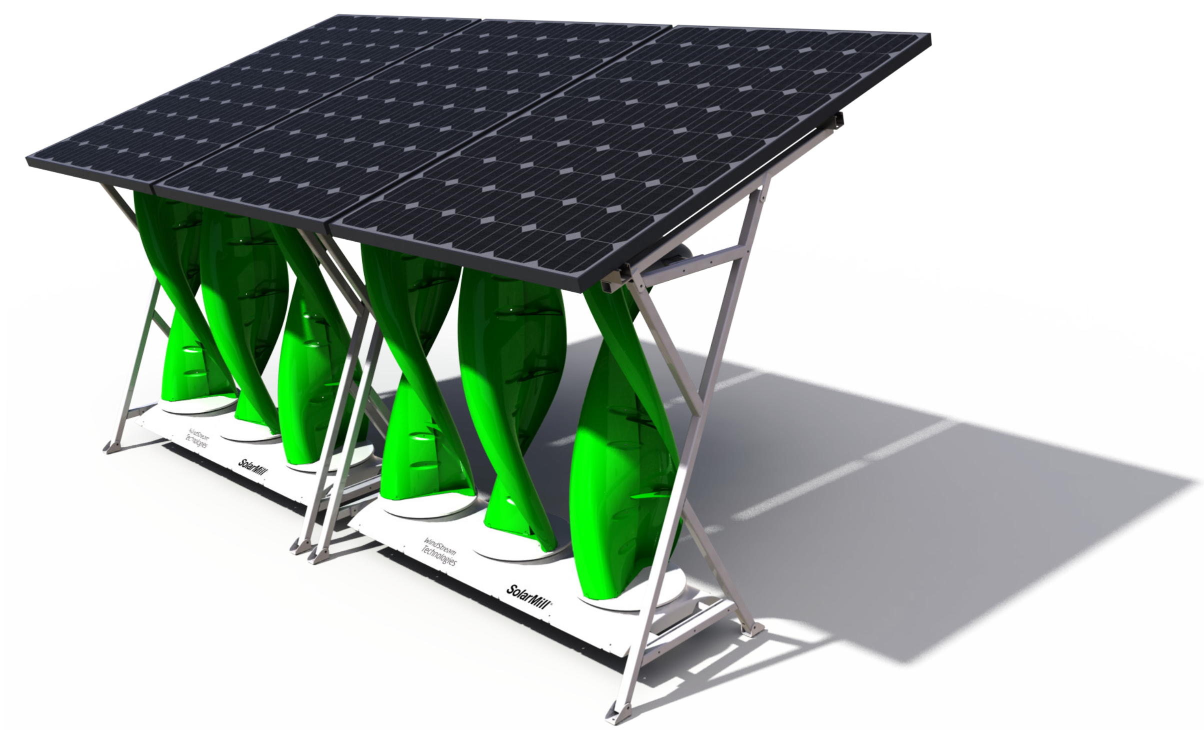
SolarMill®

SM1-1P, SM1-2P, SM2-3P, SM2-5P, SM2-6P, SM2-9P

Technical manual



SM2-3P configuration shown

(Pictures in manual may vary slightly from delivered product.)

Version 2.3 REV 6.25.14

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1. Symbols Used in This Manual


Electrical Hazard. High voltages may be present. Caution should be taken and it is recommended that this work be done by a licensed electrician.

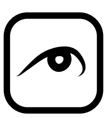

Caution: Potential for personal injury or damage to personal property.

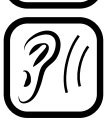

Warning: Serious injury or death may occur.

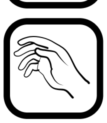

Important information or suggestion.

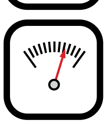

Information relevant to product warranty.


Followed by an answer to a commonly asked question


Visual observation.


Observed sound.


Manipulate or check by feeling.


Measurement taken by electrical measurement equipment.

2. Product Overview

The SolarMill® is a hybrid alternative energy product, optimized specifically for the challenges presented in harvesting green energy in an urban environment. Wind energy is converted by Savonius style vertical axis turbines, and solar energy is collected by high quality, high efficiency photovoltaic panels - all within a single footprint. The system is designed to easily integrate with any range of roof styles and types, in both grid-tied and off-grid applications. A 48VDC lead acid battery bank stores energy which is then sent to either a grid-tied inverter, an off-grid inverter, or DC loads.

2.1 Hybrid system advantages

The most obvious hybrid advantage is the increase of power available per square foot of roof by combining both power sources. But perhaps the most important factor is that the energy availability of solar and wind are very complimentary, not only on a daily scale, but also through weather systems, and even seasonally. For example, many locations are less windy in the middle of the day when the sun is at its peak, and the wind picks up after dusk. Similarly, the windiest periods in terms of weather are often present when the sky is overcast. On the seasonal scale, the winter months in temperate climates have reduced sunlight hours, reduced solar intensity, and can have increased cloud cover. It is during this lull in solar production when the wind turbines will have more available wind power because of winter weather systems and also because of the reduction of low level local wind blockage from leaves of deciduous trees. Furthermore, air at low temperatures contains more usable power at the same windspeed because of its higher density. For example, air on a very cold winter day is up to 8% heavier than air during the middle of summer, yielding 8% more power from the turbines.

Other advantages may be less obvious, such as the solar module providing protection for the wind portions of the mechanism from direct rain and hail, and assisting with the direction of air into the turbines. The solar panels also benefit. The virtue of putting solar panels into the wind is that they are regularly cleaned of dust - a problem with conventional solar-only installations that leads to system inefficiency.

2.2 Built for the city

Everything about our product is designed for the urban landscape and simplicity of use. The choice of turbine blade type was guided by several design criteria. After an extensive search of academic and industry papers on turbine design, the Savonius style turbine was chosen for its low running speed and relative insensitivity to turbulence commonly found on rooftops. Other wind generation devices which rely on lift, including both horizontal, propeller type turbines, and Darrieus turbines, suffer greatly in these regimes. They need smooth laminar wind to operate efficiently. This requires them to be mounted on large masts and guy wired towers, untenable in an urban environment.

SolarMills take advantage of areas of concentrated wind directly on the roof. Our 1 meter high turbines begin turning in the slightest breeze. Power generation begins at a windspeed of 5 mph.

Another important factor is the blade speed relative to the windspeed. Lift based turbines mentioned above typically have turbine tips that travel several times the speed of the wind, leading to significant hazards to people in an urban environment when the blades break off or shed ice. They also produce significant nuisance noise. Savonius turbines have a naturally low tip speed ratio (TSR) near 1, meaning the tip moves about the same speed as the wind for quiet, safe operation. In addition, WindStream equips each turbine with an integral centrifugal braking mechanism to deal with occasional storm gusts. The brake resets automatically when the wind speed decreases again.

2.3 The advantages of independent MPPT for both wind and solar

In order to maximize energy production at the roof, it is crucial that the system is responsive, efficient, and can take advantage of very localized gusts. WindStream has developed proprietary electronics to control turbine loading and to condition the power from both wind generators and solar panels. Each wind turbine is independently electronically controlled to its most efficient speed for the available wind. This maximum power point tracking (MPPT) is tuned to the turbines and responds to changing loading conditions continuously. Most other wind turbines do not provide electronics or MPPT and the generator outputs a raw, variable frequency AC voltage. They must rely on an aftermarket MPPT solution that can't be tuned to the system.

MPPT is also very important for the solar portion of our product. A typical solar installation will run solar modules in a long series string which goes into a high voltage inverter. Unfortunately, if even a single 6" square cell on any one of those modules stops receiving sunlight, either by shade from a plumbing vent or a leaf stuck to the panel, it limits the current in all of the maybe thousands of cells that are in the series across many modules. SolarMills utilize independent MPPT and power management for each module, which limits lost power to that single solar module. This allows our systems to adapt to challenging roof geometry and shading conditions.

The power from both wind and solar generation is routed into a common 48V DC bus which has built-in charge control for a lead acid battery bank. The units can be daisy chained for easy setup and expansion. The Company's patented platform is a cost-effective and highly efficient distributed energy solution currently unmatched in the marketplace, with unprecedented simplicity. Mounting kits are available for installation on a wide range of roof geometries.

SolarMills are sold in various configurations to suit the needs of a particular site, depending on the amount of sun and space on the roof. Additionally, a solar thermal option is available, using German designed photovoltaic panels with cooling channels tied into the hot water system of the building.

3. Document Scope

This manual covers technical aspects of installing and operating the SolarMill in the following configurations:

- SM1-1P
- SM1-2P
- SM2-3P
- SM2-5P
- SM2-6P
- SM2-9P

3.1 Audience

This manual is intended for use by qualified installation professionals and distributors ONLY Installation and maintenance by the user is not recommended because of potential for serious bodily injury or property damage.

This manual should be left with the equipment in an accessible location for future maintenance.

3.2 Safety Precautions and Warnings

Read entire manual before attempting installation of this product. Failure to follow these instructions and guidelines could result in damage to property, injury and death.

Hazardous voltages, currents, or other conditions that could cause serious bodily injury or death exist in the equipment or may be associated with its use. Do not install this device in a location accessible to children and/or pets.

Install in accordance with any local and national building codes. Once installed, use caution when approaching the device. The rotating turbines can present a serious threat that can cause injury, even at low speeds. Do not attempt to stop the turbines by hand.

DO NOT ATTEMPT to install or perform maintenance when winds exceed 4 mph (2 m/s). Use appropriate equipment and safety gear when lifting or working on a roof.

Failure to follow these directions and guideline will void product warranty.

4. Siting Methodology

4.1 Introduction

Siting a SolarMill installation requires consideration of both wind and solar exposure to maximize energy production. Wind exposure is directly affected by the local wind direction, and its interaction with the aerodynamics of the building and the large structures surrounding it. Solar positioning is primarily guided by knowledge of the movement of the sun throughout the year and attention to nearby obstructions which may cause shading. This section will discuss the process of determining the best location for the installation. Additional siting information and siting tools are also available on the website at www.windstream-inc.com.

4.2 Prevailing wind direction

As with any wind energy device, proper siting is essential to its effectiveness. The most important piece of information for siting on roofs is: "From what direction do the strong winds usually blow?" The most readily available data is provided by nearby weather stations, with high quality data coming from government regulated weather stations at all airports. Windstream has developed a set of online siting tools which can help locate and analyze years of data from nearby weather stations. Unlike a typical wind rose which presents wind direction in terms of how often winds come from each direction, the siting tools actually sum the power available from each direction to the turbomill, taking account for our turbine efficiencies and cut-out speed.

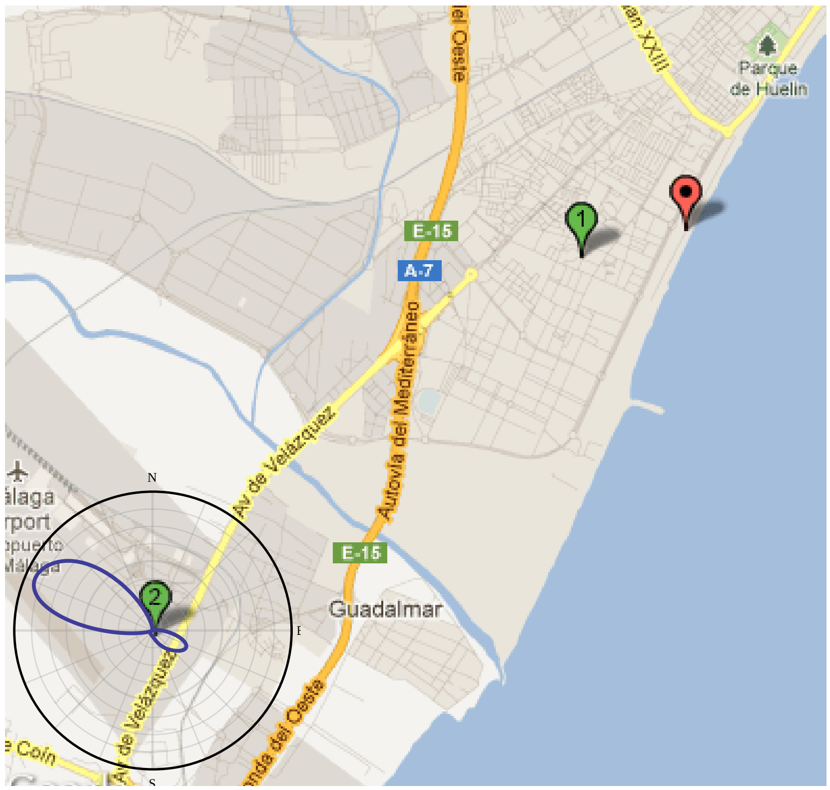


Figure 1. Using available weatherstation data Example: Malaga, Spain

As an example, in Figure 1, we see a site in Malaga Spain, shown by the red dot, and nearby weather stations. The closest weather station had inconsistent and limited data (as many less controlled weather stations do). The calculated power wind rose using nearby airport data is shown overlaid on the airport, showing a very strong directionality where the vast majority of the power available in the wind is coming from the northwestern direction. This very clear directionality is extremely common, with the notable exception of sites that are well inland where weather patterns may shift seasonally. A wind rose which does not sum based on the power available in the wind will show a much more even, and distributed wind pattern which does not provide clarity on which direction the units should face.

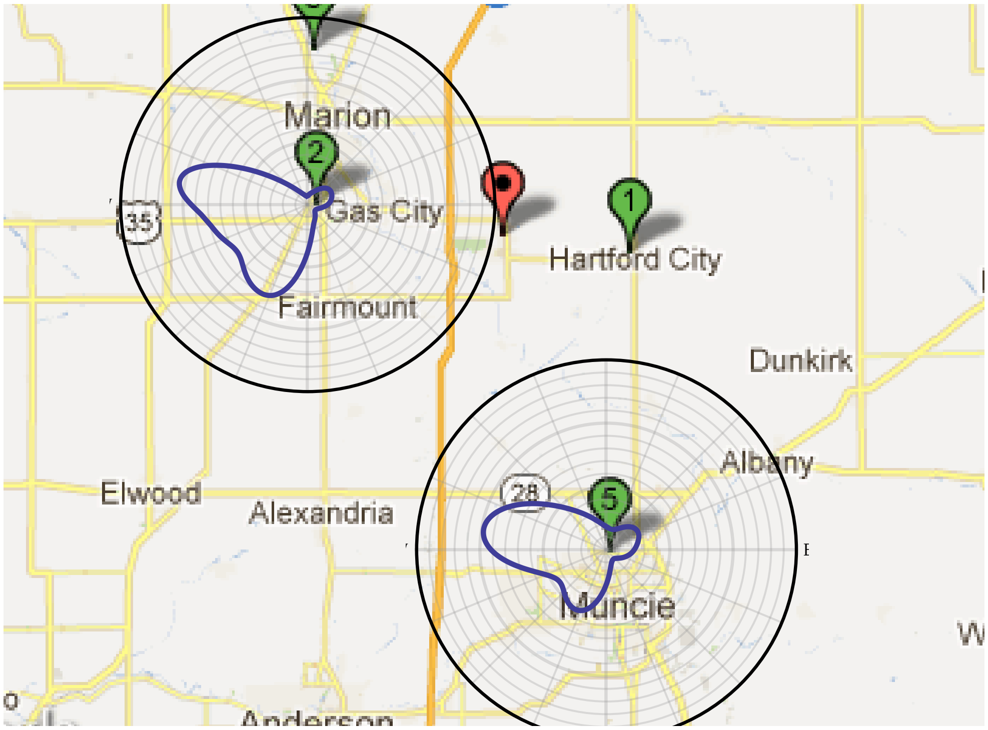


Figure 2. Central Indiana site

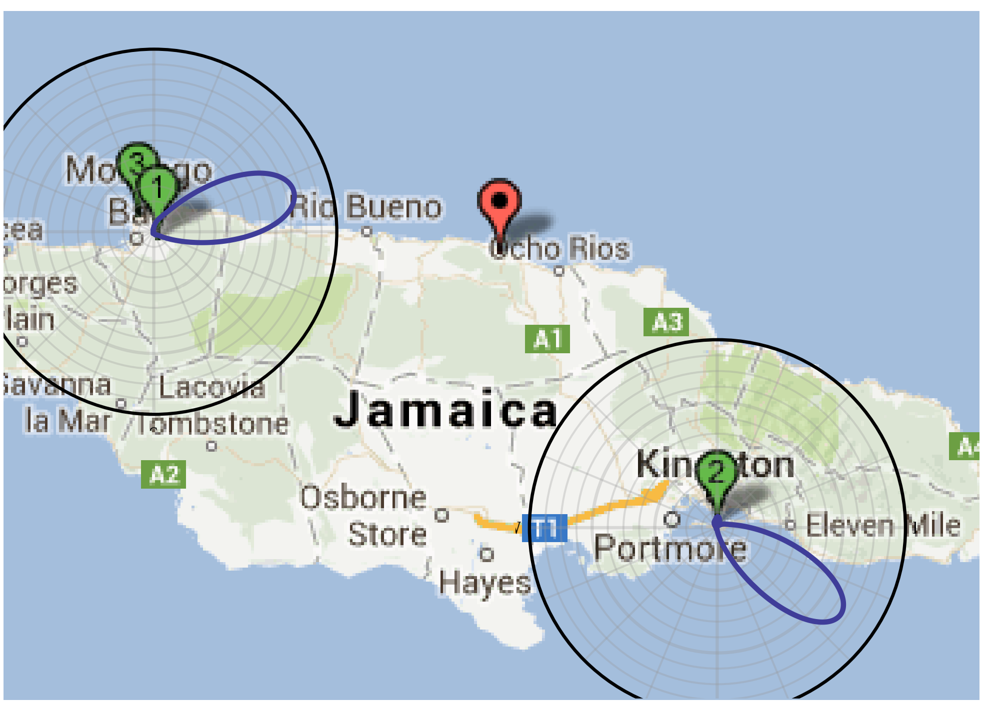
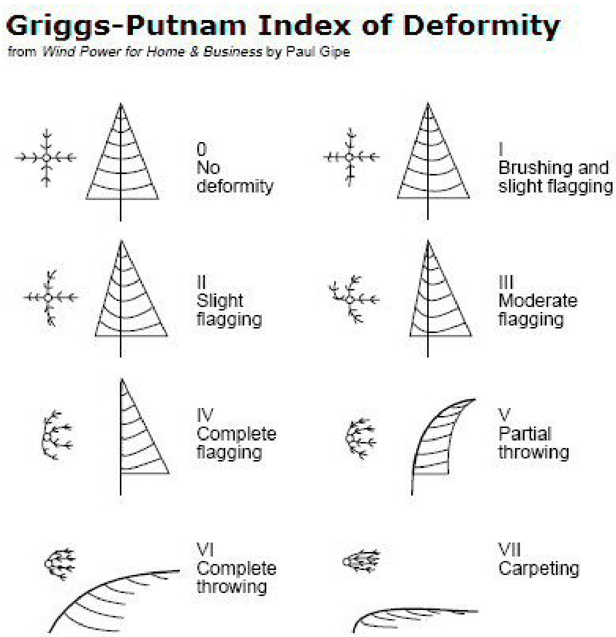


Figure 3. Wind direction measured in Jamaica

In figure 2, which shows a site in central Indiana, we see a location with a more distributed prevailing wind direction. A good portion of the available wind resource coming primarily from the southwest and the west. Even in this case, it is clear that an optimal direction would be southwest. As shown on the next page, the

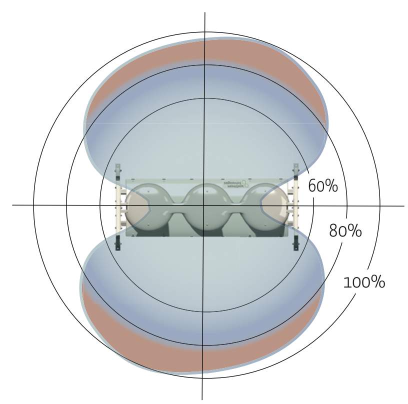
The third example shows the two main weather stations in Jamaica, in figure 3. This example shows how despite this island having a very consistent eastern wind, coastal effects are at play as wind comes off the water up onto the land.

Local wind direction will vary slightly from local weather stations, especially in mountainous regions. There are many resources to be found online to help in local wind assessment, as well as observational methods. One of which is to look for characteristic vegetation growth, as shown in figure 4. This chart will indicate both direction and rough approximation of average wind speed.



Index	I	II	III	IV	V	VI	VII
Wind Speed (mph)	7–9	9–11	11–13	13–16	15–18	16–21	22+

Although the vertical axis turbines used in the SolarMill can generate full power from wind coming from any direction, having the turbines in a line makes them vulnerable to some amount of directionality. The units maintain the majority of their power production until the angle of the wind to the line of SolarMills becomes extreme, allowing for positioning well off the optimal direction. (see figure 5). In addition, the effects that wind direction has on windflow around the building, as the next section describes, is much more significant than this reduction from optimal.



4.3 Building aerodynamics

As air hits a building, it is deflected up into a concentrated stream at the roof with an upward diagonal direction. The wind velocity in this region can exceed the velocity of nearby air at the same height by 20% or more. Once the prevailing wind direction is known, this information can be applied to the site geometry to determine where this accelerated wind flow will be located. SolarMill turbines are specifically designed to extract more energy from a flow that has an upward component.

On a simple peaked roof, as seen here in Figure 6, unless the prevailing wind direction is directly along the peak, this zone happens just above the peak of the roof, with the upward angle equal to the roof pitch. Flow then "separates" from the roof and exhibits a turbulent and low velocity area for some distance.

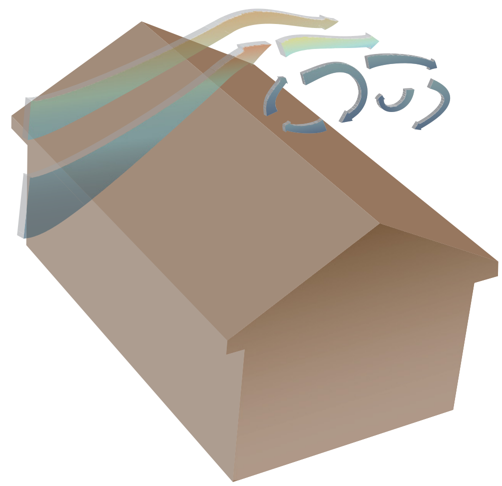


Figure 5. Flow over a peaked roof

For this reason placing SolarMills right at the peak is recommended for capture of wind coming from either side. SolarMills geometry is perfectly suited to this location on the roof, and a typical installation size will only be limited to the length of the roof ridge. A line of SolarMills would be placed along the entire ridge. Adding a double row of wind devices would be counter productive and is not recommended. On the other hand, solar capacity can easily be added to the system to accommodate larger energy needs. The next chapter will cover installation methods in detail.

On a flat roof, the wind is concentrated in a zone just above and behind the parapet, at an angle between 30 and 50 degrees upwards, depending on the height and width of the building (See figure 7). Beyond the parapet, the flow separates from the building ,forming a "bubble" of stagnant or even backwards flowing turbulent air with very little harvestable energy. After some distance, if the building is deep enough, the flow will then reattach at a somewhat lower velocity than the wind surrounding the building.

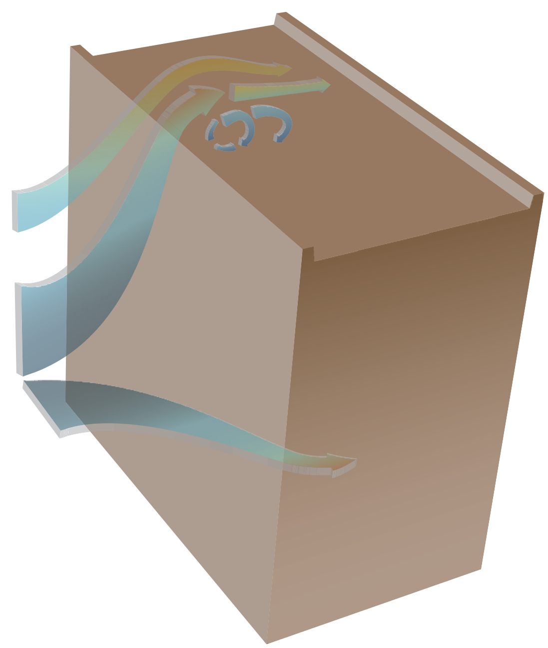


Figure 6. Flow over a flat roof

For optimal placement, SolarMills must be raised up to get the turbines within the concentrated wind zone at the parapet on the windward side. WindStream has designed leg extension kits to accomplish this. When laying out SolarMills on the building for maximal energy production per turbine, it is recommended to fully utilize the linear distance afforded on the side of the building facing the prevailing winds. If the prevaling winds approach at an angle to the building, using both sides that face towards the wind is appropriate. As figure 8 shows, air coming in at an angle sweeps vortices up on both sides. Note that to a turbine mounted on one of those sides, the wind would appear to come directly from below, not at the angle which describes the surrounding wind.

4.4 Local flow effects and blockages

Four significant things affect how the windspeed at a site correlates to local weather station measurements.

- *The boundary layer*
- *Major changes in terrain*
- *Upstream and downstream blockages*
- *Channeling effects*

The boundary layer - As wind moves across a landscape, texture on the ground tends to try and stop the air in contact with it. This results in very low velocities directly on the ground, which tends to slow down the air directly above it, which tends to slow down the air above it as well. As a result, windspeed increases as it is measured farther and farther from the surface. This layer of gradually increasing velocity is termed the "boundary layer", and the nature of the texture on the ground determines what the velocities through the boundary layer are, as well as the amount of turbulence in it. A wind coming off of the smooth surface of a large body of water is going to have a much lower turbulence and higher velocity at lower altitudes than a wind coming across highly textured and foliated landscape, or an urban setting with buildings of various heights scattered across it.

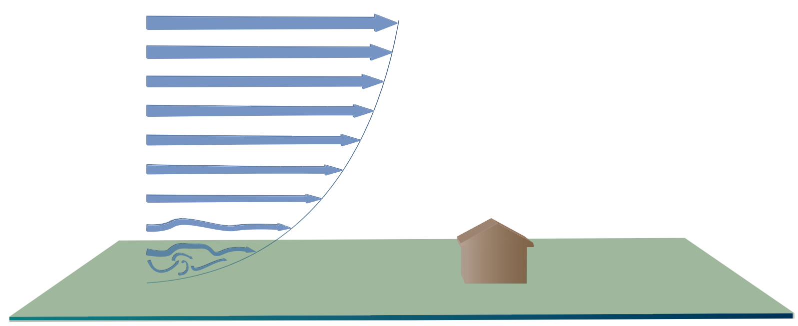


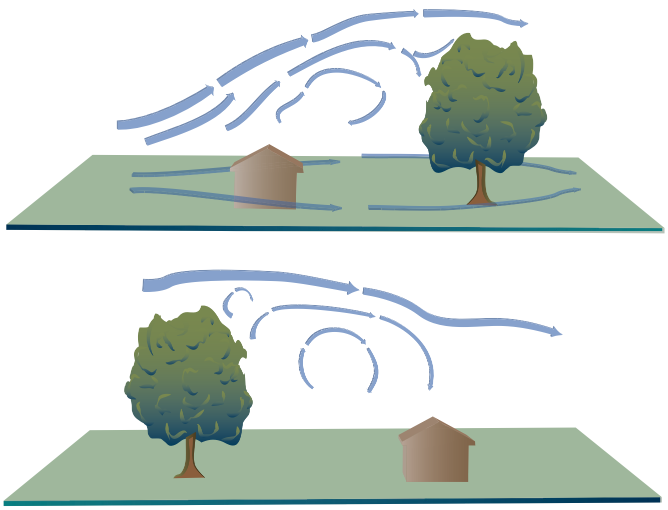
Figure 7. Boundary layer

With this concept of the boundary layer in mind, clearly sites that are elevated relative to their surroundings are going to provide a higher potential wind resource than ones lower to the ground. Generally, SolarMills should be installed on the highest point of a roof, and the optimal site for our product is on buildings which are higher than any around them.

The boundary layer calculation also helps us understand how installation site wind may relate to the gathered windspeed data from local airport weather stations. Specifications generally require airport anemometers to be placed at a 10m height. If the building being considered for SolarMills is 30m high, then it can be reasonably expected, barring effects from the other 3 elements to be descibed here, that the wind on the top of the building will be consistently greater than the windspeed recorded in the weather station data. The opposite applies to buildings less than 10m high.

Major changes in terrain - Sudden changes in terrain also play a role in local windspeeds. Just as in the previous section, it was shown that air velocity increases at the front edge of a flat roof or a peak of a pitched roof, these effects also work on a larger scale when similar geometries are present in landscape. Locations at the top of a hill, or at the edge of a bluff that faces prevailing winds can see greatly elevated windspeeds. Likewise, being on the backside of the peak of a hill can result in a reduction in average windspeed. On extremely large scale terrain or ones containing warm or cold regions, such as mountains or coastal regions, these rules of thumb may not be true, as thermal effects can cause changes to local airflow that dwarf other factors, and often result in extremely high wind potential.

Upstream and downstream blockages - Considering the actual local texture of the landscape around the site also helps to shape expectations of available wind power. The flow of air will always want to take the path of least resistance, and because of this, obstructions to the flow, including trees and other buildings will cause the gross flow of the wind to divert around the obstruction. This diversions can greatly reduce the energy potential for objects either upstream or downstream. Upstream of the obstruction, a stagnant zone occurs because the air does not have a clear exit. Downstream, the effect may last for hundreds of feet, where the velocity is greatly reduced due to flow separation and turbulence. An optimal site for SolarMill turbines is one that is 20' higher than anything within 250' of the install site in the prevailing wind direction and 100' feet opposite the prevailing wind direction. If there is no strongly defined prevailing wind direction, major obstructions in any direction will affect overall production.



Channeling effects - The exception to the detrimental effects of local obstructions is the case of either buildings or terrain that in combination with a very defined prevailing wind direction, regularly channel the wind through a narrow area. A dramatic example of this would be the extreme wind conditions that occur between buildings in Chicago, where even at ground level, people can be blown off their feet. These natural wind tunnels can provide velocities that are much higher than at other local sites.

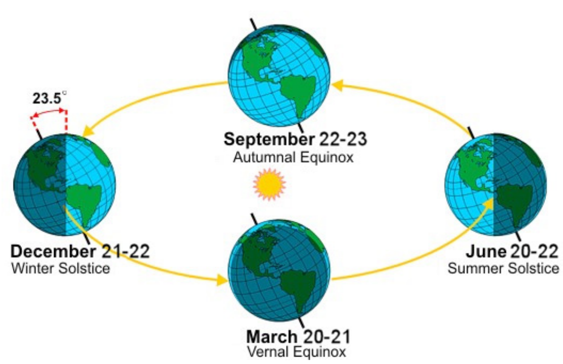
4.5 Wind power estimation

All of these factors contribute to the effective power potential available to the turbines of the SolarMills on the site, and should be considered to determine not only the suitability of a site for the product, but also to help guide positioning of the devices on the roof, if obstructions are present. The technical specifications published in this guide contain a graph that gives an estimated value of kWh produced in a year for a range of average wind speeds. Typically the local weather data will provide an average windspeed, which can then be used to read the proper value on the chart. The flow factors discussed here can provide a qualitative notion of whether to expect greater or smaller average windspeed and power production than that predicted by the nearby weather station. Large installations may want to verify the resource directly on site in a wind study to better characterize the available wind resource.

4.6 Solar Positioning

Solar panels are much simpler to site because of the ease of understanding resource availability. The primary concern is that the panels are directly and completely illuminated by the sun for as much time during the day as possible. Even small areas of shade on a solar module will result in loss of production from the entire module as well as any modules in the same series electrical circuit with it. This requires knowledge of where the shade occurs on the site throughout the year, which is determined by a combination of obstructions on the site and the path of the sun through the sky as the year progresses. If there will be unavoidable shading for some portion of the day or year, the panels should be arranged in electrical circuits that minimize production losses (see section on electrical use cases for more on this).

Also, a panel aimed directly at the sun produces somewhat more power than one tilted away, so a secondary design driver is to have the panels aimed towards the sun as much as is possible or practical. Utility scale solar plants use computerized robotic tracking to follow the sun's motion with the panel, while building mounted systems are pemanently aimed. As such, they always compromise direction to some extent. However it is important to understand what an optimal tilt angle and direction would be. This calculation, as in determining shading, requires knowledge of how the sun's path varies throughout the year, along with weather data. Unavoidable partial shading or a need to optimize for a particular season because of the specific electrical use case can result in a different optimal direction. Once an optimal direction is determined, there will be some compromise based on the architecture that is available for installing the SolarMills. The most basic rule of thumb is to face solar towards the equator (due south in the northern hemisphere and vice versa) and tilted to the same angle as your latitude, which we will see in a moment.



A basic understanding of the movement of the earth around the sun helps illustrate one aspect of the path that the sun takes through the sky throughout the year. As the earth orbits the sun, it spins on an axis that is tilted at around 23.4 degrees from vertical (see figure 10). This axis maintains its direction in space as the earth goes around the sun. When this axis, and your hemisphere, is tilted directly towards the sun, you are at summer solstice. The sun travels high across the sky, and the days are long. When the earth reaches the other side of its orbit, and the axis tilts your hemisphere directly away from the sun, you are at your winter solstice. The sun travels lower across the sky and the days are shorter. If the earth's axis was not tilted, everyday at noon the sun would fall short of directly overhead by your latitude. So if you lived in Washington DC, at 38° North, the sun would peak (90°-38°)=52° up from a point on the horizon due south. Adding in the tilt of the earth, in the summertime, the tilting of your hemisphere towards the sun adds 23.4° to this number, so at summer solstice, the sun would peak 52°+23.4°=75.4° up from this point on the horizon. At the winter solstice, 23.4° is subtracted from this number, so the sun sweeps across the sky to a maximum elevation of only 28.6°. Adding and subtracting like this means that at locations below 23.4° latitude - the tropics - actually see the sun go past vertical in the summer. At the equator, the sun swings 23.4° to the north of directly overhead on June 21, and 23.4° to the south on Dec 21.

Although the remainder of the sun's path is more complex, including where on the compass the sun rises and sets, this information will allow a rough estimate of the shadows that surrounding trees and structures will cast throughout the year. Remember to account for future growth of trees or other foliage. More accurate solar calculators are available online to calculate precise direction and elevation of the sun at any time for your location. Careful layout will allow the installation to avoid shading altogether, or estimates to be made of power loss due to unavoidable shading. As is detailed later in the manual, spacing on multi level PV configurations of the SolarMill must be adjusted to ensure that the top panels avoid shading the lower panels or other additional panels.

This change in the sun's angle also affects the optimal solar panel tilt and direction. Since the sun's elevation varies equally from the latitude number, setting the angle from horizontal to the latitude balances summer and winter sun angle (although not summer and winter power production). Pointing the array due south on the compass (in the northern hemisphere) balances between production in the morning vs in the afternoon. The power production is quite robust, however, even when deviating considerably from the optimal tilt or direction. This is important considering that any solar installation mounted to architecture will be limited by the lines and angles of the building. Windstream currently supplies the SolarMill product in 3 upper panel configurations - flat panel, 15 degree tilt, and 30 degree tilt. Call your distributor for information on the units available in your region. Lower or additional panels are adjustable tilt.

Check www.windstream-inc.com for solar production, derating, and optimization calculators.

4.7 Flexibility to match the resource

It is entirely possible that in some instances, there will be locations on a roof where there is ample wind but insufficient sunlight access, or vice versa. The SolarMill frame and mounting systems can accommodate wind-only areas, and solar only areas, and tie in to the same system. It is recommended that installations have at least some solar to ensure battery health during low wind periods. Solar resources are also measured in area, while available wind is better described on a site by describing the linear feet of length running perpendicular to the wind direction. SolarMill offers configurations that address any of these needs.

5. Mounting Requirements

Considering the flow peculiarities of rooftop wind discussed above, the primary requirement of the mounting system for the SolarMill units is to attach them securely at the location of best airflow that is present on the roof. In some cases, this will mean using a WindStream leg extension kit that elevates the turbines, especially on flat roofs with a parapet. The most secure installation method includes anchoring directly to the roof structure. However, depending on roof type and configuration, free-standing ballasted installations are possible, avoiding penetration of the roof surface.

5.1 SolarMill configurations

The SolarMill product line contains several standard configurations and can also be extended to match local resource availability. Solar panels can mount above or below the units, and supplied racking can accommodate panels running horizontally or vertically. The SolarMill turbine unit is sized to match the width of a standard 250W solar panel, and when two turbine units are placed side-by-side, the rack system fits 3 panels in a vertical direction.

5.2 Basic requirements

In the case of a flat roof, it is important to position the turbines up and in front of the stagnant wind area. Unfortunately most parapets will not be strong enough to support the turbomills, being masonry and unable to withstand a tensile (pulling) load. The structure needs to be able to raise the turbines high enough to get into the slipstream which rises above the parapet. This increases the moment arm of the turbines, and as a result, the structure has to accommodate higher forces at the base.

Generally, the structure has to be able to withstand the forces caused by the most extreme winds found in any area. This windspeed is usually available in the local building codes. The forces at these extreme windspeeds can be quite large. Those forces translate to some very high tensile forces where the base attaches, to keep the unit from tipping over. Some roof structures will not be able to support that concentrated load, so it will be typical to build a structure to spread the load, even if it is not required to elevate the turbines.

Loading calculators can be found at the www.windstream-inc.com.

Another thing that needs to be decided generally about the mounting structure is whether it will attach directly to the roof and the structure beneath, or if it will be a structure without penetrations to the roof deck. Typical installations on large flat roofed buildings use a ballasted structure to avoid the cost and complexity added when the roof deck is penetrated.

Supporting structures can be made of metal or wood, although metal is preferable because it is more stable dimensionally over time. If the parapet is low, the structure can be as simple as long members running perpendicular to the line of SolarMills, running back onto the roof. These can be wood, metal tube, or even UniStrut type rolled steel The ballast can be placed on these members. Ballast can be concrete pavers, sand bags, or large chunks of metal if available.

The structure should space the SolarMills so there is at between 5” (127 mm) and 7” (177 mm) between the ends of the units. This allows for air to flow in between the units for better off-angle response. Ultimately, the spacing will be dictated by the size of the solar panels, if they are installed.

5.3 Structure strength

The structure should be rigid, without any play at any joints, without wobble on the mounting surface, and should not emit any noises if it is subjected to a push/pull motion. Structure over parapet should leave space between it and the parapet to avoid noise if contact happens incidentally. The structure should be strong enough to not deflect visibly with application of expected loads. It can be mounted directly to the building structure or alternatively ballasted down to avoid sliding and/or tipping of the structure. It can be mounted with penetrations to the roof membrane, but there may be a cyclical load at high speeds, so the penetration hardware should be strong and rigid, and the joint should be well protected with a tough cure-in-place elastomer sealant.

6. Electrical

6.1 Components

Electrically, the SolarMill system consists of the following elements:

- 1 Axial gap, permanent magnet, AC generator under each turbine, with leads connected to the Wind Electronics Control Module for the unit
- 1 WindStream Wind Electronics Control Module per 3 turbine unit, with parallel bus connection
- 1 WindStream Solar Electronics Control Module per photovoltaic panel, with parallel bus connection
- High quality AXI-Tech photovoltaic panels

The complete installation would also include:

- 48V bank of deep-cycle AGM lead acid batteries of appropriate size
- DirectGrid micro-inverters, appropriate quantity
- Combiner box as appropriate for installation size with fuses/CB's
- Main disconnect switch on AC output line

Optional monitoring packages would include:

- 1 "BitShark" unit per 30 control modules or Windstream Power Monitoring Board
- Optional anemometer and/or wind vane for wind resource verification
- Associated wiring (cat 5)

6.2 Safety features

The wind and solar electronics control modules in the SolarMill system are daisy chained together in a parallel 48VDC bus or "string". The control units continuously monitor the amount of current that is being carried by the parallel 48VDC bus. The maximum current allowed on the bus is 30A. If a control module sees that the current is approaching 30A, it automatically limits its own power production to keep below the limit. Because of this feature, it is important to ensure that all control units are correctly connected, and that the output of the units is from the proper end of the string of SolarMills. Check markings on cables to ensure proper installation.

Another important thing to note about the 30A limit is that at 48V, the maximum power each string can carry is approximately 1500 W. If the renewable energy resources (wind and sun) available to the SolarMills are regularly in excess of that amount, strings can be split, attaching in parallel at the battery terminals. The wiring cost increase must be balanced against the potential for wasted energy production.

6.3 Wiring specifications

The DC bus is wired using standard PV wire, with a cross section of $4mm^2$, and standard, off-the-shelf MC4 connectors. Some connectors will be field installed, especially in the case of extensions that may be required to connect solar panels, depending on the layout. It is very important to ensure that proper polarity is maintained. All voltages should be checked with a voltmeter before doing final hookup, as reversed polarity will damage the units, and may void warranty.

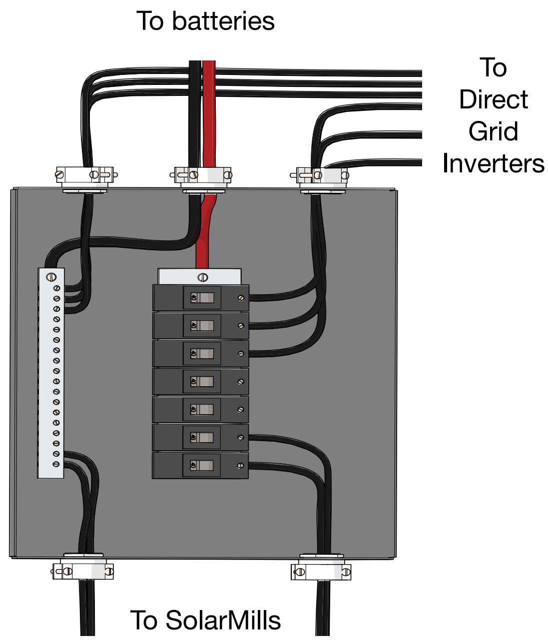
In addition, all wiring should be properly fused. The schematics that follow supply some recommendations of where fusing is appropriate, but code requirements should fully define what an installation actually uses. At the very least, each string of SolarMills should be fused using a DC rated 32 Amp fuse or circuit breaker. Inverters, if not equipped with an internal fuse protecting the DC side, should also be protected by the properly sized fuse or circuit breaker. Direct Grid inverters require this protection where they connect to the battery.

The specifics of the wiring at the battery will depend on the size and scope of the installation. A very small installation may use inline fuses, splices, and y's to combine wiring. Battery terminals may accommodate several ring terminals to allow multiple connections. Care must be taken to ensure that wiring downstream of a junction can accommodate the sum of the currents of the incoming connections.

Larger installations may need a more formal Junction setup. An example of a DC load center configured to combine and protect an installation with 2 strings of units and 3 Direct grid inverters is shown here.

Much larger installations may require additional safeguards such as master disconnect switches and conduit to protect large wiring. Local code will dictate added requirements.

Multi phase grid connections are also possible, using separate DirectGrid inverters to feed each phase. It may be necessary to ensure that the inverters will be supplying a balanced current through the 3 phases. The local utility will be able to provide specification detailing grid requirements. Contact WindStream regarding large commercial installations for guidance on recommended inverter configurations.



DC Load center detail

6.4 Battery requirements

One of the most valuable features of the control electronics in the Solarmill, is that the power is conditioned and automatically designed to charge a bank of lead-acid batteries. Lead acid chemistry has a very straightforward charge cycle that can be sensed by measuring voltage, and as such, our controllers know when it is time to stop charging to protect a battery from overcharge.

Lead acid batteries are robust, ubiquitous, and relatively inexpensive, but it is important to ensure that the battery is designed for regular, deep discharge in order for the system to have longevity. The recommended battery type is an absorbed glass mat (AGM) type battery, not only because of it's robustness when faced with large charge currents, but its safety and longevity. Deep discharge AGM batteries are slightly more expensive than standard flooded batteries, but a standard flooded lead acid battery will not stand up to daily discharge. Automotive batteries in particular, are designed only for high current, and will only last in the tens of cycles when discharged below 80%.

Battery sizing is dependent on the overall sizing of the system, and the max current that is expected from the resource. See the website for more information on this sizing.

It is also important that the batteries not be allowed to be fully discharged. Depending on the use case, there may be direct DC loads, or inverters downstream of the batteries. These devices must have a control on board that monitors battery voltage to ensure that battery depletion does not occur. Lead acid batteries have a known amount of self-dicharge, and inverters and Windstream control electronics both draw a very small amount of current when in sleep mode. It is recommended to have a mix of power sources, both sun and wind, on a given string, as this will provide the most reliable source of power to maintain battery levels, surviving through cloudy periods and windless periods alike.

6.5 Inverter requirements

Windstream has certified DirectGrid grid-tied microinverters for use with our systems. They should be purchased directly from Windstream to ensure proper configuration for the installation. Each DirectGrid inverter is rated at 460W with an efficiency higher than 92%, and can be programmed to operate between 208-240VAC at either 50 or 60 hz. The inverters can be connected in a split-phase, wye, or delta power system, either from phase to phase or phase to neutral. For large commercial installations, the DirectGrid inverters are able to scale easily to create a balanced 3-phase system.

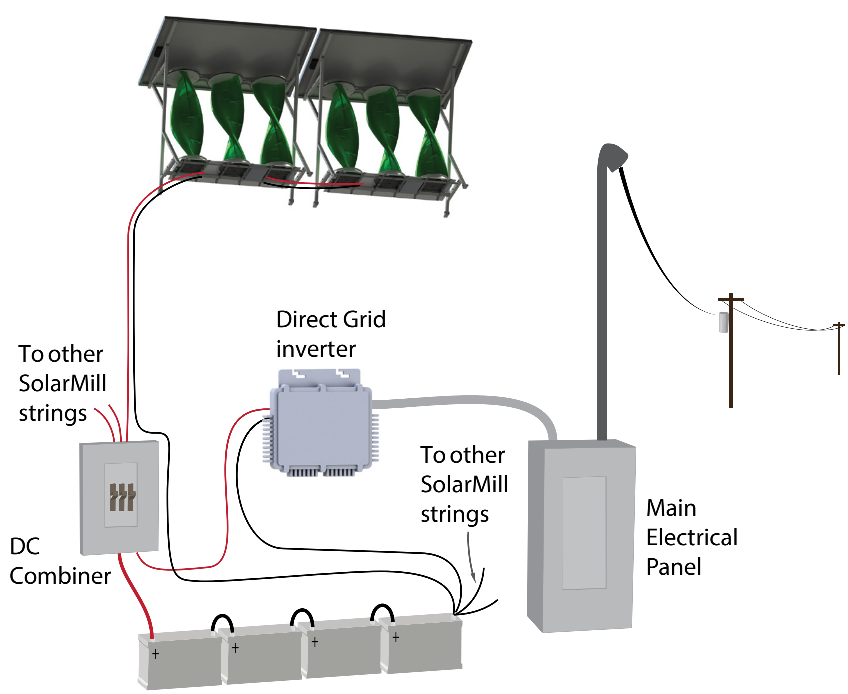
Inverters from other vendors may work with our system, but WindStream cannot guarantee the safety, efficiency or effect on the units or batteries with inverters that haven't been officially tested with the SolarMill system. If certification of an alternate inverter is desired, contact WindStream. The basic requirements of the inverters to operate with our system:

- Run on a nominal voltage of 48 VDC
- Has no internal MPPT or the MPPT can be completely disabled
- Can be set to stop pushing power to it's loads if the battery voltage goes below 46 VDC.
- Can be set to start pushing power when the voltage reaches 55 VDC.
- If grid-tied, the inverter should be able to go into a sleep mode to avoid needing to recertify grid presence during lulls in energy production.
- Minimal sleep current.

In grid tie installations with more than 2 PV modules, especially where you are not trying to store power for outages, it is more efficient to use DirectGrids programed to tie directly to PV panels, without outputting to the 48VDC bus. These micro inverters are tied to an AC feeder trunk. This trunk wiring will gradually get larger as it approaches the panel, as each feeder branching in will be adding current, and therefore losses, to the line. AC feeder trunks should be installed per local codes, with the proper junction boxes and conduit as required. As described earlier, it is important, if these feeder trunks are supplying separate phases, to maintain a balance of production between phases. This includes spatial mixing of the panels so as the installation begins to see shading in the afternoon, there will be approximately equal numbers of panels that go offline from each phase.

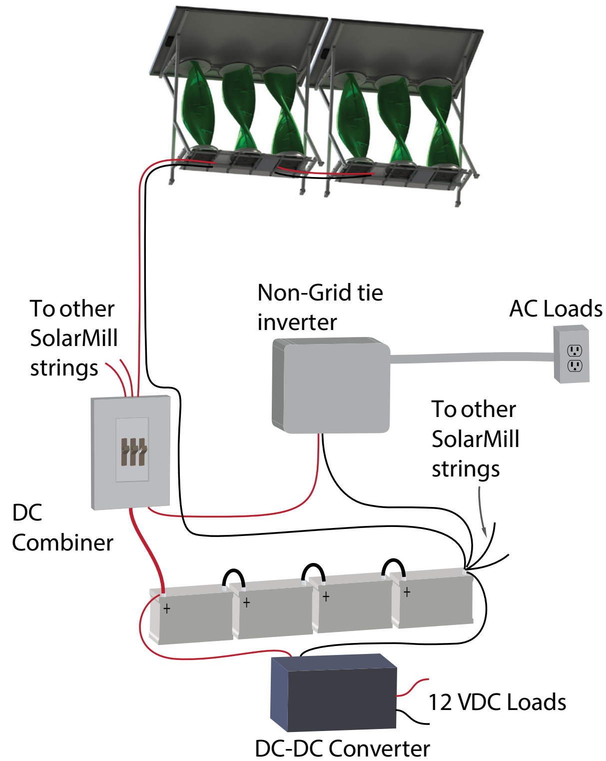
6.6 Building side wiring

The wiring of the inverters, as well as any loads downstream of the batteries, should be conducted according to all local and national electrical codes. The use cases shown here provide suggested circuits with simplified schematics, but licensed electricians should be consulted to ensure compliance with code in the install location. For large installations, a power purchase agreement, or net metering agreement may need to be worked out with the utility company, and this will necessitate addition of a power meter specifically designed to properly account for produced power (net meter).



6.7 Use cases

Grid tied



In this configuration, the bank of batteries is connected to one or more DirectGrid micro-inverters which connect to the user's electrical panel*. The inverters push power back to the grid efficiently when the batteries become fully charged. The bank of batteries stabilizes the bus voltage and absorbs power at peak production times.

**Grid connected systems may require application and agreement with the local power utility.*

Off-grid storage, with DC or AC loads

The batteries can be used to supply power to electrical devices in off grid settings. This electrical energy can power DC powered devices through a voltage converter (if necessary), or can power AC devices through a WindStream approved non-grid tie inverter**. It is important to stress that if loads are not continuously discharging the batteries, it will likely result in wasted energy producing potential. A full charge cycle on the battery can occur in a short amount of time. When the batteries are fully charged, the system will cease energy production to protect the batteries.

***Non-grid-tie inverters are not intended to push power to the grid.*

7. Product Assembly

Assembly of the SolarMill turbine unit may be easier to accomplish at the point of installation, as fully assembled SolarMills are 104 lbs (47 kg), and may be unwieldy to carry up to a roof.

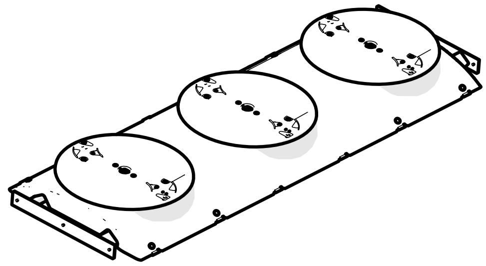
> Operations on the roof are dangerous and are intended for qualified installation professionals and distributors only. Installation by the user is not recommended, as grave risks to personal safety and property can result from working with moving equipment at roof heights. Read entire manual, including procedures on worksite preparation, before proceeding.

As inventory is taken, inspect all parts carefully for damage in shipping. The turbines should not have any visible denting or bending. The ends of the turbines should be flat to within 1/4" (6mm). If parts show damage, contact the distributor or dealer to correct the parts before installing. Damaged turbines can be dangerous to run.

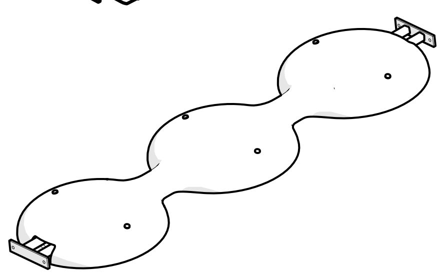
Some dust and dirt may have settled on the product during shipment. The plastic surfaces can be washed clean with a mild detergent and water on a rag.

7.1 Kit contents - turbine unit

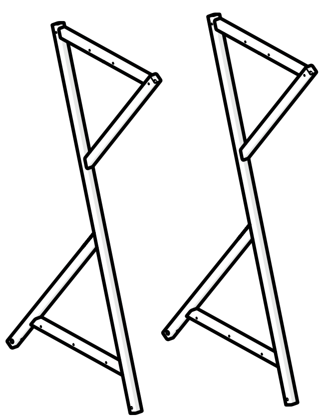
a. Base rail assembly- this houses the generators and the electronics, brakes and lower receiver plates.



b. Top rail assembly- this carries the top bearing cartridges and upper receiver plates



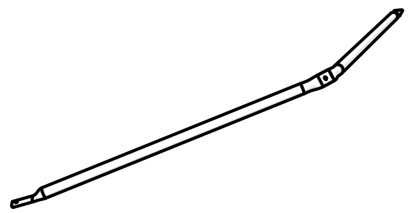
c. Uprights



d. Fastener kit

Item	Qty
6mm Socket Head Cap Screw	12
5mm Socket Head Cap Screw	8
Phillips cover screw #6	6
Screw	6
M6 Washers	4

e. Shear brace



f. 3 Turbines

7.2 Tools recommended

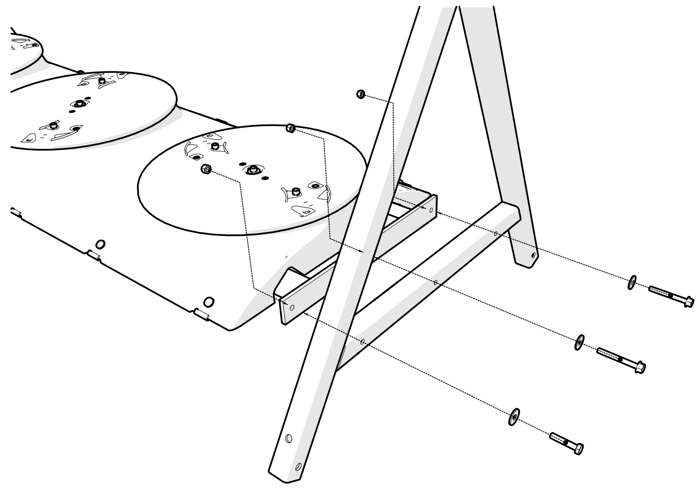
a. Torque wrench with bit holder
b. 4 mm allen head bit
c. 5 mm allen head bit
d. Phillips head bit
e. Light mallet with soft face
f. Punch to use as a drift pin
g. 10 mm wrench
h. 13 mm wrench
i. 10 mm socket
j. 13mm socket
k. Rachet

7.3 Turbine unit assembly

Attach upright frames

Step 1. Find base rail assembly. The front side of the base rail assembly can be identified by it's WindStream sticker. Rotate to underside and look for the serial number sticker, which should be located on the rear base rail. Record the serial number to the installed serial numbers list in the user's manual.

Step 2. Find right side upright.



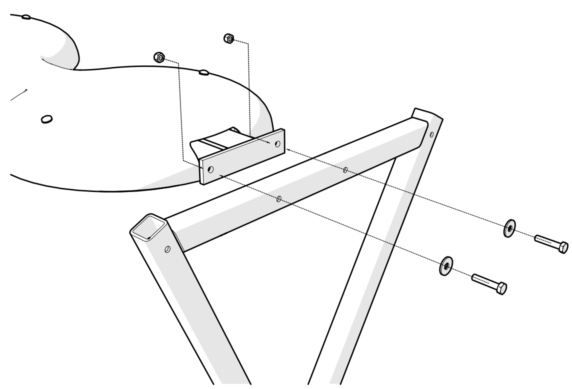
Step 3. Attach right side upright frame to base rail bracket. Turn nut using wrench and socket until it is almost down to begin tightening. Leave loose for next steps. Note that the upright will have a continuous member running from the front at the bottom to the back at the top. The front of the base rail assembly has the Windstream Logo sticker.

Step 4. Attach left side upright frame to base rail bracket. Leave fasteners untightened.

Step 5. Find top rail assembly. There is no front or back to this assembly.

Step 6. Lay unit on front.

Step 7. Attach top rail bracket to uprights using fasteners shown.



Attach shear brace

Step 8. Find shear brace.

Step 9. Remove and keep the middle fastener from the back rail of the base rail assembly.

Step 10. Install the back shear brace, with retained middle fastener, and with other fasteners shown. Do not tighten down brace fasteners.

Step 11. Tighten all bolts from steps 3 and 4, leaving brace fasteners loose.

Square up unit

The SolarMill turbine unit must be within .5" of square when fully assembled and installed. Failure to maintain proper alignment on the frame may result in interference or rubbing of the turbines.

Step 12. Before tightening shear brace screws, take measurements diagonally and ensure that the numbers match as close as can be measured. Adjust the frame until satisfactory, and then tighten screws on shear brace. Check once more after tightening.

Turbines should be stored until the remainder of the unit installation is completed., including the full structural installation of the units and all electrical work is complete. The 48VDC bus must be energized before allowing turbines to spin, as the raw AC voltage coming from the generators can damage the electronics unit irreparably even at moderate windspeeds. This will void product warranty. In addition, allowing turbines to spin can be hazardous, and units can tip before being properly attached or ballasted.

Step 13. Turbine unit is ready for adding solar panels and mounting.

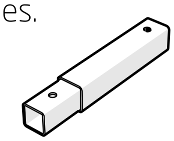
7.4 Add top solar support tubes (all SolarMill models)

There may be installation sections where wind-only devices are desirable because of shading issues. For those units, skip this section.

Install tilt extensions

Step 1. Find top rear of uprights. (front of the unit has the WindStream sticker).

Step 2. Locate extension tubes.



Step 3. Remove cap on top of upright where extension will be installed.

Step 4. Insert extension tube.

Step 5. Line up hole.

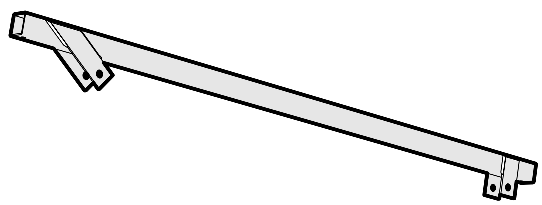
Step 6. Insert fastener shown, and leave loose.

Step 7. Place retained cap in top of extension tube if not already fitted with one..

Step 8. Repeat for opposite side

Install solar support tubes

Step 9. Locate solar support tubes



Step 10. Fit solar support tubes onto top of uprights. Holes should line up. A soft rubber mallet may be helpful to tap the tube into alignment.

Step 11. Insert fasteners. Tighten all fasteners.

7.5 Leg kits

Leg extension kits are available for all models in 3 different heights which raise the base of the turbine to heights of 0.5, 1.0, and 1.5 meters. Leg kit design will vary depending on the building geometry and lower panel count and configuration. See the section regarding mounting to determine the appropriate leg kit. All leg kits are designed for stowing, as well as easy and safe deployment when installing near the edge of a roof. The unit is laid on it's back for installation of the legs, and then the back legs are attached to the framing. The unit can then be safely and controllably hinged into final position, eliminating some of the risk of working near the edge of a flat roof. This same action allows for the unit to be stowed to protect it from extreme storms such as hurricanes.

Some installations will require no leg kits at all, and the swiveling feet can be installed directly to the bottom of the upright frames. For example, the unit is designed to straddle a roof peak, and can mount directly to unistrut rails running the length of the peak.

All leg kits come with assembly instructions and have swiveling feet to anchor directly to any flat or sloped surface. Typical installations use rolled steel railing, Unistrut or an equivalent, either to bridge between anchor points at roof members, or as a ballasted skid.. Once leg kit/lower solar support kits are installed and anchored to roof or skid, proceed to the next section adding solar racks and panels.

7.6 Add top solar panel rack (all SM2 models)

Note: Large installations which do not need to stow (installation on units not in hurricane zones) may benefit from tying the top solar rack of all units together with continuous lengths of Unistrut (using mechanical splices to join the Unistrut). This procedure can be adapted to accomplish this by installing all turbine units and then adding the unistrut.

Step 1. Set up 2 turbine units. Spacing should be approximately 6 inches (152mm) between the unit uprights. This step can be performed with the unit standing up or stowed as appropriate.

Step 2. Lay 120" length of 1-5/8" slotted Unistrut across solar support tubes, ensuring the extra length is the same on both ends of the units. Line up with mounting holes in the solar support tubes.

Step 3. Use fasteners shown to attach Unistrut and tighten all fasteners

7.7 Add solar panels

Solar panels are attached to the Unistrut support rails using standard solar clips and spring loaded t-nuts in the Unistrut. If top solar panel rack is tied along multiple units, unistrut splices may need to be drilled through to allow connector fasteners to attach through. Careful layout before rack installation will avoid this situation.

Step 1. Insert t-nuts into rail in approximate locations

Step 2. Place first solar panel on Unistrut in with panel extending down beyond the lower unistrut by 6-8 inches. Edge of panel should be within 2" (50mm) of end of unistrut..

Step 3. Adjust spring nut location at end to allow easy fastener insertion.

Step 4. Add end clips and fasteners. Edge of end clip should be flush with end of unistrut. Tighten.

Step 5. Adjust spring nut location on unfastened side of panel to allow easy fastener insertion

Step 6. Place next solar panel on unistrut, leaving space for mid connector.

Step 7. Add mid connector and fastener. Tighten.

Step 8. Repeat steps 5 through 7 for all additional panels.

Step 9. At end panel, install end clips. The end cilps should not extend beyond the unistrut. If there is insufficient space, go back and ensure that there are no gaps in the panels.

Optional end caps

Step 10. Loosen solar end connectors.

Step 11. Tap end cap into unistut with soft mallet.

Step 12. Retighten solar end connectors.

7.8 Turbine installation

After all units are fully secured, and the electrical system is fully functional and connected to charged batteries, turbines can then be installed.

Step 1. Find a turbine.

Step 2. Gently press upwards on the center of the top receiver plate to slide upper shaft up and provide room for turbine to fit between plates.

Step 3. Roughly center turbine on lower receiver plate.

Step 4. Roughly center turbine top on upper receiver plate.

Step 5. Spin upper receiver plate to align plastic ridges with profile of turbine endplate. If the profile is reversed, check turbine orientation.

Step 6. Align one of the top holes in the plate to the mounting hole in the turbine. Use of a punch may aid in this step.

Step 7. Attach plate using (2) M6 screws (one for each side of blade). Hand tighten screws.

Step 8. Repeat the process to attach the turbine to the bottom receiver plate.

Step 9. Repeat steps b. through g. for the other (2) turbines.

Step 10. Secure all turbine screws to the recommended torque.

7.9 Mounting Notes

Once the SolarMills are physically installed, they should be thoroughly checked for functionality. The SolarMill structure should be able to accommodate some amount of non-flatness of the structure, and it will not harm the units to be mounted slightiy out of plumb but if the structure is excessively out of flat, it could rack the structure. It is recommended that if after installing 3 corners, the other one sits considerably above it's mounting point, to shim it to avoid too much twist on the structure skeleton, as that can lead to a rubbing turbine.

All the turbines should turn very freely, and there should be no rubbing or grinding sounds from the top or the bottom of the turbines. If there is a rubbing issue, there is an entry in the troubleshooting section that addresses this condition.

8. Maintainance

8.1 Introduction to maintenance

This section contains rudimentary troubleshooting for an installer or service personnel of the TurboMill dealer. It is not recommended that the user attempt any repairs on the roof. The troubleshooting section will either suggest a remedy or point towards a maintenance procedure, which are all located in the next section.

8.2 What to expect in high winds

The turbine portion of the SolarMill is designed with 2 speeds in mind. It will operate in sustained windpeeds of 55 mph, short bursts of 65 mph. When the electronics begin to rise in temperature, they will unload the generators. The turbines will then be “freewheeling”, and will begin to spin faster until they reach brake activation speed, around 1200 RPM. The brakes will engage each turbine with a clicking noise, and once the turbine is completely stopped, the brake will remain engaged until the winds go below 10 mph, at which point the brake will release and the turbine will start spinning again. In the unlikely event of brake malfunction, the turbines are designed to fully fail without allowing any parts to break off from the unit. The turbine and receiver plates will deform to absorb the energy, and will need replacing, along with the bearing cartridge.

If the turbines have taken on any damage in shipping or in use, they may vibrate the unit at high windspeeds. Carefully check the turbines when installing them, looking for bent areas, dents, or missing or loose rivets. Damaged turbines should be taken to the distributor for replacement.

Is there anything that can be done to protect the SolarMills in the event a storm with high winds is forecast.

Yes, if a rope is secured through the turbines, they will survive everything except for hurricane winds. If a hurricane is forecast, removal of the turbines, and perhaps of the entire unit is recommended, or, if fitted with a hurricane stow kit, it should be stowed.

8.3 Troubleshooting

WARNING! All procedures listed in this troubleshooting section should follow maintenance and safety procedures outlined in the next chapter.

Problem: Turbine not spinning freely

Source 1. Local wind effects - The SolarMill turbine generators are extremely low friction devices, and some mismatch in rotation speed can be expected at very low windspeeds, right at the threshold of starting the turbines spinning. However, in a stiff breeze, the turbines should all be turning at a healthy pace, at very similar speeds to one another, unless the wind is coming directly down the line of turbines, in which case the first turbine will spin much faster than the downwind ones. A turbine directly behind a wind blockage, like a chimney or other obstruction, can also cause a local disturbance in the airflow which can affect a single turbine. If these are not the case, then the following checks will help to identify and correct the problem.

Source 2. Mechanical interference

Test — Listen with ear close to the installation. Specifically listen to the turbine top and bottom. Look closely for rubbing of the plastic at the base of the turbines.

Remedy — Adjust plastic cover. Ensure that the cover is fully seated onto the extrusions, and that none of the extrusions are higher or lower than the other ones.

Test — Remove problem turbine (see maintenance procedures) and adjacent turbine. Spin the top receiver plates of the two turbines at roughly the same speed. If the problem turbine plate slows down much more quickly, the problem is most likely in the bearing cartridge.

Remedy — Replace the bearing cartridge as described in maintenance procedures.

Test — Spin the bottom reciever plates at roughly the same speed. If the problem turbine place slows down much more quickly (50% of the time), the generator has interference or bearing issues.

Remedy — Replace the problem generator as described in the next section.

Source 3. Turbine issues. Damaged or defective turbines may cause running issues.

Test Swap problem turbine with adjacent turbine. See if problem follows turbine to new location. Common issues are that the turbine endplates are distorted and therefore not perpendicular to the end of the turbine. Also check turbines for bending or kinking in the helix.

Remedy Suspect turbines should be replaced to ensure safe and efficient operation

Problem: Noise coming from SolarMill installation

A properly secured, installed, and operating SolarMill system should not generate excessive noise. However there are certain situations where vibration can indicate there may be problems with your equipment or installation.

Source 1. Installation structure noises

Test Listen closely to the joints of the structure. Listen for squeaks or rattles, and watch for rocking of the system.

Remedy If structure is generating noise, tighten joints. If the system is impacting the roof surface, increase ballast/tighten connection bolts to roof to eliminate the source of noise.

Source 2. Turbine noises

Test Listen to the turbines. If there is a periodic sound, either a scraping or a ticking noise, slowly turn turbine, and look specifically for the noise to happen at a certain place in the rotation. If the noise happens at a consistent location, swap turbines and see if it is alleviated.

Remedy Replace turbine.

Source 3. Insufficient power usage/generators unloaded - the turbine control electronics sense generator rpm, which is related to the amount of power available in the wind. The electronics load the generators in response, which slows the turbines down appreciably and results in much less system speed and vibration. If the electronic control system is not functioning properly, or if there is no available path for the energy and the batteries are full, the system will unload the turbines and allow them to spin freely. While this in itself should not harm the system, as the braking system will protect the turbines from overspeed damage, this may result in higher than desired vibration.

Test Perform electrical system diagnostics as detailed in the next troubleshooting section.

Problem: System not producing expected power

Power available from a renewable energy system is variable and directly related to energy availability, so it is important to understand the conditions that could lead to loss of power production.

Source 1. Solar shading - a solar module can see almost total loss of production from shade on only 3 cells in the module. However, be aware that because of the variation of sun position in the sky throughout the year, there may only be shading for a very small portion of the year. In this case, it may not make sense to move the panels.

Remedy Increase spacing or change layout to eliminate sunlight. The lower panels are typically the panels seeing shade, as they are under the turbines and upper panels, so slide the panels further from the turbines.

Source 2. Wind shading - blockage in front of or behind the turbines can result in a significant loss of power from the wind turbines.

Remedy Relocate the turbine units or eliminate blockage.

Source 3. Battery bank at end of life - the batteries in the system function to establish and maintain the bus voltage.

Test If the batteries cannot take a charge, and quickly spike to a high voltage upon a charge current (>56V at less than 5A), or if they fall to an excessively low voltage (<45V at a discharge of 5A), then it is likely the battery bank has insufficient capacity.

Remedy Replace batteries. If batteries failed in a short period, call Windstream technical support or your distributor for further help.

Source 4. Incorrect wiring

Remedy See Windstream website for appropriate schematic and ensure proper connections. Specifically look for polarity mistakes, panels connected to the wrong place (an "input" or "output" vs a "solar" labeled wire), and blown fusing.

9. Maintenance procedures

9.1 Preparations for Maintenance

Before starting any maintenance procedure, read entire procedure as well as any referenced ones.

9.2 Securing the work area

Maintenance should only be performed on a day with wind speeds less than 4 mph (2m/s). WindStream recommends maintenance be performed only by authorized, trained personnel.

All safety precautions should be taken when working in high places. Area should be clear of debris and surfaces should be dry. All appropriate safety equipment should be used, including safety harnesses and proper lifting equipment.

Maintenance procedures require handling small components. A drop cloth under maintenance areas and a container for holding fasteners is recommended.

9.3 Tools required for maintenance procedures

4mm allen bit for 5mm Socket head cap screws and 6mm button head cap screws.

5mm allen bit for 6mm Socket head cap screws

Phillips screwdriver

Small flathead screwdriver (or flat pry tool)

Small punch or drift pin

Torque wrench with bit holder

9.4 Fastener torques

6mm Socket Head Cap Screw	176 in-lbf (20 N-m)
6mm Button Head Screw	88 in-lbf (10 N-m)
5mm Socket Head Cap Screw	106 in-lbf (12 N-m)
Cover Screw	53 in-lbf (3 N-m)

9.5 Securing the SolarMill for maintenance

WARNING! Serious injury could occur if spinning turbines are stopped by hand.

If turbines are turning very slowly (less than 2 rev/sec) the turbine can be stopped with a gloved hand on the lower turbine receiver plate. Alternatively, a heavy blanket can be thrown over the unit, which will stop the airflow and interfere with rotation. Once the turbines are stopped, they should be secured with rope . The securing rope can be attached across the turbines through stiffeners and to the uprights.

9.6 Finishing maintenance procedures

Upon completion of any maintenance procedure, check all visible fasteners and pull on mounting structure to find loose joints. Tighten any loose joints as necessary. Uprights should be visually inspected for cracking and turbines should be checked for any damage to stiffening members or any denting to the surface.

9.7 Bearing Cartridge replacement

Turbine removal is not required for replacement of the bearing cartridge.

Step 1. Secure SolarMill

Step 2. Remove top cover - Top cover is held on by 6 philips head screws covered by plastic caps. Use a sharp flat pry tool to flip up the caps and remove the screws. The cover can be lifted straight up. Retain screws for using later.

Step 3. Remove bearing cap.The bearing cap is retained by a single 5 mm screw. Removing the screw allows the cap to tilt off, exposing the bearing cartridge and shaft.

Step 4. Remove shaft retaining screw. Holding the turbine or top turbine receiver plate, remove the shaft retaining screw. Retain screw for later use.

Step 5. Remove old bearing cartridge - The bearing cartridge can be lifted straight out of the top bridge. If the fit is tight, light taps on the side of the cartridge with the mallet will loosen it.

Step 6. Insert new bearing cartridge - After ensuring alignment of the inner bearing sleeve flats, the new cartridge can be slid onto the shaft. It may need tapping to seat fully in the extrusion.

Step 7. Replace bearing cap - Bearing cap should be tilted into position over the bearing cartridge and secured with the retained screw. Ensure bearing cap is square with rails before installing.

Step 8. Cover is re-installed in the same manner as removed.

> A drift pin or punch may be used to help align screw holes in the top cover with grommets in the bearing cap.

Step 9. Tighten top cover screws and replace trim caps over the screws.

9.8 Turbine replacement

Step 1. Secure TurboMill - see procedure above

Step 2. Each turbine is attached by two 6mm cap screws on each end. Removal of the screws allows the turbines to be removed.

Step 3. To install turbines, lift the top plate to the limits of its travel. This should allow the turbine to be slipped into place and secured with the retained screws.

> Turbines are directional, so care must be taken when re-installing turbines. Receiver plates at the top and bottom of the turbine have plastic ridges that should follow the profile of the turbine end plate.

9.9 Turbine receiver plate replacement

Step 1. Secure SolarMill - see procedure above

Step 2. Remove turbines - see procedure above

Step 3. Remove turbine receiver plate - The Turbine receiver plates are secured to the generators on the bottom and to the top shaft on the top. Remove and retain screw for reinstallation. Receiver plate can be lifted straight off the top shaft or generator shaft. Note any shims under the receiver plate and ensure they are present when reinstalling the turbine receiver plate.

> IMPORTANT! On units manufactured before November 2013 the screw securing the bottom receiver plate to the generator has Left Handed threads.

> Top and bottom turbine receiver plates are distinct. They can be identified by the direction of the ridges on the surface. Bottom receiver plates also have the brake mechanism attached.

Step 4. Install turbine receiver plate and any spacers which were previously installed- Once seated, tighten the retaining screw to the specified torque. If your units were manufactured before November 2013, remember to tighten the lower bolt in a counter clockwise direction.

Step 5. Re-install turbine - See procedure above.

9.10 Cover adjustment (if plastic interference detected)

The plastic base rail cover is snapped into aluminum guides and attached with screws. Some covers can exhibit slight warpage at the lower edge which can result in the cover rising up under the receiver plates and touching the underside, resulting in a minor plastic rubbing which keeps the turbine from spinning in low winds. The cover can be adjusted by slightly bending downwards the aluminum cover supports. If it is clear that the receiver plate is not centered over the large aperture in the cover, then make sure the cover is on in the correct direction, especially if the cover has been removed for maintenance reasons.

9.11 Electronics replacement

Remove electronics - Depending on the installation structure, the electronics may be accessible without unmounting the SolarMill. The electronics and wiring harness assembly is screwed to the underside of the SolarMill unit. SolarMill power cables should be disconnected from the SolarMill string, as well as any communication cables. Next, cables to the generators should be disconnected. All cable ties securing the wires should be cut and the electronics lowered out of the bottom of the unit.

In the event that one of the turbines consistently moves slower than the turbines on either side of it, the distributor or installer should be contacted for service. If any turbine appears to be wobbling excessively or generating audible noise at low windspeeds, it is in an indication of turbine damage, and an authorized distributor or approved installer should be contacted for service.

If a SolarMill is not operating properly, it is recommended that the customer refer all maintenance of the units to the distributor for servicing.

If the customer has installed metering equipment to measure the energy produced by the Solar Mill units, and the meter shows low power production even in stiff winds, this may indicate a problem with the system and the customer should consult with their distributor or installer.

Contact information is provided at the end of this manual.

10. Contact Information

Please have your serial number(s) handy before contacting your distributor.

Distributor:

Manufacturer:

WindStream Technologies
819 Buckeye St
North Vernon, Indiana 47265
Email: info@WindStream-inc.com
Website: www.WindStream-inc.com

All specifications and content of this document are subject to change without notice.