play' with or near 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 a potential to become a 'falling hazard' in fault conditions or high winds. Every effort should be made to keep the area around your turbines free from people, animals, buildings and vehicles at all times.

NEVER run the turbine without a load connected to it as they must be loaded to operate within their safe limitations. *The importance of this cannot be overstressed.* Failure to heed this warning may result in the blades breaking, the tower collapsing, or bearings being destroyed prematurely. Failures may result in electric shock or other personal injury that may cause death.

Always wear appropriate personal protective clothing and use the correct tools for the work being undertaken.

The user will be required to maintain the turbine and may have to carry out periodic repairs. The tower will require tilting down to ground-level on occasions that should be carried out with the assistance of at least two other fit, able and informed people.

FUTURENERGY Ltd has no control over what 'the constructor' does when carrying out the advisory instructions described in this guide. No responsibility or liability in any form whatsoever will be accepted for any losses, damage to persons or property, injury to persons or animals, or any consequential losses, that occurs either directly or indirectly when operating the turbines or using these instructions.

5. SITING OF THE TURBINE

5.1. Tower height

The higher the turbine is mounted in the air, the more power it will produce. In practical terms this means, wherever possible, positioning the tower on an elevated site, clear of obstacles and buildings at a height that is most practical in the local circumstances.

5.2. Turbine noise

When choosing a site, the user should be conscious that the turbine will produce some noise that will increase in level with the wind speed. This may be audible to yourself and neighbours and positioning the tower where the least effect is noticeable and no nuisance occurs is important. The relative noise of the turbine will reduce as the wind speed noise increases that will eventually mask the turbine.

5.3. Turbine shielding

Wind turbine performance is greatly affected by turbulence induced by buildings, trees and topography. To generate the most power, ensure the turbine has an open vista towards the direction of the prevailing wind and is at least 5m, (7.5m is better), above the roofline of any buildings in the immediate area. A position in the lee of a hill or the bottom of a narrow valley is not ideal. Even hedgerows and shrubs can have an effect so the best position is essentially in the middle of an open field. If in doubt about the viability of any position, carry out or commission a wind survey before investing in equipment to ensure suitability.

5.4. Turbine location

To find the site that best suits the turbine carefully consider the space around the tower. The guyed towers tilt up into position and will therefore have to tilt down to allow maintenance of the turbine. In practical terms, leave a space around the tower base equal to or greater than 1.5 times the tower height. For a turbine mounted at 7.5m this represents a circle of 7.5 x 1.5 = 11.25m radius around the base. If the complete circle of space is not available it is important to create enough space to allow the tower to tilt down without any risk to other buildings or people.

5.5. Turbine mounting

The turbine should always be mounted on a suitable tower. The ***AirForce*® *1*** is designed to fit onto a standard scaffolding pole, (size of tube is 48.3mm outside diameter x 4.0mm wall thickness, mild steel with a galvanised finish), and an installation kit is available for a free-standing unit that includes all necessary items.

It is not recommended that the pole be secured onto the side or on the top of a building, (unless it is a steel-framed building), as over time the turbine vibration can damage the structure. Whatever type of building it is attached to, the turbine is likely to introduce noise into and through the building.

5.6. Ideal location

The ideal site for your tower will be on an elevated piece of land, free from trees, bushes and buildings, and in an area which satisfies the safe zone mentioned above. Don't position your tower next to or on a building, (unless it is a steel framed building and more than 5m above the roofline), or where it will be shielded in any way from the prevailing wind. If in doubt about the viability of any position, carry out a wind survey using your own anemometer or commission a report before investing in equipment to ensure suitability.

6. INSTALLATION SCHEMATICS

Installation schematics for the variety of applications, including hybrid installations with solar panels, are shown in Annex A to this document.

7. AVAILABLE EQUIPMENT PARTS LIST

7.1. *AirForce*® *1* micro-wind turbine kit

The ***AirForce*® *1*** micro-wind turbine is supplied as complete kit in separate boxes as shown below.

Box 1 contents (turbine body and fin)

Item	Description	Qty	Part No
1a	Turbine complete with 24V PMG and hub adaptor	1	A0344
1b	Turbine complete with 48V PMG and hub adaptor	1	A0345
2	Nose cone	1	P0378
3	Turbine body cover	1	P0377-3
4	Cable crimp connection with heat shrink	3	P0775
5	M6 x 25mm bolts (rotor hub attachment)	5	PMG fix-kit
6	M6 washers (rotor hub attachment)	5	PMG fix-kit
7	M6 locknut (rotor hub attachment)	5	PMG fix-kit
8	M10 x 80mm SS screw (nose cone attachment)	1	SCR1080
9	M10 washer (nose cone attachment)	1	WASHM10
10	Aluminium distance tube (nose cone attachment)	1	TUB01
11	M6 x 35mm stainless steel bolt (tail fin attachment)	2	P0673
12	M6 stainless steel washer (tail fin attachment)	2	WASM6
13	M6 locknut (tail fin attachment)	2	NUT06
14	Rivet fixings (plastic) (housing cover to front plate)	5	P0756
15	Tail bar	1	TAL02/S
16	Tail fin	1	P0794
17	Stop-switch	1	A0257
18	Assembly Instructions	1	13108E

Box 2 contents (control and anemometer)

Item	Description	Qty	Part No
1	***AirForce*® *control***	1	A0519
2	Davis Anemometer	1	T0094

Box 3 contents (turbine blades and rotor)

Item	Description	Qty	Part No
1	Rotor blade set (3 off)	1 set	A0113
2	Rotor Hub enclosures (2 off)	1 set	HUB03
3	28° blade pitch locking pins	3	PITCH28
4	Blade static balancing discs & cable	1	A0206
5	M6 x 20mm SS cap screws (hub halves attachments)	6	SCR620
6	M6 stainless steel washers (hub halves attachments)	6	WASM6
7	M6 stainless steel locknuts (hub halves attachments)	6	NUT06
8	Blade installation instructions	1	

7.2. *AirForce*® *control* function and features

- Provides configurable automatic control of the turbine
- Prevents damage due to turbine overspeed
- Improves system safety, reliability and longevity
- Compatible with
  - 3 phase AC turbine installations
  - 24V and 48V battery charging installations
- Touch screen interface
  - Automatic power-save 'screen off' function (180 sec - touch to restore)
- Ability to monitor performance of the wind turbine
  - Power (W)
  - Energy (Whrs)
  - Wind speed instant (m/s) plus time averaged value
  - Wind direction (cardinal and ordinal)
  - Battery voltage (Volts)
  - Current (Amps)
  - Turbine speed (rpm)
- Remote monitor capability with WiFi and internet connection
- Configurable automatic stop/start functionality, parameterised on;
  - Maximum battery voltage (turbine stop) with turbine restart voltage
  - Maximum charge current (turbine stop)
  - Wind speed maximum (turbine stop) and restart value
  - Turbine restart delay time (seconds)
- Augments manual stop-switch
- Maintains battery systems at optimum levels to prolong life
- Negates the need for dump loads

7.3. *AirForce® 1* turbine tower kit

The kit part number A0149 comes complete with the items as listed below.

Item	Description	Qty	Part No
1	**Turbine tower kit (complete)**	**1**	**A1049**
	comprising the following items		
2	Ground anchor	5	P0891
3	Turnbuckle unit, cone clamp & rope grips	8	P0330
4	Steel rope (4x 5m & 4x 7.5m Long)	8	P0086
5	Tube coupling	2	A0023
6	M12 x 35 screw	8	P0092
7	M12 nyloc nut	11	P0091
8	M12 x 90 screw	3	P0639
9	Key clamp tee-piece	1	P0597

8. INSTALLING THE TURBINE

8.1. Introduction

The information assumes that the user is installing an ***AirForce® 1*** micro-wind turbine system including ***AirForce® control*** with anemometer using the FUTURENERGY installation kit and a gin-pole raising arrangement.

⚠ This kit is not suitable for other wind turbines.

8.2. Preparing the site

Once the position of the tower is chosen, the ground will need to be prepared for mounting the base, and guy anchor points. Level the ground where possible to make positioning and measurements simpler.

Ensure the chosen location for the ground anchors is free from any buried services such as electrical cables, gas pipes or drains.

8.3. Marking the anchor points

Select the direction in which the tower will tilt and position the anchor point markers in the positions described in figure 1 to indicate where the tower centre and 4 guy anchors will be.

Position a marker to indicate the centre of the tower. Measure 3.0m from the tower centre point to anchor point 1 and place a marker and continue around a 3.0m radius circle positioning markers for anchor points 2, 3 & 4. The simplest method to ensure that the anchor points form a square is to use a 4.25m marked line held at anchor point 1, drawn tight to anchor point 2. The position where this line intersects with the 3.0m circle is the correct point for the marker. Repeat for locating anchor point 3. Check that the measurements from points 2 & 4, and 3 & 4 also equal 4.25m. Marking the positions accurately which will make future aspects of the construction simpler.

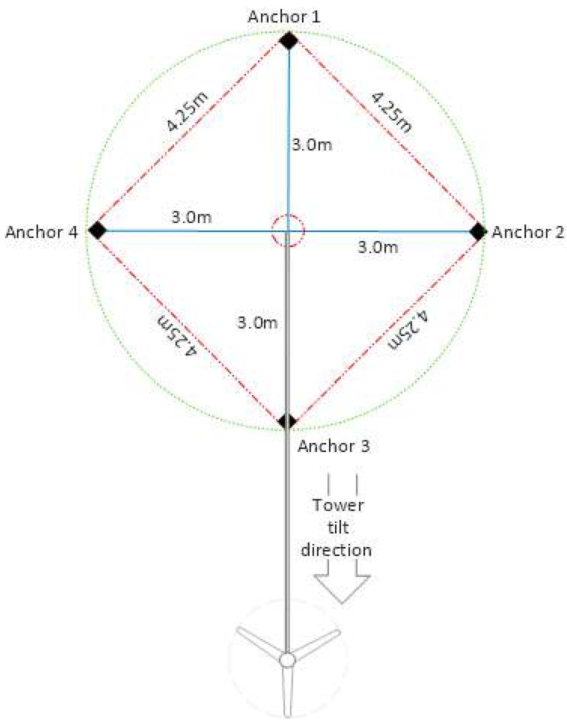


Figure 1 - Tower base anchor points

The ***AirForce*® *1*** installation kit part number A0149 constituent parts are listed and illustrated below:

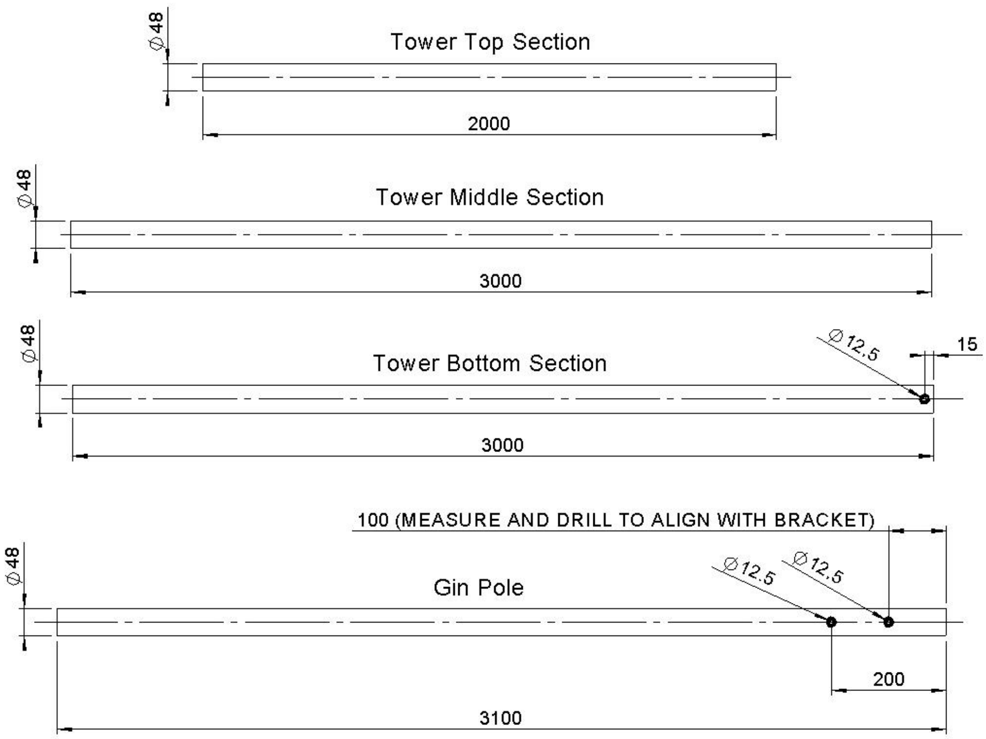
P0891	Ground anchor	5 off
P0330	Turnbuckle unit, cone clamp & rope grips	8 off
P0086	Steel rope (4x 5m & 4x 7.5m Long)	8 off
A0023	Tube coupling	2 off
P0092	M12 x 35 screw	8 off
P0091	M12 nyloc nut	11 off
P0639	M12 x 90 screw	3 off
P0597	Key clamp tee-piece	1 off

8.4. Tower mast and gin-pole

The tower mast and gin-pole are not supplied as part of the tower kit and consist of 4 sections of tube of the type used in the construction of scaffolding or hand railing in the building industry and is generally galvanised. These are usually locally sourced, (FUTURENERGY can supply on request), and readily available from a builders' merchant or steel stockholder. The tube is typically supplied in 6m lengths, 2 lengths will be required.

The supplier may be able to cut these to length;

2 off -	3m long	(Lower-tower sections)
1 off -	2m long	(Top-tower section)
1 off -	3.1m long	(Gin-pole)



Drill the poles as shown above except for the outer hole of the gin-pole. This should be marked through from the ground anchor point fixing during the first trial tower raising to ensure accuracy and ease of later fitting.

8.5. Installing the ground anchors

The tower centre and guy rope ground anchors are driven into the ground using a clockwise twisting motion with the tool provided until the head is flush with the ground.

Drive the centre anchor first and ensure that it is correctly aligned so that the tower raising line is exactly in line with one of the corner lines. It may be necessary to slightly adjust the corner anchor points, but take care to ensure that they remain at 90° to each other and aligned though the tower centre.



Various obstacles such as; tree roots, bricks or stones can be encountered and are usually easily overcome using a piece of pipe or scaffolding for greater leverage through the anchor head. Ensure that the anchor is perpendicular to the ground beneath for minimal disturbance to the soil and best anchoring effect.

All corner ground anchors must be driven in to the ground to their full length to gain maximum pull strength capacity. The central anchor is in compression due to the weight of the tower and turbine and pull down on the guy cables.

8.6. Attaching the mast sections

Bottom section with tee-piece fixed to centre anchor

Align and lay the three tower sections and couplings on the ground starting with the lower section attachment hole close to the base hinge bracket and slide through the open section of the tee-piece.

Thread a length of cable pulling rope through the tower sections and couplings for cable pulling when ready.

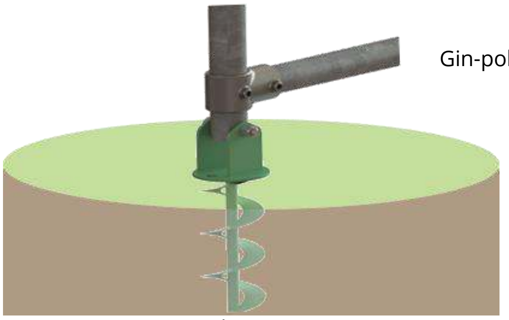
Secure the base section in place between the fork of the centre anchor using the M12 x 90 bolt and nyloc nut. Do not overtighten as the mast still needs to be able rotate in the fixing. This now forms the pivot point for the mast lifting.

Slide the lower coupling to the top of the lower mast section ensuring that it is inserted fully up to the internal stops. Rotate the coupling on the lower shaft so that the guy rope lugs point to the four corner ground anchors, tighten the grub screws and secure using thread lock adhesive to clamp the coupling to the tube.

Repeat with the remaining two tower sections and couplings ensuring that the lugs point to the ground anchors, that the shafts are fully inserted to the coupling stops and the grub screws have been tightened and locked using threadlock adhesive. (The top section is the 2m tube length).

8.7. Fitting the gin-pole

Secure the gin-pole into the closed section of the tee-piece. Position the tee-piece on the mast shaft so that the gin-pole stands vertically to the tower and ground (with the mast laid flat) and can lay flat into the anchor point 1 clevis (figure 1 above); this will accommodate any slight gradients, curves, bumps or obstructions that might otherwise obstruct the position of the pole. Once the point is chosen, tighten the 3-off tee-piece screws using threadlock adhesive to prevent them coming undone.



8.8. Attaching the guy ropes to the couplings

Attach the four, short guy-ropes to the lower coupling on the mast using the M12 screws inserted through the coupling lug and the preformed eyelets on the end of the guy ropes. Tighten the nyloc nuts just enough so that the eyelet can still move.

Similarly, attach the four long ropes to the upper tower coupling.

8.9. Attaching the guy ropes to the anchors

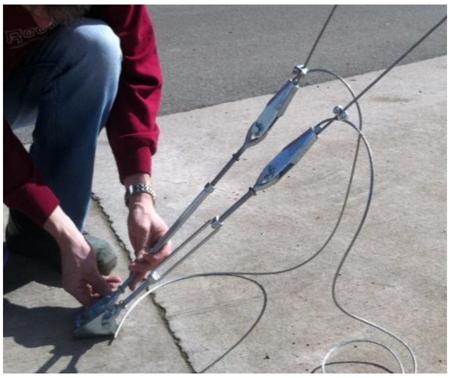
Attach six of the eight guy-rope anchor turnbuckles to the anchor points 2, 3, and 4 as shown and the other 2 onto the shaft of the gin-pole using a M12 x 90mm bolt and nyloc nuts with the clevis secured around the shaft of the bolt as shown.

ⓘ Extend the turnbuckles to their maximum length prior to connecting to the guy-ropes to provide maximum adjustment when it comes to tightening the turnbuckle.

Connect the guy-ropes to each turnbuckle, starting with those to anchor points 2 and 4.

Thread the guy-rope through one side of the rope-grip, into the narrow end of the wedge socket, out and around the wedge, (positioned with the pointed end directed into the wedge socket), loop back and in through the wide end of the wedge socket, and finally through the rope-grip from the opposite direction.

Connect the wedge socket onto the eye-end of the turnbuckle using the locating pin and securing split-pin.



The length of the guy-ropes can be adjusted by feeding through the wedge socket so that most of the tension is applied prior to making any adjustment to the turnbuckle ends. Tighten the rope grips.

Tension the guy-ropes equally either side of the gin-pole (anchor points 2 and 4) using the turnbuckles before the tower is raised as this helps with stability whilst lifting.

Using the length of the side guys (anchor points 2 and 4), as a guide, set the guy-ropes attached to the end of the gin, anchor 3, and to anchor 1 opposite the gin-pole, at an approximate length and tighten the rope-grips.

8.10. Trial raise of the tower

With all guy ropes attached it is essential to raise the tower without the turbine fitted to check the guy-rope lengths are correct and to that the tower is vertical when erected.

It is strongly recommended that three people are involved with tower lifting and lowering. Using a mechanical device to winch the tower up may reduce the need for additional hands but is not covered by these instructions and is entirely at the user's risk.

Ensure that any winch used is of the type that cannot run backwards (with a pawl lock) that in the case of failure will prevent the tower collapsing. A chain winch or tirfor winch is suitable.

Remember to tie off the rope that has been passed through the tower tube for the later turbine cable pull-through so that it does not fall back down during trial lifting.

- Securely attach a rope to the end of the gin-pole so that it will not slide down the pole. Take care to tie securely as if this rope should become detached the tower will fall back to the ground.

Pass the rope under the M12 x 90 gin pole fixing bolt at anchor point 1 as this ensures an equal pulling force is imposed throughout the lifting process.

- Ensure that the anchor point is secure in the ground before raising the tower as the loads imposed will be approximately equivalent to that experienced by a 50-year maximum gust.

To raise the tower two people should pull the gin-pole rope while a third person lifts the tower directly.

- The person lifting the tower should avoid the area directly under the tower throughout the lifting exercise.

When the tower is fully up push down on the gin-pole until it has been bolted to the ground anchor bracket.

- <u>Until the gin-pole is secured the tower can freely hinge back down to the ground under its own weight</u>.

Tension the guy-ropes so that the tower is perfectly vertical.

Secure the excess guy-rope back to the main tensioning rope by slipping through the rope grips and tightening the U-bolt, with the grip positioned at the end of the excess length.

Lowering the tower is the reverse procedure.

Weigh down on the gin-pole, remove the bolt fixing the gin pole to the gin pole anchor bracket and hold in position. Re-attach the lifting rope with one person supporting the tower directly and two people taking the rope strain and slowly lower the tower to the floor.

- Avoid standing directly under the path that the tower will fall.
- Take care to avoid the various guy ropes that will be trip hazards.

8.11. Fitting the turbine to the tower

These instructions assume that the turbine is pre-assembled and ready to fit.

Support the end of the tower at a comfortable working height on a builder's trestle or similar.

Connect the turbine cables and pull down through the tower tube using the previously inserted pull cord.

Ensure that the turbine cannot rotate by electrically braking the turbine during the installation either by using a FUTURENERGY stop-switch or by shorting together the cables from the turbine.

Fit the turbine to the top of the tower and secure the two grub screws to clamp the turbine mount to the tower tube using thread lock adhesive on the grub screw threads.

8.11.1. Anemometer installation on the mounting pole

Install the anemometer to the mounting pole in accordance with the manufacturer's instructions supplied using the u-clamps.

The anemometer should be located outside of the rotational area of the turbine to ensure that it is not affected by blade wash and in free air.

During the final installation ensure that the mounting arm of the anemometer is perpendicular to the pole and is pointing due north.

Route the cable to the ***AirForce® control***. In some cases it may be possible to route the cable within the pole. Ensure that cable is secured to prevent possible damage. The cable may be extended to around 165m before the signal levels are affected, details of cable specification are in the instructions.

8.12. Raising the turbine on the tower

Ensure all assembly guy-ropes are attached and tensioned before lifting.

Ensure the gin-pole rope is securely attached and raise the tower and turbine as before with two people pulling the gin-pole rope while a third person lifts the tower directly.

The turbine weighs 19kg so take appropriate care throughout the lifting exercise.

Raise the tower and secure the gin-pole into position with the securing bolt.

Check and if necessary adjust the tension on the guy-ropes.

Commission the turbine for operation as required for the individual operation.

9. TOWER CHECKING AND ROUTINE MAINTENANCE

The amount of maintenance required is primarily subject to the environmental and ground conditions that will change with the seasons.

Routine check intervals are suggested below but higher wind speeds dictate more regular checking, as does soft (wet) ground conditions.

All maintenance checks should always be matched to the local environmental conditions and weather events experienced.

9.1. Post installation checks

Carry out the following checks daily for the first few days following installation, then less regularly as time progresses.

Ground anchors	check for security into the ground
Guy-ropes	check tension and adjust where required.
Nuts & bolts	check for tightness and security.
Turbine and tower	visually check for signs of defects

9.2. 3 months check

After the first 3 months following installation lower the tower and carry out the following:

Ground anchors	check for security into the ground
Guy-ropes	check tension and adjust where required.
Nuts & bolts	check for tightness and security.
Tower couplings	check for tightness and security.
Turbine maintenance	refer to the turbine maintenance manual.

9.3. Annual check

Every 12 months lower the tower and carry out the following:

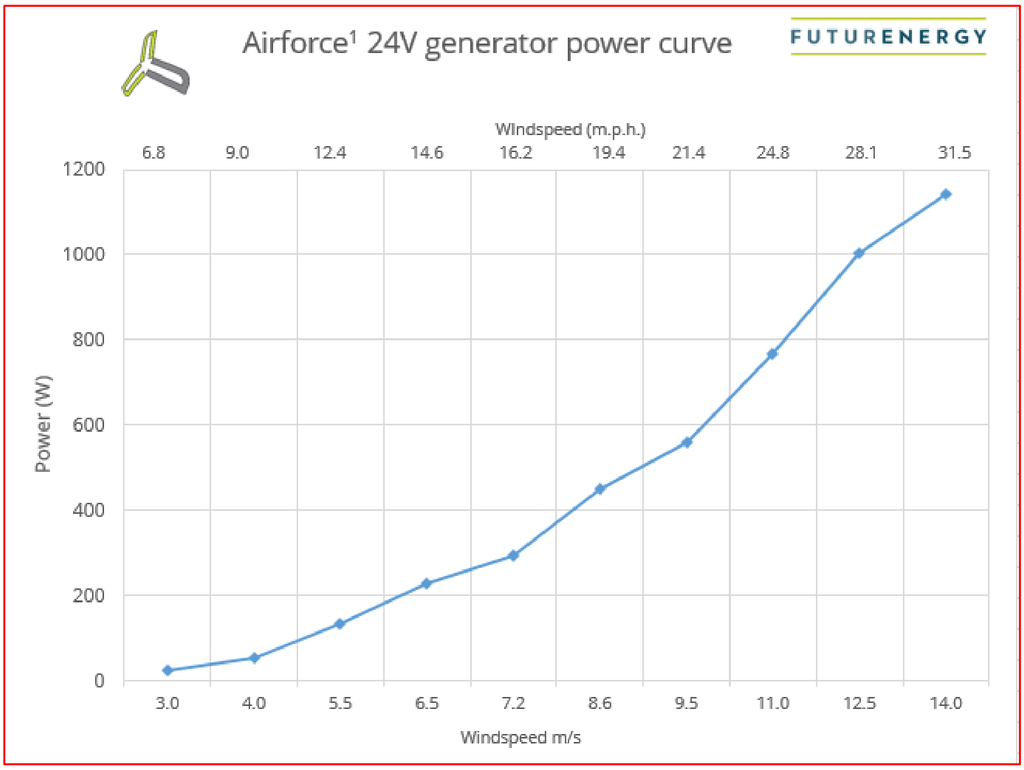
Ground anchors	check for security into the ground
Guy-ropes	check tension and adjust where required.
Nuts & bolts	check for tightness and security.
Tower couplings	check for tightness and security.
Turbine maintenance	refer to the turbine maintenance manual.

10. *AIRFORCE® 1* POWER CURVE

10.1. *AirForce® 1* 24V AC wind turbine performance data

Turbine Model = AF1-24v-0125 (406 PMG)
Turbine Blades = 3 (28° blade pitch)
Battery Load = 24V
Start-up Wind Speed = 2m/s
Charging Initiation Wind Speed = 3.0m/s
Charging Initiation RPM = 258

Wind speed			Turbine rpm	Output Current (A)	Battery Voltage (V)	Power	
m/s	m.p.h.	knots				(W) instant	kW/day
3.0	6.8	5.9	258	1.0	26	26	0.624
4.0	9.0	7.8	280	2.1	26	55	1.310
5.5	12.4	10.8	310	5.0	27	135	3.240
6.5	14.6	12.7	316	8.4	27	227	5.443
7.2	16.2	14.1	400	10.2	29	296	7.099
8.6	19.3	16.8	420	15.0	30	450	10.800
9.5	21.3	18.5	442	18.0	31	558	13.392
11.0	24.7	21.5	460	24.0	32	768	18.432
12.5	28.0	24.3	480	30.0	33.4	1002	24.048
14.0	31.4	27.3	490	34.0	33.6	1142	27.418



10.2. *AirForce® 1* 48V AC wind turbine performance data

Turbine Model = AF1-48V-0122 (408 PMG)
Turbine Blades = 3 (28° blade pitch)
Battery Load = 48V
Start-up Wind Speed = 2m/s
Charging Initiation Wind Speed = 3.0m/s
Charging Initiation RPM = 380

Wind speed			Turbine rpm	Output Current (A)	Battery Voltage (V)	Power	
m/s	m.p.h.	knots				(W) instant	kW/day
3.0	6.8	5.9	258	1.0	26	26	0.624
4.0	9.0	7.8	280	2.1	26	55	1.310
5.5	12.4	10.8	310	5.0	27	135	3.240
6.5	14.6	12.7	316	8.4	27	227	5.443
7.2	16.2	14.1	400	10.2	29	296	7.099
8.6	19.3	16.8	420	15.0	30	450	10.800
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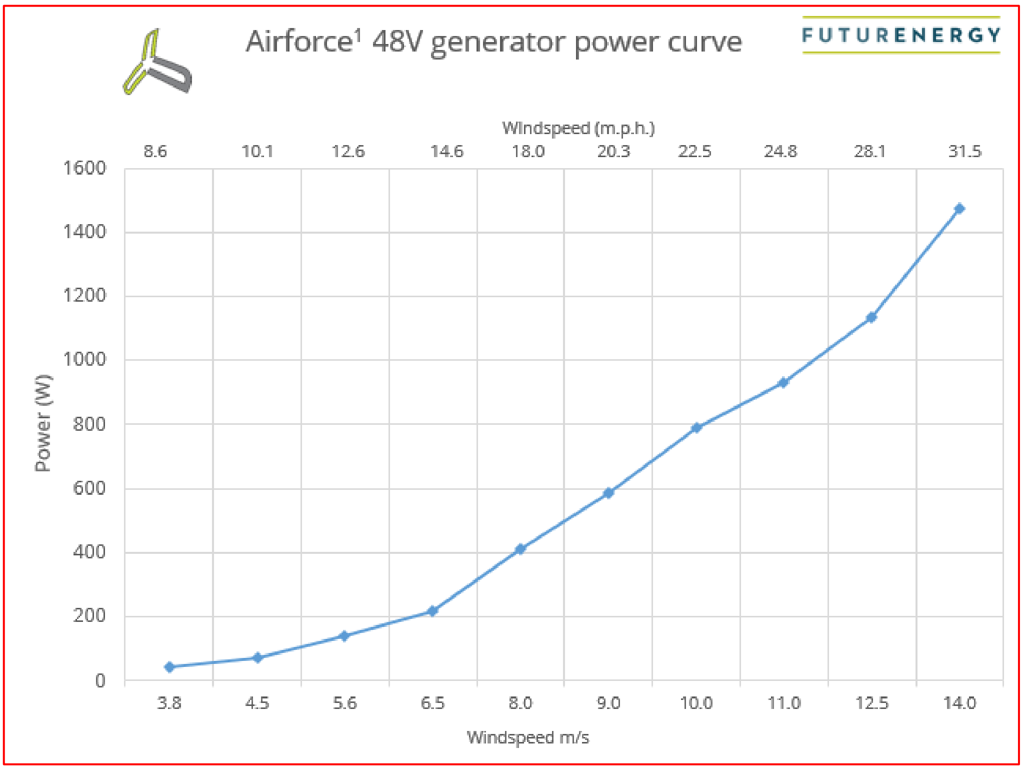
14.0	31.4	27.3	490	34.0	33.6	1142	27.418



11. INSTALLATION SCHEMATIC

11.1. 24V or 48V Battery charge installation

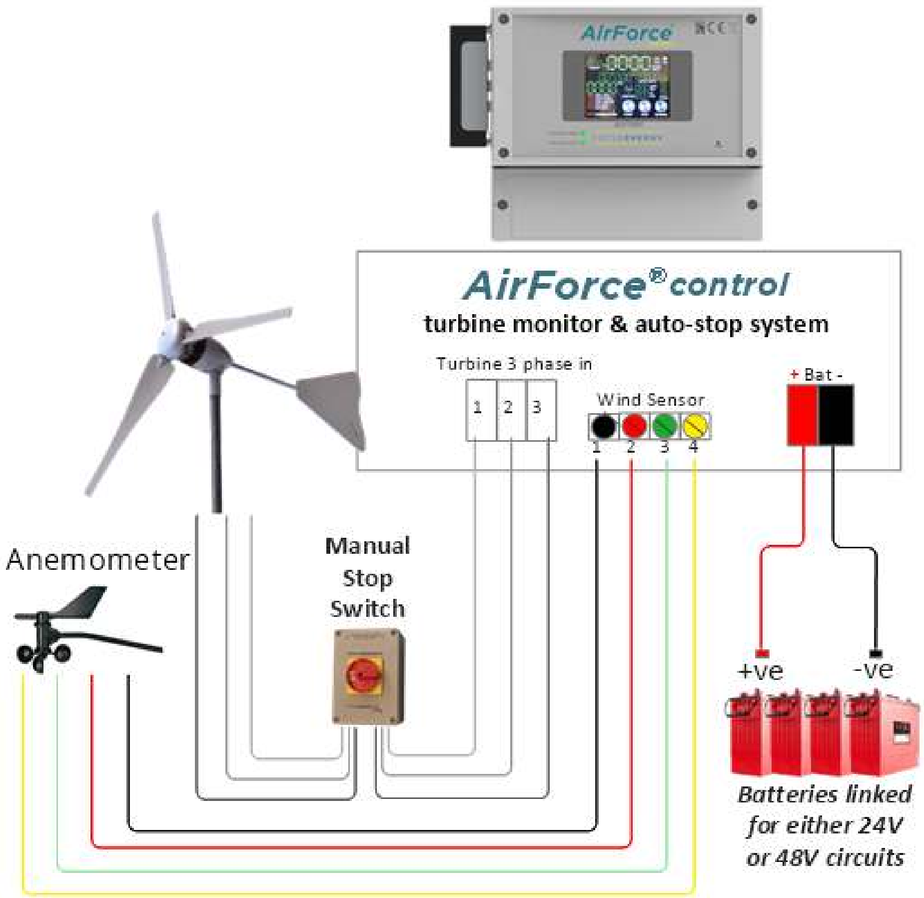


Figure 2 - Generic 24V or 48V circuit diagram
(plug-in connectors used, detail shown for information)