BUILD YOUR OWN WIND GENERATOR

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INTRODUCTION

If you have never considered alternative energy sources then you are missing a lot. Nature has all the resources you need to build your own wind power and you don't have to be a rocket scientist to build one for yourself and your family. You may have heard that both wind and solar systems are the fastest growing alternative energy source and that they complement each other very well. Thus, having both installed will dramatically increase your alternative energy supply. According to many renewable energy experts, an electric system that combines home wind electric and home solar electric (photovoltaic or PV) technologies offers several advantages over either single system that ultimately reduce your overall energy demand.

Why Wind Power

It is abundant. China, for example, has enough harnessable wind to increase its electricity consumption 16-fold.

It is carbon-free. Reducing carbon emissions is a key part of any plan to transition from fossil fuels.

It is non-depletable. What we use today doesn’t affect how much we have tomorrow.

It does not require any water. This is in contrast to other water-intensive energy sources, such as nuclear and natural gas.

It does not use any fuel. Wind farm developers are ready to sign 20-year fixed-price contracts, Brown said, because the main cost associated with wind is building the farm.

Wind turbines don't use a lot of lands. It’s true that wind *farms* take up a lot of lands. But the turbines themselves only occupy 1 percent of a wind farm's land area, which leads to the next point…

Land owners can double-crop. It’s possible to produce cattle, wheat, corn, and other commodities while also harvesting wind energy. Far from creating a NIMBY (not-in-my-backyard) problem, wind farms become very desirable in agricultural areas.

It is locally available. Wind is everywhere.

It scales up easily. A wind farm can go from 20 to 400 megawatts easily.

Wind farm construction is not time-intensive. The power can be brought online very quickly.

Important Notice

Wind power offers so many advantages, but there are however certain things you need to consider before you think of investing in wind power. Location and cost must be put into due consideration before even thinking of investment in wind power. You have to find out if your location has sufficient environmental conditions that will be sufficient for your energy needs. Furthermore, the cost of operating your household and business appliances must be put into due consideration.

An effective wind energy system has an average wind speed of about 10mph. Hence, it is important to determine the wind speed that your property experiences on a daily basis to determine if alternative energy system will be suitable for your needs. In essence, alternative energy system using wind power may not be your best choice if your property barely experiences a daily wind speed of just about 3mph.

Learn About Wind Turbine

Wind turbines operate on a simple principle. It involves the conversion of kinetic energy generated in the wind into mechanical power. The mechanical power generated is then converted into work such as grinding grain, pumping water or a generator that converts mechanical energy into electrical energy. Majority of wind turbines fall into two major categories (the horizontal-axis variety and the vertical-axis variety) depending by which way the turbine spins. The horizontal-axis variety is the type that comes to mind when many of think about wind turbines, owing to the two or three propeller-like blades around a rotor that these type of turbines possess. The three-bladed wind turbines are considered to be operated ‘upwind’, that is, with the blades facing into the wind. The two-bladed type on the other hand is considered the downwind’ type having. Wind turbines usually have a rotor that s connected the main shaft which spins a generator that creates electricity. In order to improve the efficiency of wind turbines it is imperative to mount wind turbines on a tower, with the blades having an aerodynamic curved shape in order to capture the most energy from the wind. Another part of the wind turbine that is worthy of mentioning is the gear-box which amplifies the energy output of the rotor, by increases the frequency of rotation of the rotor to drive the electrical generator. In order to prevent the blades from being pushed into the tower by high winds they are usually made stiff.

The Horizontal Axis Wind Turbine

This is probably the type that most of us are familiar with. It is very popular because they have a similar design to that of a windmill. A typical horizontal-axis wind turbines (**HAWT**) consists of a main rotor shaft and electrical generator at the top of a tower, which maybe pointed into or out of the wind. It is common practice for small wind turbines to be pointed by a simple wind vane. Larger wind turbines on the other hand generally have a **wind** sensor, a servo motor and a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator. That is, it increases the frequency of rotation of the blades. Horizontal axis wind turbine dominate the majority of the wind industry. Horizontal axis means the rotating axis of the wind turbine is horizontal, or parallel with the ground. In big wind application, horizontal axis wind turbines are almost all you will ever see. However, in small wind and residential wind applications, vertical axis turbines have their place. The advantage of horizontal wind is that it is able to produce more electricity from a given amount of wind. So if you are trying to produce as much wind as possible at all times, horizontal axis is likely the choice for you. The disadvantage of horizontal axis however is that it is generally heavier and it does not produce well in turbulent winds.

The Horizontal Axis Wind Turbines has the following advantages:

- Variable blade pitch, which gives the turbine blades the optimum angle of attack. Allowing the angle of attack to be remotely adjusted gives greater control, so the turbine collects the maximum amount of wind energy for the time of day and season.
- The tall tower base allows access to the stronger wind in sites with wind shear. In some wind shear sites, every ten meters up, the wind speed can increase by 20% and the power output by 34%.
- High efficiency, since the blades always move perpendicularly to the wind, receiving power through the whole rotation. In contrast, all vertical axis wind turbines, and most proposed airborne wind turbine designs involve various types of reciprocating actions, requiring airfoil surfaces to backtrack against the wind for part of the cycle. Backtracking against the wind leads to inherently lower efficiency.

Vertical axis wind turbine

With vertical axis wind turbines, the rotational axis of the turbine stands vertical or perpendicular to the ground. Vertical axis turbines are primarily used in small wind projects and residential applications. Vertical axis turbines can produce enough power even in tumultuous wind conditions. Vertical axis turbines are powered by wind coming from all 360 degrees, and even some turbines are powered when the wind blows from top to bottom. Because of this versatility, vertical axis wind turbines are thought to be ideal for installations where wind conditions are not consistent, or due to public ordinances, the turbine cannot be placed high enough to benefit from the steady wind.

Types of vertical axis wind turbine: Darrieus wind turbine and Savonius wind turbine

A Savonius is a subtype of vertical axis wind turbine (VAWT) generator invented in 1922 by *Sigurd Johannes Savonius* from Finland though similar wind turbine designs had been attempted in previous centuries.

The Savonius is considered to be a **drag-type** VAWT which operates with the same mechanism as a cup anemometer. With a **Savonius wind turbine**, it does not matter from which direction the wind is blowing, since there will always be more force exerted on whichever cup has its open face into the wind, and this will push the rotor around. This makes this design of wind turbine ideal for areas with very **turbulent wind**.

However, Savonius wind turbines typically only have an **efficiency of around 15%** – i.e., just 15% of the wind energy hitting the rotor is turned into rotational mechanical energy. (This is much less than can be achieved with a Darrieus wind turbine which uses *lift* rather than drag.

A **Darrieus** is a type of vertical axis wind turbine (VAWT) generator. Unlike the Savonius wind turbine, the **Darrieus** is a **lift-type** VAWT. Rather than collecting the wind in cups *dragging* the turbine around, a Darrieus uses *lift forces* generated by the wind hitting **aero foils** to create rotation.

Vertical axis wind turbine pros

- Vertical axis turbines inherently favor production of torque over power compared to horizontal axis, one to three blade horizontal designs.
- Largely because of their advantages in the production of torque they are capable of generating power at lower wind speeds than horizontal axis turbines.
- They may produce more power in the lower range of their power curves than their horizontal counterparts. (The opposite is true regarding the upper parts of their power curves.)
- They can be installed at ground level reducing the costs (and benefits) of tall support structures.
- Provided sufficient structural support they can be installed on the top of tall buildings.
- The best designs are aesthetically pleasing—they look cool.

Vertical axis wind turbine Cons:

- The maximum theoretical efficiency of a vertical axis will **always be less** than the maximum theoretical efficiency of a horizontal axis turbine. The actual efficiency of the best vertical designs has ***always*** been less than the actual efficiency of horizontal designs.
- When accelerating, the upper downwind side of the blade set on the side to which the blade set rotates (left side for clockwise rotation and right side for

counter-clockwise rotation) will ***always experience*** increased turbulence and vibration from the wake of the upwind wind side of the blade rotor. (Note Well: This trait is significantly reduced by blade rotors with a helical design ***or*** a bowed shape to the vertical sides of the blade rotor.)

- It is very hard to create a mechanism to adjust the blade pitch on a vertical axis machine (particularly in the case of a helical blade design). This means a reduction in efficiency and a tendency to stall at higher wind speeds.
- In vertical axis designs using multiple axle bearings the lowest bearing experiences enormous stress from the bending moments imposed by stress on the vertical axle support housing, the drive shaft, and the structure of the bearing itself. This leads to early lower bearing failure relative to typical bearing design which must be compensated for with greater than usual bearing support.
- The most common solution to solving the "lower bearing" problem is to construct the rotor support structure to feed to a single center bearing, or several bearings set a short distance from each other at the vertical center of the rotor. This, in turn, means that special attention needs to be given to the ultimate and elastic strength of the axle housing and seating structure for these bearings. However, this solution is probably warranted as a means to reduce differential stress on lower bearings and drive train components from bending moment at the base of the vertical axle housing. (Note: This "solution" to bearing stress is likely to reduce the aerodynamic efficiency of the blade set by crossing the swept area with internal supports for the blade set on the diagonal.)

- The most durable form of transmission for a vertical axis turbine is a so-called "soft" transmission capable of absorbing or flexing to accommodate irregular bending motions and vibration. Soft transmissions, while more durable, are less efficient.
- A vertical axis turbine **has never been designed** that could pay for itself during its design life given high normal utility rates. In remote locations, one might be able to beat diesel generation on the cost of operation.

What to look for in a vertical axis turbine:

If you must buy a vertical axis turbine, please look for the following features:

- Support bearings near the center of the blade rotor. Avoid turbines with multiple bearings on a long axle that runs the entire length of the blade rotor unless you are opting for a "bow-shaped" rotor.
- Look for either a helical blade shape or bow-shaped blades. Both designs will result in a longer system life by reducing differential vibration during acceleration.
- More blades mean more torque and fewer blades combined with a larger swept area mean more power.
- The wider the aspect ratio on the horizontal the better (a wide rectangle versus a tall rectangle of swept area or a wide bowed area versus a tall bowed area). This is simply a more efficient profile and will likely reduce wind shadow and turbulence effects.

- Make sure that extra attention has been paid to the structural integrity of bearings, locations on the drive shaft and drive shaft housing where bearings are located and the base of the support structure/drive shaft housing.
- Pay attention to serviceability. How easy will it be to inspect or replace parts? How cheap are replacement parts?

Where vertical axis designs would make sense:

- Portable power supplies for temporary military, emergency, and scientific encampments. If you could install these units on tilt-up support structures on trailers they might be very serviceable for providing battery charging for power supply to mobile operations locations.
- Irrigation pumping *as opposed to generation*: Since one of the virtues of the design is the ability to generate torque at lower wind speeds there might be applications where it may be more efficient overall to use vertical axis blade rotors for direct drive of pumps.
- Rooftop direct drive compressor and ventilation operation: Again, as above using vertical axis blade rotors for direct drive machinery versus generation has logic behind it. The efficiency you gain from eliminating a power transfer step compensates for the loss of efficiency in the inherent design of a vertical axis machine.

Dispelling wind power myths

It is needless to say that despite numerous benefits that wind has yet numerous controversies on the use of wind power has generated over the last few years. It has been said that wind energy is noisy, threatening to wildlife and unpredictable. But much of these controversies are not supported by facts. Hence they are mere gossips. Most of these controversies stem from the lack of sufficient knowledge on the potential benefits or the working principle of a wind generator. This is not to say that wind power or any other alternative energy source is not without setbacks, but the potential benefits far outweigh its disadvantages. For instance, one of the criticisms levied against wind power is lack of standards upon which they operate and lack of a regulatory framework upon which standards can be measured. Thus there is little or no minimum specification for equipment used by manufacturers of renewables. Hence, the proliferation of ‘junk' products has been sold by manufacturers who don’t offer the best value for money. Things have improved anyway, probably owing to the rapid developments in the area of renewable energy. New and improved methods are constantly developed daily to make renewable energy easy and affordable for all.

Among the many misconceptions that have generated from the use of wind power is that the energy generated from the wind is not sufficient to meet their everyday needs. This misconception can also be attributed to lack of sufficient knowledge about the working principle of wind speed.

Site specificity in relation to average wind speed is another misconception levied against wind power. In fact, buyers and dealers alike often believe that a wind generator can only function optimally in areas experience about a wind speed of 10 mph. It has become a usual practice for the dealer to ask a prospective buyer what their average wind is, and in situations where the buyer's wind speed is down around 8 or 9 mph the dealer usually advises a prospective buyer to opt for solar panels instead. The use of average wind speed of a location is insufficient to judge the efficiency of wind power. Hence, the average wind speed of a location is not enough to disregard a wind installation.

Another issue with the use of average wind speed in the assessment of wind power efficiency is the actual source of the wind data. A vast majority of wind data collected are from National Weather Bureau or a local airport which are not truly representative of our immediate wind resources. The data collected is highly dependent on the location and height of the recording instrument. Weather bureau, for instance, are interested in the wind that is generated where people are. But wind turbines are usually mounted on towers which can be as high as 90 feet high above ground level disturbance, turbulence, and obstacles. This situation is also true for airports which are usually located, traditionally, in sheltered areas because of the need for airplanes' to cope with cross winds thus facilitating proper landing. However, modern jets and planes can easily cope with cross winds. Therefore, wind speed readings from traditional airport locations are insufficient to judge the efficiency of wind turbines. In essence, the average wind speed at heights where wind generators are installed is significantly higher than those recorded by weather bureaus and airports.

You have probably been advised to wait a year or two to get a good idea of the wind resource in your location. You might have even considered installing a PVs (solar panels) instead. Instead of waiting a year all you have to do is install a (page 21 continued)

Not Reliable

It is often misconceived that wind power is unreliable, especially individuals that derive their major source of energy from solar power. There are however wind power systems that are even more reliable than solar power systems (SV). I have seen wind generators that had been in service for more than fifty years.

Among many criticisms levied against wind power (and alternative energy source in general) is that they are unaffordable, costly to install and difficult to maintain. The fact that a wind installation would have to be mounted on a tower has often discouraged folks from considering this alternative source of energy. It should, however, be understood that the investment needed for the installation of a wind generator on a tower is worth it and offers more economic gains than that which is needed for a PV array tracker. For instance, the setup cost of a wind generator with a 3KW capacity will be almost equal to the setup cost of a 3 kW PV since the cost of installing a tower come in at approximately the same price as trackers which are needed for PVs. (continue on the example on 20- 40% cost)

The wind has often been criticized as being erratic, inconsistent and thus unpredictable. You can easily predict what time of the day the sun will come out and what time of the day it will come down, unlike the wind which comes and goes. As stated earlier, the majority of these misconceptions arise from insufficient knowledge of the working principle of wind power. Power plants are usually compared using a term called the net **capacity factor** of a power plant. It is defined as the ratio of a plant’s actual output over a period, to its potential output if it were possible to operate at full name plate capacity indefinitely. Calculating the capacity factor for any power plant is not difficult. You don,'t need to be a math whiz to do that. All you have to do is take the take the total amount of energy the plant produced during a period and divide it by the total amount of energy the plant would have produced at full capacity. A PV operating in an area with an average of six peak hour of sunlight daily (24 hours) would have a capacity factor of 25 percent. It has been estimated that the annual average capacity factor for fixed PV in the lower 48 runs is between 8 and 25 percent. An increased value would be obtained in the northern tier of the state with the addition of a tracker. A wind generator, on the other hand, has an annual capacity factor that ranges from 10 to 28 percent. This value is even greatly increased if your tower is high enough. To predict what time of the day the wind blows, a rule of thumb which is well documented is that the wind usually blows when the sun does not shine, and the sun is usually very bright when the wind isn't blowing.

To determine accurately if wind power will be right for you to understand the pros and cons of PVs and the pros and cons of wind power

Pros of PVs

1) Solar energy is appropriate for smart energy networks with distributed power generation
2) Photovoltaic panels, through photoelectric phenomenon, produce electricity in a direct energy generation way
3) Operating and maintenance costs for PV panels are considered to be generally affordable
4) PV panels are silent, producing no noise at all. Consequently they are good solutions for residential applications
5) Residential solar panels are easy to install on rooftops or on the ground without any interference to residential lifestyle

Cons of PVs

1) Solar energy panels require additional equipment (solar inverters) to convert direct electricity (DC) to alternating electricity (AC) to be used on the power network
2) In case of land-mounted PV panel installations, they require relatively large areas for deployment and often the land space is committed for this purpose for a period of 15 – 20 years – or even longer.
3) Solar power efficiency levels are relatively low (between 14 – 25 %) compared to the efficiency levels of other renewable energy systems
4) Though PV panels have little or no considerable maintenance cost, they are fragile and can be damaged relatively easily

Pros of wind power

1) wind energy is a cost-effective source of electricity
2) wind energy is a renewable energy source
3) wind energy has a huge potential to generate clean power
4) wind energy is space efficient
5) Production of electricity through wind turbines is a sustainable process. Once turbines are installed cost of fuel shall be zero

Cons of wind power

1) wind energy can produce visual noise and pollution
2) vertical wind turbines represent a threat to birds and bats

How much power can you expect from a wind turbine?

Wind turbines are typically rated in terms of mega Watts (MW) of nameplate capacity. Thus, the energy produced by wind turbines is typically the number of MW over a period. The standard is a mega Watt-hour (MWH), which is the **energy** produced when the turbine is operating at an optimal level for one hour. For instance, A 1.5 MW nameplate capacity turbine could produce 1.5 MW when operating in the right winds for an hour. However, all generators do have capacity factors. This is the ratio between how much energy in MWH they generate in a year vs. how much energy in MWH they could potentially generate in a year if they ran full time in perfect winds with no downtime.

The amount that they could potentially generate is easy to calculate.

- Potential energy generation = nameplate capacity x 24 hours in a day x 365 days in a year

Let's look at that 1.5 MW nameplate capacity turbine:

- 13,140 MWH = 1.5 x 24 hours in a day x 365 days in a year

It is also important to understand that the size of blades, the speed of the wind, and density of air will influence the overall power that can be generated by a wind turbine. For instance, the bigger the size of the blades the greater the energy.

Obviously, the power in the wind varies enormously. A light wind for instance only has few watts compared to high wind which has a huge amount of watts. Moreover, environmental conditions may not be so predictable. There will definitely be days that the wind will constantly be changing which could result in extreme power fluctuations. Hence the need to capture and store energy when it is available cannot be overemphasized. Moreover, a backup power source is a requirement for every wind power source operating especially in industrial areas.

The formula below is useful for calculating the average power output from a wind turbine:

$$\boldsymbol{P = 0.5 \times rho \times A \times Cp \times V^3 \times Ng \times Nb}$$

Where:

P = power in watts

Rho = air density

A = rotor swept area

Cp = Coefficient of performance

V = wind speed in m/s

Ng = generator efficiency

Nb = gearbox/bearings efficiency

Should you buy or build a wind turbine

One of the many advantages of wind energy is that you can decide to buy or build a wind turbine. This is because all wind turbines have the same basic components and you don't have to be an aerodynamic or mechanical engineer to build your wind turbine. All wind turbines are constructed from blades, a generator, a mounting, tower, and a control system. The decision to either build or purchase a prefabricated wind turbine will depend on your home's energy needs. If the aim of considering alternative energy sources is just to reduce your energy dependence then building your wind power yourself might be just right for you. In a situation where you are just looking to supplement your home's energy needs then purchasing a prefabricated turbine might just be a better option. Purchasing a large wind turbine can cost about $5000 or even above $25000 depending on the size, power, and functionality. However, large wind turbines may only be necessary if you are considering supplying your whole home or facility with wind energy. Despite the high cost that seems to be involved, wind energy system has long-term economic gains that will significantly reduce your utility bills by around 75% and will also offer you the best value for money. A more cost-effective alternative is to build your wind turbine and the supplement it with a solar panel.

Generators: what you should know about them

On a broad basis, wind turbines are grouped into the following:

1) Permanent magnet alternators
2) Brushed DC Motor
3) Induction generator

To fully understand the working principle of generators used in wind turbines it is pertinent to define simple terms such *as stators and rotors, magnets, and electromagnets*

Stators and rotors

The stator is basically the immovable component of an electrical machine that's going around the rotor. The stator contains the windings and provides mechanical support and protection for the motor

Magnets

Electric motors are all about magnets and magnetism. A motor uses magnets to create motion. Since the north end of one magnet repels the north pole of another magnet (and similarly, the south will repel south). The interaction between the attractive forces and repulsive forces creates rotational motion. Magnets create a magnetic flux in this interaction, and this flux is utilized in generators. Modern PMAs make use of rare earth magnets such as Neodymium which is the strongest and best choice. It should be noted that the stronger the magnet, the stronger the flux and therefore the higher the voltage that will be produced for any given RPM

Electromagnets

Also termed electromagnetic coils and they have diverse applications in electrical engineering in which electric currents interact with magnetic fields in generators. Electromagnets are grouped into iron and ironless cores (also called air cores). The iron core types are widely used commercially owing to their ability to amplify the intensity of magnetic flux and thus improving the generator's efficiency. The rotational motion created by magnets creates an alternating flux field which excites the electromagnetic coil and thus induces a current in the coil thus creating an electrical voltage which is reversed with each change of polarity of the magnet thus creating an *alternating current.* To construct a wind power that will be suitable for your needs, it is essential to first determine your desired voltage, maximum current, and speed. All these put into consideration will influence the winding design of your wind turbine since the higher the coil winding, the higher, the higher the voltage that will be produced with lower currents and vice versa.

Note: the net power remains the same, and higher coil winding results in increased resistance to the flow of current.

Air gaps and flux

It is normal to have some sort of gap between your stator and rotor to allow them to spin. The lesser the air gap, the lesser the resistance and the higher the efficiency and vice versa. The gap between the stator and rotor can be adjusted to either increase or decrease your voltage.

Induction generator

These type of generators are often used in wind turbines (and also in some micro-hydro installations owing to their ability to produce useful power at varying rotor speeds). Induction generators have the added advantage over any other type of generator because of their simplicity. They are mechanically simpler and electrically simpler than other generator types. They are also more rugged, and they require no brushes or commutators to perform efficiently. A brief understanding of the working principle of an induction motor will be helpful in understanding the working principle of an induction generator. In an induction motor, a rotor rotates in response to the relative velocity between the rotating magnetic field and the rotor (called the **slip**). The rotor tries to catch up the synchronously rotating field of the stator, but it never succeeds. In a situation where the rotor eventually catches up the synchronous speed, the relative velocity becomes zero and the rotor experiences no torque. If an AC supply is connected to the stator terminals of an induction machine under the influence of a magnetic field. The rotating magnetic field produced in the stator pulls the rotor to run behind it. It is important to note that the machine takes reactive power from the AC power line and supplies active power back into the line. In other words, the induction generator is not a self-excited machine.

Now, if the rotor is accelerated to the asynchronous speed using the prime mower, the slip becomes zero, and hence the net torque becomes zero. Thus, the rotor current will be zero when the rotor is operating at synchronous speed. In a situation where the rotor is then made to rotate at speed more than the synchronous speed, the slip becomes negative, and a rotor current is generated in the opposite direction which produces a rotating magnetic field in the rotor that pushes onto the stator field. This causes a stator voltage which pushes current flowing out of the stator winding against the applied voltage. Hence, **induction generators** are also referred to as **asynchronous generators**.

Although induction generators are relatively simpler than other types of generators, they, however, have a problem with gearing when used in wind turbines. A gearing is always needed to meet the synchronous; hence you need the induction motor to run at 1500+RPM

Permanent Magnet Alternators (PMA)

These are considered to be superior alternatives to traditional induction motor described above. The biggest advantage of permanent magnet generators is that they do not depend on definite environmental conditions to work properly which thus enable their widespread utility in wind energy projects. They have the added advantage of mobility owing to their relatively small size and thus helps in saving space where they are installed.

PM generators require powerful magnets to work optimally; the magnet is allowed to rotate around conducting wires which thus creates electricity. PM generators also have the additional advantage since these generators are specially constructed and certified for long-term usage and once installed can operate for years. Hence, permanent magnet generators are highly durable, and reduces the dependence and strain on the environment.

Brushed DC Motor

This type of motor is commonly used home-built wind turbines. In a brushed DC Motor, the electromagnets spin on the rotor with the commutators helping to achieve a unidirectional torque (power) In this type of motor, gearing is not required, and you can still get a battery charging voltage in light wind. They are also easy to find since they can easily be purchased on online stores such as eBay

The importance of towers

Towers are not just structures to support your wind turbines. The tower is perhaps the most important parts of a wind turbine. And it can also be the potentially most dangerous part. In a situation where you don't feel comfortable building your tower I recommend that you purchase one or have a contractor build one for you

Location

It is important to consider your location before even starting a wind turbine project. The location must be free of obstacles that may obstruct the free flow of wind. The higher the altitude, the faster the wind speed and thus increasing the power and efficiency of your wind turbine greatly. One method to determine the wind speed at different heights is through the use of an anemometer. It is also important to have a solid foundation upon which the tower will be installed. Another factor that needs to be put into consideration is the federal or state laws pr local laws concerning the use of alternative energy and wind turbine.

The basic types of towers

Free Standing Towers

Most very large (utility scale) wind turbines are on free-standing towers; they don't seem very commonly used in the smaller system probably because of their cost. Free standing towers ae considered a relatively innovation in the industry. **Free**

standing towers can be built from thicker scaffolding poles, but a much larger (and therefore more expensive) foundation would be required at the base and the structure, though looking nicer and taking up less space, will be inherently weaker than a **guyed tower**. Lattice towers can also be guyed making for a very strong wind turbine tower.

Lattice Towers

These towers are manufactured using welded steel profiles. The basic advantage of lattice towers is cost since a lattice tower requires only half as much material as a freely standing tubular tower with similar stiffness. The main disadvantage of lattice towers is their visual appearance (although that issue is debatable). Well, for aesthetic reasons lattice towers have almost disappeared from use for large, modern wind turbines.

Tilt-up Guyed Tower

Obviously, installing a wind turbine at the top of a tower can be both difficult and dangerous. Thus a tilt-up tower is mostly preferred. In a tilt-up tower, the base of the tower is fitted to a hinge which is bolted into the concrete foundations and often a gin pole is also fitted to the base of the tower which acts as a mechanical arm to give leverage to raise the tower.

With such a system, the top of the tower can be tilted down to ground level for installation of the wind turbine or future maintenance. The whole structure can then be man-hauled or winched up to the vertical relatively painlessly and safely (see image above). At least two and more if possible people should be on hand to help erect the wind turbine keeping the guy wires taught and the ascent smooth.

A tilt-up tower must have guy wires on four sides (rather than the usual three) because it is impossible to safely tilt up a tower with guy wires on just three sides.

Gin Pole

This can be found in many tilt-up towers. The gin pole system allows installers to easily raise and lower wind poles for turbine installations and service visits. The unit attaches to the tower base at a 90-degree angle. A cable attached to the gin pole end and tower bracket is used to raise or lower the system. The gin pole may be removed once the tower is upright and bolted to the foundation.

Battery Basics

The lead-acid battery has been used commercially for over a century. The same chemical principle that's being used to store energy is basically the same as our great grandparents used.

A battery can be compared to a piggy bank. If you keep taking out and putting nothing back, you'll have nothing left. Present day battery power requirements are huge. Consider today's vehicle and all the electrical devices that must be supplied with power. All these electronics require a reliable source power, and poor battery condition can cause expensive electronic component failure.

The lead-acid battery is made up of plates (or electrodes), lead, and lead oxide (various other elements are used to change density, hardness, porosity, etc.), with a

35% sulfuric acid and 65% water solution called an electrolyte, which causes a chemical reaction that produces electrons.

The process of full charge and full discharge

When a fully charged battery is connected to a load (for example a light bulb). A chemical reaction takes place between sulfuric acid and the lead plates. The chemical reaction between sulfuric acid and the lead plates produces an electric current and electricity is generated in light the bulb. This chemical reaction also begins to coat both positive and negative plates with a substance called **lead sulfate** also known as **sulfation** (shown as a yellow build-up on plates). This build-up of lead sulfate is normal during a discharge cycle. As the battery continues to discharge, **lead sulfate** coats more and more of the plates and battery voltage begins to decrease from the fully charged state of 12.6-volts.

During the battery recharge cycle **lead sulfate (sulfation)** begins to reconvert to lead and sulfuric acid.

How to Charge

The process of charging a lead acid battery is not a difficult one, you just have to give it more than 2.15v or high per cell, the higher the voltage the faster the charging process. It should be noted that the charging voltage must be higher than the battery voltage.

As a rule, typical charging voltages for a 12 volt battery are between 12.9 and 14.4v. These voltages will completely charge the battery without the risk of overcharging or damaging the battery. In order to achieve full and fast charging without damaging or over charging the battery, is recommended that you charge your battery in stages. These stages are divided into three and they include: Bulk charge, absorption charge and float charge.

Bulk charge: this is the first stage and the battery is charged to around 80 or 90 percent in this stage. It involves applying a high voltage to the battery. There is no recommended voltage for doing a bulk charging. But typically, between 10.5v to 16v will be optimal for bulk charge. During this process, you will have to wait until the battery voltage rises to the predetermined voltage which is typically between 12.6v and 13.5v.

Absorption charge: This stage is also referred to the *topping off* stage. It involves applying a constant voltage typically between 14.1v and 15v. This process causes an increase in internal resistance within the battery which then results in a gradual decrease in current. You will have to wait until the battery voltage rises to the predetermined voltage which is typically 14v.

Float Charge: This is the final stage of the charging process and it involves *floating* the battery at a voltage that will keep it fully charged and ready for use. This process also helps prolong the lifetime of the battery. As soon as absorption charge is complete, the voltage will drop to around 12.6v to 23.8v. This process is often referred to as t**rickle charge.**

Most modern chargers make use of a Pulse Width Modulation (PWM) that pulses the power to battery only a percent of the time proportional to the charging voltage several hundred or thousands of times a second. This also achieves the process of regulating the voltage.

Steps on how to build a turbine

The following are important things to be noted before building a turbine.

Safety measures

1. Always wear protective clothes. For example; mask, helmet, eye goggles, etc. to prevent accidents. Also, avoid loose clothes.
2. Make sure the others working with you are careful to avoid putting themselves and you at risk.
3. Always keep the workshop clean because hazards can occur in an unkempt workshop.
4. There should work ethics in the workshop it reduces risk.
5. Be careful when handling metal work, they get hot during activities like welding and so on.
6. Any work activity that produces high-velocity dust or sparks should be done in a safe zone where it cannot cause a fire outbreak, or the debris can't cause harm to any worker.
7. Always be careful when working with tools that can cause injury.
8. Be careful when lifting steel parts to avoid back injury. Wear helmets when working under wind turbines.
9. Handle steel mechanisms with care.
10. Do not touch lives electrodes or bare cables.
11. Be careful when using resins they can be toxic. Avoid skin contact with resins and wear eye goggles.

12. When handling magnets take away items that can be damaged by it. Wear eye protection because of broken pieces of magnets can be flying around due to the attractiveness of themselves.

13. Be careful and take note of the voltages before handling any wiring.

14. Shock hazards can arise from wind turbines when they are disconnected from the battery.

15. All circuits from batteries must have the circuit breaker or fuses to prevent fire outbreak.

16. Be careful with batteries they are explosive and avoid contact with spills from batteries.

Construction of the wind turbine

The below are the basic parts of a wind turbine:

1. Batteries and charger controller
2. A tower to get it up into the wind
3. A mounting that keeps it turned into the wind.
4. Blades
5. A generator

Materials that can be used for the basic parts of the turbine

1. Pole to serve as the tower
2. Nuts and bolts

3. Motor to use as a generator
4. Large plastic pipes to use as blades.
5. A square metal tube to use for the base.
6. Some pieces of metal.

Tools required

1. Protective equipment
2. Screws
3. Power drill and drill bits
4. Straight edge (ruler) and pencil
5. Jigsaw(band saw)
6. Socket set
7. Wrenches
8. Compass and protractor

Steps to building the turbine

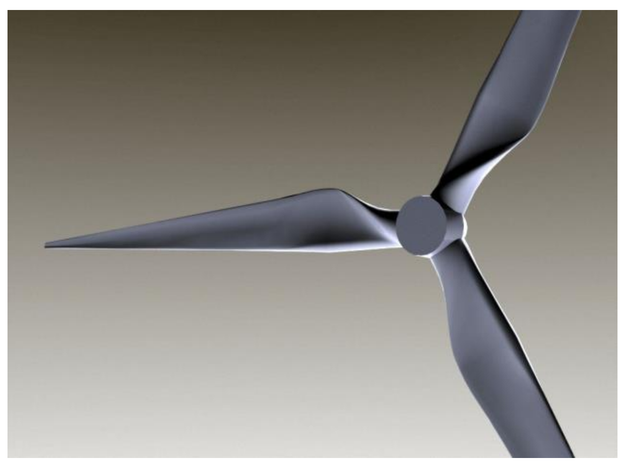
Step one: acquire the generator/motor

The generator is the most important part of the wind turbine. Some motors produce electricity when spun, and others are different, but the best kind of motor is the permanent magnet brushed or brushless motor.

Permanent magnet types work well as generators. They don't usually require high RPMs to get usable power.

For a small turbine, RPM of about 25 RPM per volt is good. Therefore the more RPM per volt, the faster the wind turbine turns to charge a battery. Ametek 30 is a popular motor that works well for building a turbine. Moreover, they can even obtain from online stores like eBay. Usually, your chosen motor will come with a hub attached to it, and if it doesn't, you will have to find something else that works. HDPE plastics or a piece of scrap metal of a hub from something else might work well. It should be remembered that your wind turbine can get up to several hundreds of RPM. Thus you need to choose a hub is appropriate for your needs. Also, the motor should be easy to turn by hand and should produce a bit of voltage with a hand.

Steps two: building the blades



Use the thickest material possible for the blades and if it's vulnerable to UV damage then paint it. Pipes, ABS and PVC, are very good as blades.

Always consider the wind velocity before coming up with your blade design. Always keep the blades short and thin it helps in producing a lot of power.

Making PVC/ABS Blades

These are instructions for 24” blades made out of 4in ABS pipe.

If you are using black pipe, use a paint pen or white pen to mark it.

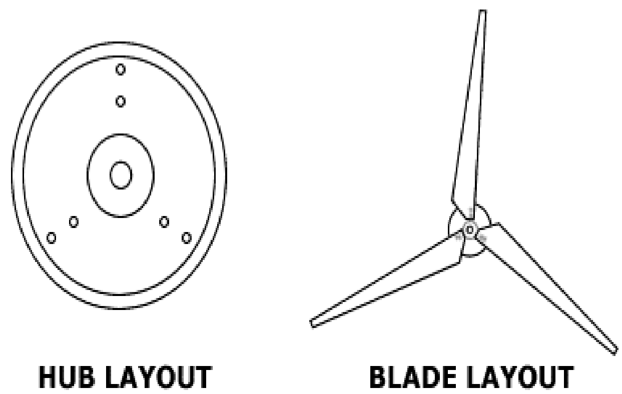
1. Place the 24” length of ABS pipe and a straight edge side by side on a flat surface. Push the pipe tight against the straight edge and mark the line where they touch. This is line 1.
2. Tape 3 sheets of 8.5 × 11 paper together, so that they form a long completely straight piece of paper. Wrap this around the section of pipe at each of the two the marks you just made, one then the other. Make sure the short side of the paper is straight along line A, and the paper is straight against itself where it overlaps. Mark a line along the edge of the paper at each end. Call one line 2 and the other line 3.
3. Start where line 1 intersects line 2. Going left around line 2, make a mark at every 5½”. The last section should be only 4½”.
4. Start where line 1 intersects line 3. Going right around line 3, make a mark at every 5½”.
5. Mark each line using a straight edge.
6. Cut along these lines, using the jigsaw or band saw. A speed controlled jigsaw is good in order not to melt the plastic while cutting it.
7. Cut a notch for bolting it.

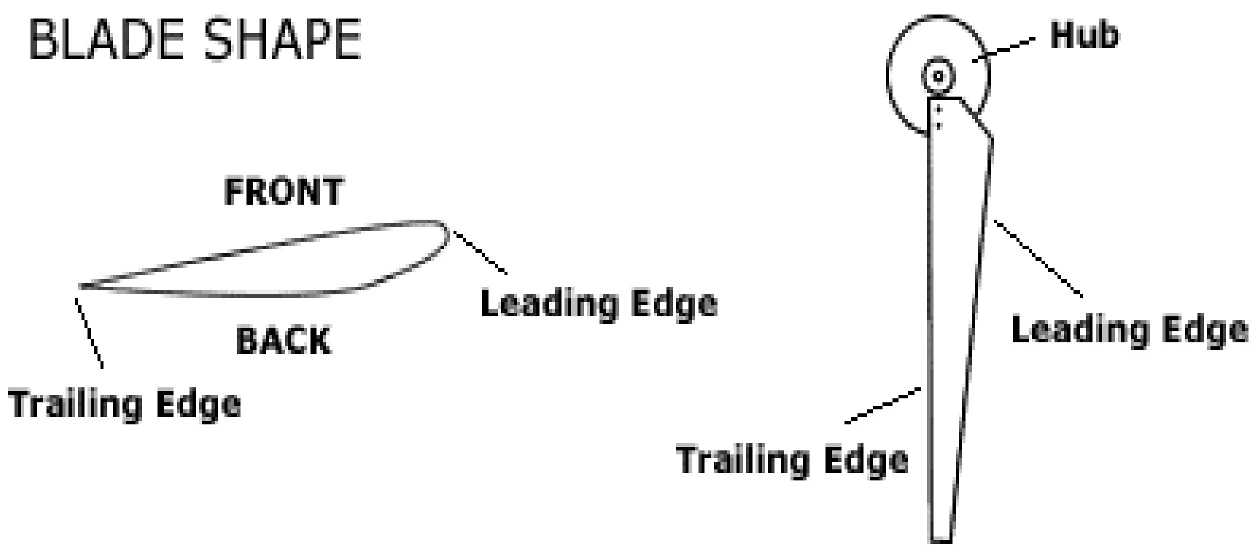
Step three: sanding the blades

Although by the angle they were cut creates an airfoil, you should sand the blades to achieve an even better airfoil. This will increase the efficiency of the blades and making them quieter. The angled (leading) edge wants to be rounded, while the straight (tailing) edge wants to be pointed. Any sharp corners should be slightly rounded to cut down on noise.

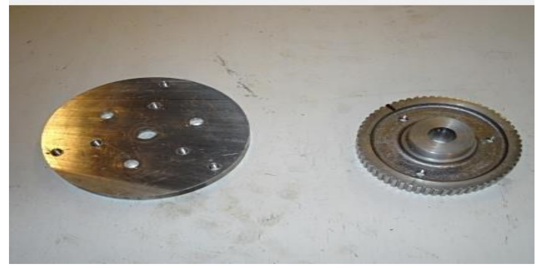
Step four: Getting blades on the hub

Motors like tread mill motor may come with the hub attached. The hubs screw clockwise, which is why the blades turn counterclockwise. The hub has cooling fins which made it harder to bolt to it. Since the motor can be sealed completely then just grind them flat (if you're remove cooling fins then the current rating for the motor will be lower).





1. Make a template of the hub on a piece of paper, using a compass and protractor.



2. Make three holes, each about 3" from the center of the circle and equal distance from each other.
3. Place this template over the hub and punch a starter hole through the paper and onto the hub.
4. Drill these holes to the size of your choice, although it's mostly ¼” to ⅜”.

5. If you're good at tapping holes, then use tapping, if not just use nuts. Make sure you at least lock washer to keep them secure.
6. Bolt the blades onto the hub. At this point, the outer holes have not been drilled.
7. Measure the distance between the straight edges of the tips of each blade. Adjust them so that they are all an equal distance from each other. Mark and punch each hole on the hub through an empty hole in each blade.
8. Label the blades and hub so that you can match which blade goes where.

9. Remove the blades and then drill and tap these outer three holes.

10. Bolt the blades back on, and you're done.

Step 5: protect the generator

It is important to protect our motor. This protection can be in the form, of an enclosure or sleeve. Some experts have recommended the use of a PVC pipe that is large enough to fit into a motor. Light gauge aluminum and RTV will also work fine as an enclosure for your motor.

Step 6: Mount and Tail

A sturdy mount and tail are required. The mount is welded to the yaw pipe. Also, ensure that your tail is properly positioned and if it vibrates add a bolt that goes all the way through the mount. It should be noted that the bigger, the better and tails have to be square with the blade

Step 7: Balancing your blades

It is important for your blades to be properly balanced before putting your wind turbine out. This will have the advantage of stopping unnecessary vibration, noise and thus making your wind turbine more efficient at converting wind power into electricity. This can easily be achieved by placing the wind turbine on a flat, horizontal table. The rotor is spanned with the blades on it and observe if any imbalance in the weight of the blades. If one lade is heavier or slightly out of place than the other, the end can then be lightly trimmed until the blades are even and balanced. The use of a real weighing balance is recommended but not necessary

Step 8: Set up the tower

It is important to have a good and strong tower. The tower should be buried and the cemented to give the strongest mechanical support for your wind turbine. A guy wire should be installed after cementing the base.

Choose the guyed tower

The Guyed towers were applied for the wind turbines from 500W to 5kW with the simple structure, low cost, and easy installation, so it is especially suitable for home use. However, it needs more land space than the monopole tower, and there was some vibration because of the small size tower pole. Generally, the tower body is seamless steel tube with 4 or 8 wires. The design survival wind speed is 45m**/s.**

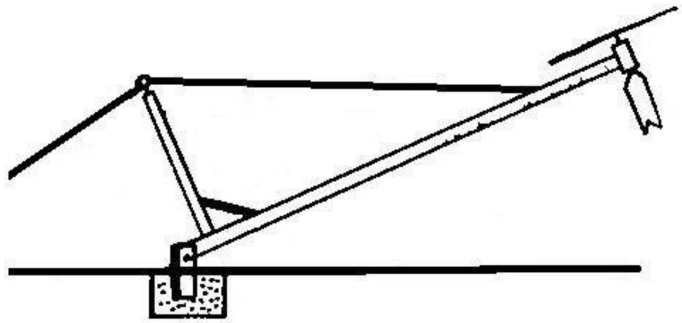
The mast

Masts are usually constructed from steel. But mostly, water pipe or tube can also be used because of accessibility. The steel tubing that is commonly used for water pipe has the advantage of being east to find, light, easy to also work with, drill and weld. Steel pipes can be found in dumps, recycling centers, and salvage yards.

Tower Hinge

A hinge for tilt-up pinnacle is an imperative part. It must have the capacity to withstand the everyday power and endure the maltreatment of rising and lower the whole weight of the tower and turbine. A concrete foundation is generally recommended with either the embedded part of your hinge in the concrete foundation or properly bolting it in the foundation.

Gin pole



Most tilt up usually have what is called a Gin pole which is usually at right angles to the main mast. It has an arm which helps lift the tower off the ground. Usually, it consists of a steel pole of equal diameter and the tubular tower pipe and the longer the ginpole, the easier it is to lift the tower. In essence, a gin pole makes it easier to raise a tower.

Guy Wires

Guy wires generally help support the stresses imposed from the wind pressing on the turbine and any other horizontal force the turbine receives. Guy wires basically consist of stranded metal cable. A 3/16" galvanized wire may be purchased from any hardware store around you, and it is compatible with most towers. In a case where you are installing your turbine in a temporary position, it is recommended that you use a standard rope instead of metal cables. The next step involves putting there or four guy wires per layer evenly spaced around the tower. As a rule of thumb, each layer should not be any further than 18ft between each layer or 18ft from the top or bottom of the tower. In a situation where your tower is twenty feet tall, you should use one layer of guy wires at 18ft, if your tower was 30ft tall use one layer at 12ft and another later at 25ft.

Concrete blocks

The best support for your tower is a concrete block foundation. This offers more than just an aesthetic appeal but also makes your wind power installation looks more professional. It is important to calculate how much weight you want for the support of the turbine.

A dead man

A dead man is essentially a deeply buried object which is used as an anchor. It should be noted that rope and any other corrodible material should not be used as the deadman. A lateral made from Stainless Steel bolt of chains are excellent for use as the deadman

To use the dead man, dig a hole and bury a piece of still pipe, treated lumber or any such material that will not degrade overtime. It is recommended that the deadman should be buried very deep although the depth needed will depend on the forces involved, the type of ground upon which your tower is installed and the size of the dead man.

Posts and stakes

Keep in mind that you need good soil to hold stakes in. Stakes must be driven at right angles from the path of the guy wire. For small wind turbines, you can get away with posts or large stakes to use as guides

Yawning

The most common yaw ‘bearing' is by skipping a larger size of the tube over the end of the tower or the other way around. They must be snug to each other but still be able to live freely. To do this appropriately absolute creativity is needed. Depending on your design needs you might have to weld a plate on the top or on the bottom of the mount to keep the two tubes in together. The cable can hang down the middle of the tube of the tower. For effectiveness, a pipe unioner will have to be used, simply unscrew one of the sides from the unioner and apply thick water proof grease to the inside of the flange of the other side. Loosely tighten the side that was removed to allow the opposite side to spin freely. Apply JB weld around the screwed side and then allow to harden. Once this is completed a perfectly made yaw mount should be produced. Although this unit will not last forever, but it will definitely last for years.

Step 9: Wiring the system

This step involves generating electricity out of the motor and off the tower. To do this, select a proper gauge of wire and run it down or inside your tower then connect it to your wind turbine

Step 10: Connect the batteries and the charger controller

Now that the mechanical part of the wind turbine is all set up, the next thing is to complete the electronic part of the project. A wind turbine power system essentially consists of one or more batteries in order to store power generated by your wind turbine, a blocking diode which serves to prevent unnecessary power from the batteries being wasted spinning the motor/generator, a secondary load to dump power from the turbine into when the batteries are fully charged, and a controller to run the whole wind power system.

A controller is probably the essential component of your wind turbine whether you built one or purchased one. The controller majorly serves a protective function. What the controller does is to monitor the battery's voltage in the system and either sends power from the turbine into the batteries in order to store and energy and charge the batteries or dumps the power from the turbine into a secondary load if the batteries are fully charged in order to prevent overcharging and destroying the batteries. The controller is connected to the wind turbine and then to the battery, and all loads are taken directly from the battery. When the battery voltage drops below 11.9volts, the controller switches the turbine power to charge the battery. In a situation where the battery voltage rises above normal, that is, to 14volts the controller switches to dumping the turbine power into the alternate *'dummy'*. Trimpots should also be made available to adjust the voltage levels at which the controller toggles back and forth between its two states.

Final thoughts

You are probably tired of paying ever-increasing electric bills or worried about the future of availability of electricity as a result of the burden which is already imposed on fossil fuel. Whether you are a home owner or you need electricity to run your business, I recommend you consider an alternative energy sources such as wind power and save yourself from unnecessary worries over the availability of electricity. You can even have a startup and generate electric power at several windy sites and sell it to the utilities. Wind power is here, and it is yours to harness its potentials.

I want to thank you for reading this guide and for the support you have been showing for my work.