

Wind Power

Wind-power systems can be cost effective if the average wind speed is 9 mph or more at the location of the wind generator. Adding a secondary charging source, like wind power, to PV can make an off-grid power system more stable by increasing the amount of time that energy is being produced, reducing dependence on energy stored in the batteries. Using off-grid wind to supplement solar photovoltaic power can be cost effective even if good wind is only partially available throughout the year, especially if the solar potential is low at that time.

Siting Considerations

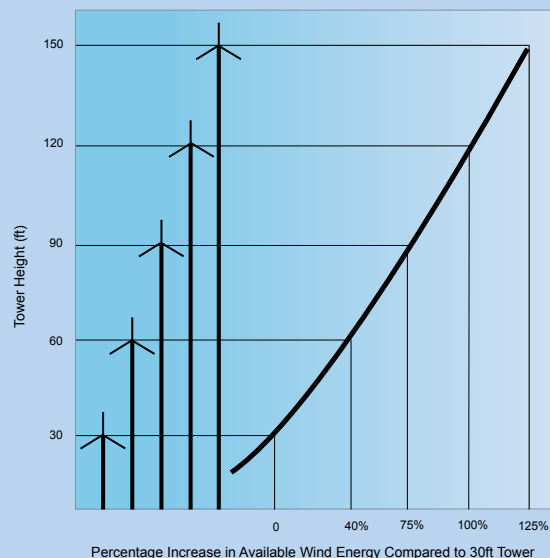
The amount of power generated by a wind turbine is dependent on wind turbulence, wind speed, and tower height. Like water, air is a fluid, and is subject to the same fluid dynamics principles, such as turbulence created by obstructions in the flow. A stream flowing over boulders becomes turbulent, creating wakes and eddies, and is robbed of much of its energy by friction.

Similarly, wind blowing over a landscape with trees and buildings obstructing its flow also becomes turbulent and loses energy to friction. Turbulence degrades the wind resource, both upwind and downwind of obstructions. Wind turbines placed in turbulent air wear out prematurely and produce little usable power.

To avoid air turbulence, wind turbines should be placed on a tower high enough that the bottom of the turbine rotor's swept area at least 20' to 30' higher than any buildings, trees, or other obstructions within a 300' to 500' radius. If the wind at the site primarily comes from a particular direction, and the obstructions are not in the wind path, then less clearance may be allowable as long as the flowing air is smooth. In the illustration below, a kite with long streamers tied to the line at 10' intervals can be used to find the height above ground level where the air flow smooths out. Look for the first streamer to be fully furled out, as opposed to flapping around.

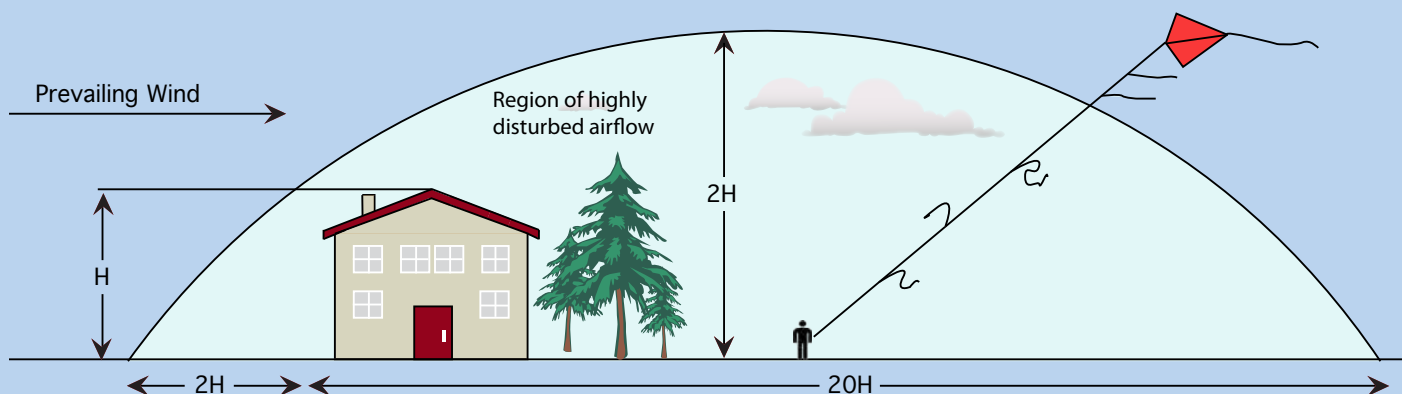
The power available in the wind increases with the cube of the wind speed. This means that there is nearly twice as much power available in a 10 mph wind as there is at an 8 mph wind. Wind speed increases as you get higher above the ground due to the loss of friction between the air and the ground. You can expect that the wind speed at 30' above the ground will be about 25% greater than at eye level (at 60', it's about 37% greater; at 90' about 45% greater; and at 120', about 50% greater). And since power output increases exponentially with increases in wind speed, a turbine mounted on a 60' tower can produce about 40% more power than the same turbine would on a 30' tower (75% more power at 90' and 100% more power at 120' compared to 30'). Most wind generators are designed to deliver maximum power at a wind speed of 30 mph. At 15 mph, they will deliver about 1/8 their rated power. Therefore, increasing tower height is a cost effective way to get more power out of a wind turbine.

The power output of a wind generator decreases roughly 3% for every 1,000' of elevation above sea level due to lower air pressure.



Measuring Wind Speed

Before installing a wind-power generator, measure the wind-power resource at the site. Local weather data will be helpful, but wind is very site-specific based on local terrain, site elevation, wind direction, and any obstructions such as trees or buildings. Average wind speeds should be calculated along with peak wind speeds during storm events. Installing a wind data logger and monitoring site conditions for a year, or for the target season, will yield enough information to predict the amount of power that can be produced by a wind turbine.





APRS

Wind Data Loggers

The **Wind Data Logger** is an affordable and easy-to-use tool for wind site evaluation and wind generator performance analysis. It records wind speed, time, and date directly to a Secure Digital (SD) card for convenient data downloads. The logging interval is adjustable from 10 to 60,000 seconds (16.6 hours). The 2 gigabyte SD card (included) will store a year of data at 30 second intervals and many years of data at longer logging intervals. Common spreadsheet software (i.e. MS Excel™) can be used to view, graph, and analyze your wind data. Easy to use web-based software is provided. Simply upload the data, and the software will automatically plot the data as well as provide basic statistics. A 16-character x 2 line backlit LCD screen displays current information and is used for configuring the data logger. A simple menu-driven interface using the LCD and three front panel buttons makes setup easy. A bright backlight makes the data logger easy to use at night. The data logger is housed in a waterproof enclosure.

The **solar powered models** work well for wind data logging in remote areas without access to AC power. The included 10W solar panel and sealed battery will run the data logger almost indefinitely. They come with a 10W PV module, a side-of-pole mount for the module, a charge controller, and a 7 amp-hour battery.

The AC model comes with a Universal AC power supply that accepts 90–264 VAC, 125-370 VDC, 47-63 Hz instead of a solar module and battery; however, it does have a space for 8ea D cell alkaline batteries for 30 day power backup (batteries not included).

The optional **#40R anemometer** is a more rugged, extra heavy duty version of the standard 3-cup anemometer. Both AC and DC models are housed in a weatherproof Pelican case with self-resetting fusing, and have lightning protection for all sensor channels and solar input.

APRS Wind Data Loggers

Description	Item code
APRS 6060 wind data logger - solar powered	016-00270
APRS 6063 #40R wind data logger - solar powered	016-00271
APRS 6061 wind data logger - AC Powered	016-00273
APRS 6062 #40R wind data logger - AC Powered	016-00274



Kestrel

Wind and Weather Meters

The **Kestrel 1000** measures instantaneous maximum and average wind speeds in knots, meters per second, kilometers per hour, miles per hour, feet per minute, and Beaufort. Hold it up to measure wind speed. It offers a large, easy-to-read liquid crystal display with $\pm 3\%$ accuracy, and measures down to 0.3 m/s (0.67 mph). Its impeller and protective housing pop out for easy and inexpensive replacement, and it includes a slip-on hard case that protects the impeller, buttons, and display from damage in your pocket or toolbox. It is waterproof, and it floats. The replaceable battery provides up to 400 hours of use. 5-year warranty.

The **Kestrel 2000** has all the features of the Kestrel 1000, and is also capable of measuring wind temperature and speed. The Kestrel 2000's external temperature sensor and waterproof casing allow you to gauge the temperature of water and snow, as well as open air. Hard slip-on case included. 5-year warranty.

The **Kestrel 4000** has all the features of the Kestrel 2000, plus the capability to store up to 2,000 points of weather data in order to track changes over time with data storage, graphing functions, and computer interface technology. You can view data as graphs on the Kestrel 4000 display, or with Kestrel's Communicator Software and a Kestrel interface. Data can be downloaded to a PC or Mac for long-term storage, in-depth analysis, and detailed charting. Kestrel Interface kits are available with either a serial or USB port connection, and include an interface cradle unit, serial or USB cable, and CD with easy-to-use software. The Kestrel 4000 is also available with integrated Bluetooth® wireless data transfer, allowing both real-time and logged data to be transferred wirelessly and automatically to a laptop or PDA, eliminating the need for a separate interface and cabling. The 4000 comes with a soft carry pouch. Carry case optional. 5-year warranty.

Kestrel Wind and Weather Meters

Description	Item Code
Kestrel 1000 pocket wind meter	016-00253
Kestrel 2000 pocket thermo/wind meter	016-00256
Kestrel 4000 pocket weather station	016-00259
Kestrel 4000 pocket weather station with Bluetooth	016-00258
Kestrel 4000 computer interface - USB	016-00260
Kestrel 4000 computer interface – serial port	016-00261
Kestrel 4000 K4000 carry case	016-00263
Kestrel replacement impeller for all models	016-00255

Southwest Windpower

AIR Wind Turbines

AIR wind turbines harness the wind's energy to charge an off-grid battery bank. AIR turbines are extremely popular and frequently used in sailboats, RVs, remote cabins, and offshore platforms.

The AIR wind turbine incorporates a three-phase brushless permanent magnet alternator and integrated microprocessor-based charge controller to optimize its power production capability. The microprocessor continuously adjusts the loading of the alternator to keep the turbine operating efficiently in most wind regimes.

The **AIR Breeze** is designed for battery-charging applications in coastal areas, on boats, and for other marine uses. Corrosion-proofed for use in coastal and nautical applications, it has a white powder-coated housing and sealed electronics designed to prevent damage from salt spray. Rated power: 160 W at 28 mph (12.5m/s). Lifetime limited warranty.

The **AIR 40** provides energy for off-grid homes, water pumping, lighting, telecom, and anywhere you need electricity and have average annual wind speeds under 15 mph. It has a bare aluminum finish for use in non-corrosive environments, so it is not suitable for marine use. Rated power: 160W at 28 mph (12.5m/s). CSA Listed for the US and Canada. Lifetime limited warranty.

The **Air 30** is the best choice for reliable battery-charging in very high wind areas (above 15 mph average annual wind speed). The Air 30 has lower energy production at lower average wind speeds than either the AIR Breeze or the AIR 40. It has a bare aluminum finish for use in non-corrosive environments, so it is not suitable for marine use. Rated power: 400W at 28 mph (12.5m/s). CSA Listed for the US and Canada. 5-year limited warranty.

All units weigh 13 lbs, have a 46" rotor diameter (11.5 ft² swept area) and mount on a 1.5" Schedule 40 steel pipe (1 7/8" [48mm] outer diameter). Made in USA.



AIR Wind Turbines												
Model	Approximate Monthly kWh Production vs. Average Annual Wind Speeds										DC battery voltage	Item code
	mph →	8	9	10	11	12	13	14	16	18		
	m/sec →	3.57	4	4.5	4.9	5.36	5.8	6.25	7.15	8		
AIR Breeze Marine		13 kWh	17 kWh	22 kWh	28 kWh	38 kWh	43 kWh	50 kWh	--		12	016-00987
											24	016-00989
											48	016-00990
AIR 40		13 kWh	17 kWh	22 kWh	28 kWh	38 kWh	43 kWh	50 kWh	--		12	016-01038
											24	016-01039
											48	016-01040
AIR 30		7 kWh	10 kWh	14 kWh	20 kWh	25 kWh	31 kWh	35 kWh	50 kWh	60 kWh	12	016-01032
											24	016-01035
											48	016-01037



MidNite Solar Stop Switch

MidNite Solar's Stop Switch allows you to stop an AIR wind generator and disconnect it from the battery, all in one motion. The MN-Stop Switch comes with a neutral busbar and ground box terminal. Rated for wind turbines up to 63 amps at 150 VDC. Enclosure size: 9"H x 5"W x 4"D. Weight 3 lbs. ETL Listed for the US and Canada.

Description	Item code
MidNite Solar Stop Switch (code compliant)	053-00121



AIR Turbine Tower Kits and Accessories

AIR tilt-up tower kits are available as hardware kits (not including the tower pole) in 27' (8.1 m) and 45' (13.5 m) heights, and in a 29' (8.8 m) **EZ Tower™** kit that includes the pole for the tower. All towers use a 4-guy-wire set-up, and are assembled on the ground with the wind generator and tilted up into place.

The **27' and 45' tower kits** come with all the hardware necessary to install a tower, except guy-wire anchors, pipe, and concrete. All parts bolt or clamp together, and no welding is required. Purchase 1-7/8" steel tubing from a local chain link fence supplier (for up to 90 mph at 27', or 70 mph at 45'), or use 1.5" Sch 40 Galvanized water pipe (1-7/8" OD and up to 120 mph at 27' and 90 mph at 45'), to build the tower. These tower kits include a simple elbow/tee for its base that, when combined with a short length of pipe, eliminates the need for a concrete pad, swivel, and base plate. Two people are required to erect one of these towers, but no winches or vehicles are needed. AIR towers are PE stamped and approved for the California buy-down program. Contact us for engineering "wet stamps" (additional cost).

The **AIR Marine Tower** is the easiest way to mount your **AIR Breeze Marine turbine** on a boat. It's simple to install on wood or fiberglass decks. The 9' (2.7 m) white powder-coated aluminum mast has an outside diameter of 1.9" (48 mm) and two 9' (2.7 m) long fully-adjustable stays with a 1" (25.4 mm) outer diameter. The Hardware Kit contains stainless-steel hardware with self-locking nuts, and vibration mounts to minimize sound transmission. Designed to withstand hurricane-force winds. Order the Mast and hardware kit separately.

Roof mounts are also available and include vibration isolators, wall brace clamps, and a safety leash, but do not include pole or lag screws. Caution should be exercised with roof mounts as wind turbines can transmit vibration into a building, causing stress on the structure, and its occupants. Mounting on wood-framed living structures is not recommended.

The **29' EZ Tower™** kit comes with all the parts you'll need, including Galvanized tubing, cable and hardware. This tower uses lightweight tubing while providing plenty of strength to withstand winds up to 110 mph. Two people can easily erect the EZ Tower™ without winches or vehicles. The EZ Tower™ includes a simple yet effective tower base and anchoring system which eliminates the need for a concrete pad. The kit comes with guy-wire anchors that are driven into the ground (depending on the soil conditions, concrete may be necessary for proper guy anchoring). Can ship via UPS in one 74" (1.9 m) box weighing 80 lbs.

Earth Auger Sets

Screw-in "auger" type guy anchors can be used in loamy and gravelly soils. Other soil types may require concrete footings or expansion bolts. Consult an engineer or geologist if you have questions about guy supports.

Air Turbine Tower Kits and Accessories		
Model	Description	Item code
1-TWA-20-03	AIR Marine Tower Hardware kit	016-01128
1-TWA-20-02	9' AIR Marine aluminum mast and 2 stays	016-01131
1-TWA-19-02	Roof Mount kit without roof seal	016-01134
1-TWA-19-01	Roof Mount kit with roof seal	016-01137
2-TWA-100	Roof seal – for Roof Mount kit	016-01140
1-TWA-10-01	27' AIR guyed tower kit	016-01086
1-TWA-10-02	45' AIR guyed tower kit	016-01092
1-TWA-11-01	29' EZ Tower kit including pipe and anchors	016-01081
1-TWA-12-01	36" Auger - set of 4; use with 24' & 27' towers	016-01113
1-TWA-12-02	36 Galvanized Auger - set of 4; use with 24' & 27' towers	016-01116
1-TWA-12-03	48 Auger - set of 4; use with 32' - 50' towers	016-01119
1-TWA-12-04	48 Galvanized Auger - set of 4; use with 32'-50' towers	016-01122
2-ARAC-101	AIR Stop Switch (not code compliant). No enclosure included	016-01351
3-ELOT-1147-01	5 amp circuit breaker kit - for 48 V AIR Breeze / AIR-40	053-17005
3-ELOT-1147-02	10 amp circuit breaker kit - for 24 V AIR Breeze /AIR-40 ; 48 V AIR-30	053-17006
3-ELOT-1147-03	20 amp circuit breaker kit - for 12 V AIR Breeze /AIR-40 ; 24 V AIR-30	053-17007
3-ELOT-1147-04	40 amp circuit breaker kit - for 12 V AIR-30	053-17008
3-ELOT-1147-05	50 amp circuit breaker kit - for 12 V AIR-30 (very high wind area)	053-17009

Grid-Tie Inverters for Wind Turbines

A grid-tie wind-power system is composed of a wind turbine with a permanent magnet AC generator or alternator, a turbine controller or interface, and a grid-tie inverter designed to work with a wind turbine.

The turbine's rotor spins as the wind blows through it, and that mechanical energy is converted into electrical energy by the turbine's permanent magnet (PM) AC generator. The voltage and frequency of the AC generated by the wind turbine are variable and depend on the wind speed. This is commonly referred to as "wild AC".

To be exported to the utility grid, the power needs to be first converted to the frequency and voltage level of the grid. To do that, the wild AC is first fed into a turbine controller or interface, which provides rectification to DC and diversion load control. The DC voltage and current are then fed into a grid-tie inverter, and then on to the grid. This energy will first be used by any AC loads that are drawing power on-site. Any excess energy produced can then be exported to the utility grid, running the meter backwards and creating "credit" for the owner (Net Metering, where available).

The diversion load control, when connected to a properly sized resistive load, provides over-voltage control of the turbine output in high wind, over-speed conditions and loss of grid which will cause the unloading of the wind turbine. Most controllers supplied by the manufacturers of the wind turbines do not provide enough protection against over-voltage conditions, and should not be used with grid-tie, batteryless inverters. Use the wind interface units supplied by the inverter's manufacturer instead.

Grid-tie inverters for wind turbines can be used in parallel with PV grid-tie inverters on the same utility service as long as the service is rated above the maximum current output of the combined inverters.

SMA

Windy Boy Inverters



Windy Boys are single phase inverters that convert DC current into AC current and feed the energy generated by a wind turbine system into the utility grid. Windy Boy inverters have a special operating mode for wind generators that allows performance adjustment to the turbine's characteristic curves for maximum yield from wind turbines from many different manufacturers.

Most small wind turbine systems use a permanent magnet generator. For converting the variable frequency AC generator voltage into DC current, a rectifier system like the **Windy Boy Protection Box** is needed. Since most rectifier/controllers supplied by the wind turbine manufacturers do not have adequate over-voltage protection, they are not recommended for use with Windy Boy inverters.

The Windy Boy also has a soft-start parameter "P-Wind-Ramp". This parameter protects the mechanical components of your wind turbine system and thus contributes to a longer system life. Other adjustments are possible to optimize the maximum performance of the Windy Boy with a particular wind turbine system, by adjusting the regulation speed and also by setting the switch-off and switch-on times.

The **Windy Boy 3000US** and **4000US** can be used in 240 VAC single-phase systems, and 208 and 240 VAC three-phase systems (WYE or Delta). The **Windy Boy 5000US**, **6000US**, and **7000US** can be used in 240 VAC single-phase systems, and 208 and 240 VAC three-phase systems (WYE or Delta) and in 277/480 VAC WYE three-phase systems. The Windy Boy 8000US can be used in 240 VAC single-phase systems, in 240 VAC three-phase systems (WYE and Delta) and in 277/480 VAC WYE three-phase systems.

Because wind turbines can produce more than their rated power under high-wind conditions, it is recommended that the Windy Boy inverter be oversized by at least 30%. For example, for a wind turbine with a maximum rated power of 5 kW, it is recommended that a 7 kW Windy Boy inverter be used with one Protection Box 600.

For larger wind turbines, multiple Windy Boy inverters with multiple Protection Boxes can be used. Windy Boys can be paralleled in 240 VAC single-phase systems, or used in sets of three to balance the power on all three phases of a three-phase system. For example, with a 30 kW wind turbine operating in a 208 VAC three-phase system, 6 Windy Boy 7000US inverters and 6 Protection Boxes can be used (two inverters in parallel between each pair of phases).

All Windy Boy inverters are Listed to UL 1741 and UL1998 for the US and Canada. They also comply with IEEE1547, FCC Part 15 (Class A & B), 10-year warranty standard, and 5 or 10-year warranty that is extendable.

SMA Windy Boy Inverters

SMA Model	Max power rating	Max recommended turbine rating	AC output volts	Max AC output current	DC input voltage range (MPPT)	Max DC voltage	Max DC input current	CEC rated efficiency	Dimensions (H" x W" x D")	Weight	Item code
WB3000-US	3,000 W	2,300 W	208 VAC	15 A	180-500 VDC	500 VDC	17 A	95.0%	14 x 18 x 9	88 lbs	030-03080
			240 VAC		200-500 VDC			95.5%			
WB3800-US	3,800 W	3,800 W	240 VAC	16 A	250-600 VDC	600 VDC	18 A	96.0%	14 x 18 x 9	88 lbs	030-03169
WB4000-US	4,000 W	3,100 W	208 VAC	17 A	250-600 VDC	600 VDC	18 A	96.0%	14 x 18 x 9	88 lbs	030-03170
			240 VAC								
WB5000-US	5,000 W	3,800 W	208 VAC	27.9 A	250-600 VDC	600 VDC	21 A	95.5%	24 x 18 x 9.5	143 lbs	030-03171
			240 VAC	24.1 A							
			277 VAC	20.9 A							
WB6000-US	6,000 W	4,600 W	208 VAC	33.3 A	250-600 VDC	600 VDC	25 A	95.5%	24 x 18 x 9.5	143 lbs	030-03172
			240 VAC	28.9 A				95.5%			
			277 VAC	25.0 A				95.0%			
WB7000-US	7,000 W	5,400 W	208 VAC	34.0 A	250-600 VDC	600 VDC	30 A	95.5%	24 x 18 x 9.5	143 lbs	030-03173
			240 VAC	34.0 A				96.0%			
			277 VAC	32.0 A				96.0%			
WB8000-US	8,000 W	6,200 W	240 VAC	32.0 A	300-600 VDC	600 VDC	30 A	96.0%	24 x 18 x 9.5	143 lbs	030-03174
			277 VAC	32.0 A							



SMA Windy Boy Protection Box

The **WBP-Box 600 Protection Box** contains an AC-to-DC three-phase rectifier and overvoltage protection. The Protection Box's rectifier converts the variable AC voltage of a permanent-magnet wind turbine into DC voltage, and uses this to power the Windy Boy. The WBP-Box limits excessive voltage and power from the generator and redirects it to a load resistor without limiting the power of the wind turbine. This reliably protects the inverter from high input voltages and ensures trouble-free operation. It is delivered as a turnkey unit and can be used with nearly all types of generators from various manufacturers and with different power classes. The Windy Boy 500 has all of the features that the model 600 has, but with a maximum DC voltage of 500 V and a maximum input power of 5 kW. Use this unit with the Windy Boy WB3000-US.

The Protection Box has a nominal power of 7 kW, a maximum input voltage range of 500 VAC and a maximum phase current of 11.5 A. The integrated overvoltage protection limits the DC voltage to 600 VDC. Connect one wind turbine with maximum of 7 kW of output per WBP Box 600 (one WBP Box 600 can be used with two WB3000 inverters or one each of the 5, 6, and 7 kW inverters). You can use multiple Protection Boxes if the wind turbine power is greater than 6 kW.

SMA Windy Boy Protection Box

SMA model	Description	Item code
WBP-Box 500	Windy Boy Protection Box 500 - includes load resistor, 5 kW - 500 VDC Max Voltage	call
WBP-Box 600	Windy Boy Protection Box 600 - includes load resistor, 7 kW - 600 VDC Max Voltage	030-03150



Unsurpassed Tech Support and Customer Service. AEE Solar has the in-house expertise to help you do it right. Our personal, friendly, responsive customer service is second to none. **Call us at 800-777-6609.**