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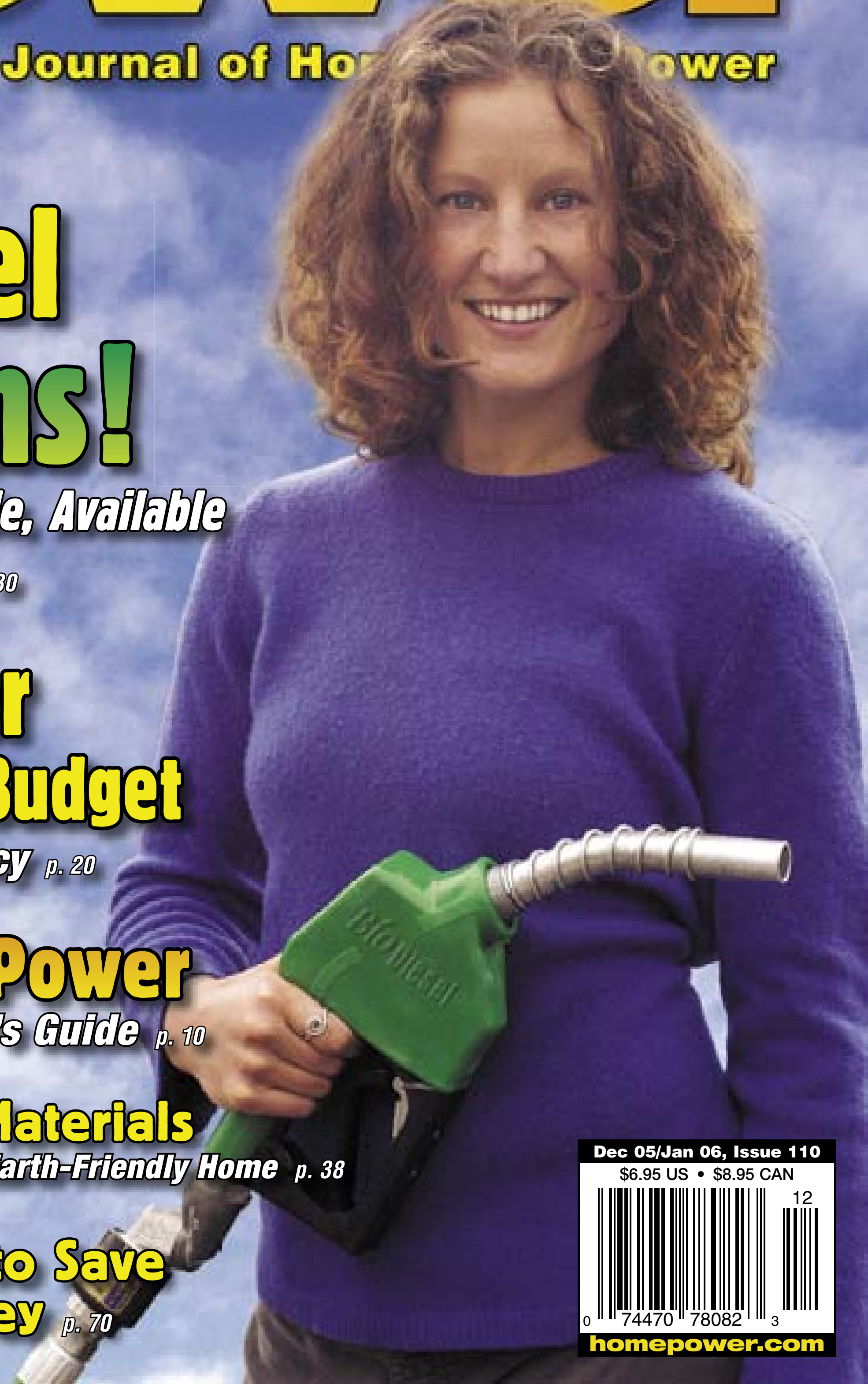

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Wind-Electric Systems SIMPLIFIED

Ian Woofenden

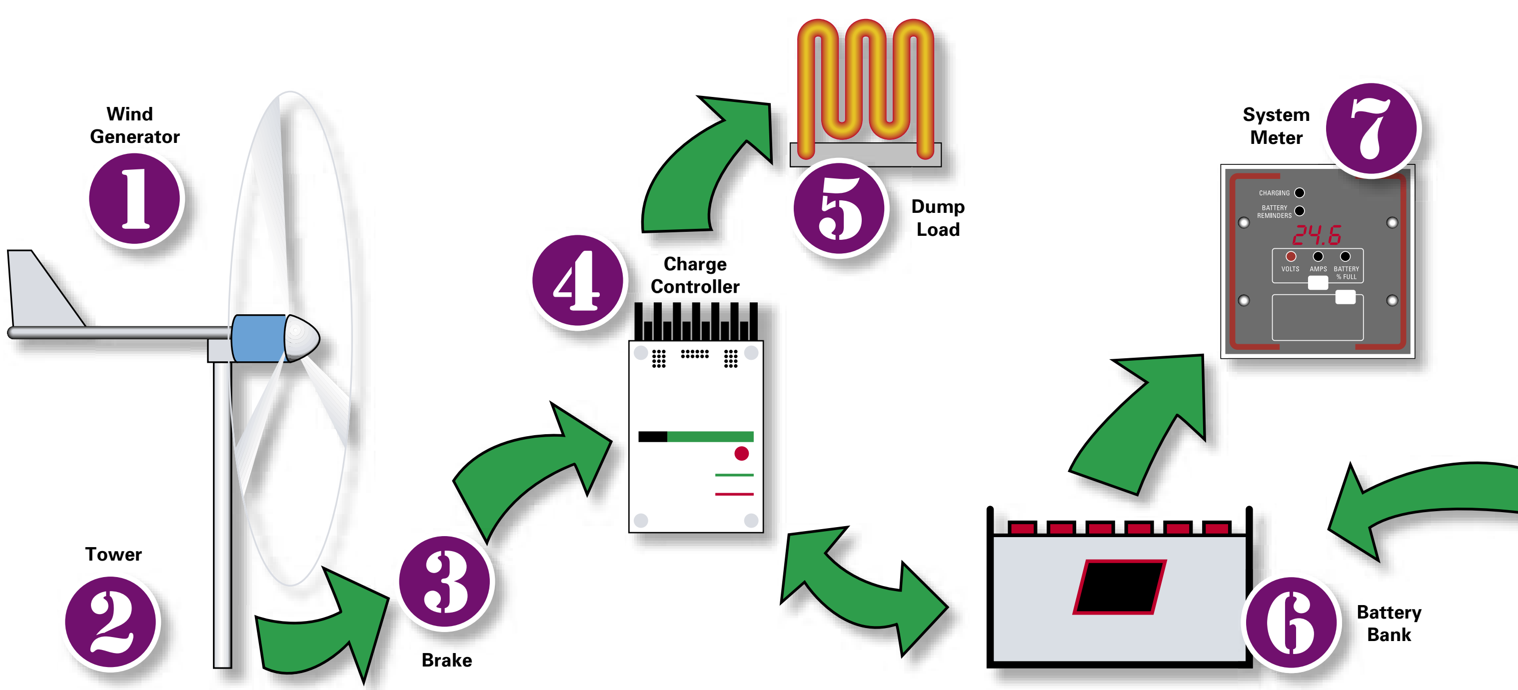
Wind-electric systems may be the most captivating of the three main renewable electricity technologies. Most of us just love to watch a wind turbine spin. But these systems are also the most prone to problems, and can be more complicated and expensive to install.

To get you started down the right road in using wind energy, this article will outline the basic system components and types. It will help you understand the systems better, so you will make better choices if you decide that wind energy is right for you.

OFF-GRID WIND-ELECTRIC SYSTEM

Off-grid wind-electric systems are battery based. People generally choose these systems because their home or other energy use is not connected to the grid, and connection would be expensive. Others prefer the independence of off-grid systems, or live where utilities and governments make it difficult to tie a renewable energy system to the grid.

Off-grid systems are limited in capacity by the size of the generating sources (wind turbine, solar-electric array, fuel-fired generator, etc.), the resources available, and the battery bank size. Off-grid homeowners have to learn to live within the limitations of their system capacity.



1 Wind Generator *AKA: wind genny, wind turbine*

The wind generator is what actually generates electricity in the system. Most modern wind generators are upwind designs (blades are on the side of the tower that faces into the wind), and couple permanent magnet alternators directly to the rotor (blades). Three-bladed wind generators are most common, providing a good compromise between efficiency and rotor balance.

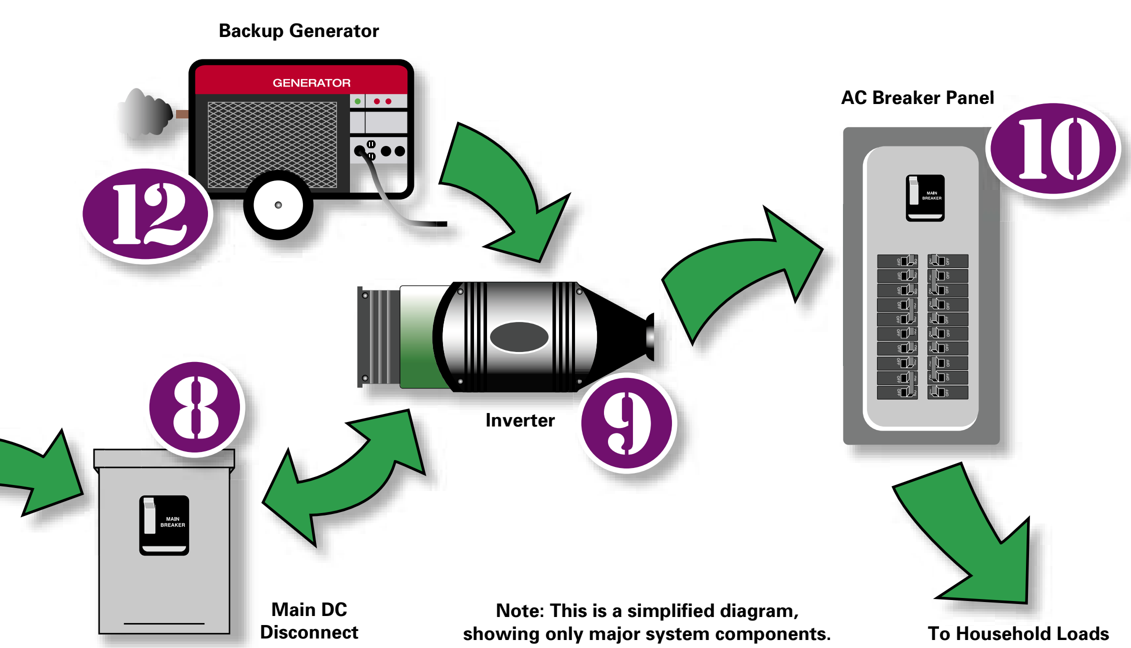
Small wind turbines protect themselves from high winds (governing) by tilting the rotor up or to the side, or by changing the pitch of the blades. Electricity is transmitted down the tower on wires, most often as three-phase wild alternating current (AC).

It's called "wild" because the voltage and frequency vary with the rotational speed of the wind turbine. The output is then rectified to direct current (DC) to charge batteries or to be inverted for grid connection.

2 Tower

A wind generator tower is very often more expensive than the turbine. The tower puts the turbine up in the "fuel"—the smooth strong winds that give the most energy. Wind turbines should be sited at least 30 feet (9 m) higher than anything within 500 feet (152 m).

Three common types of towers are tilt-up, fixed-guyed, and freestanding. Towers must be specifically engineered for the lateral thrust and weight of the turbine, and should be adequately grounded to protect your equipment against lightning damage. See my article "Wind Generator Tower Basics" in *HP105* for information about choosing a tower.



3 Brake

AKA: emergency shutdown mechanism

Most wind turbines have some means of stopping the turbine for repairs, in an emergency, for routine maintenance, or when the energy is not needed. Many turbines have "dynamic braking," which simply shorts out the three electrical phases and acts as a disconnect. Others have mechanical braking, either via a disc or drum brake, activated by a small winch at the base of the tower. Still others have mechanical furling, which swings the rotor out of the wind. Mechanical braking is usually more effective and reliable than dynamic braking.

4 Charge Controller

AKA: controller, regulator

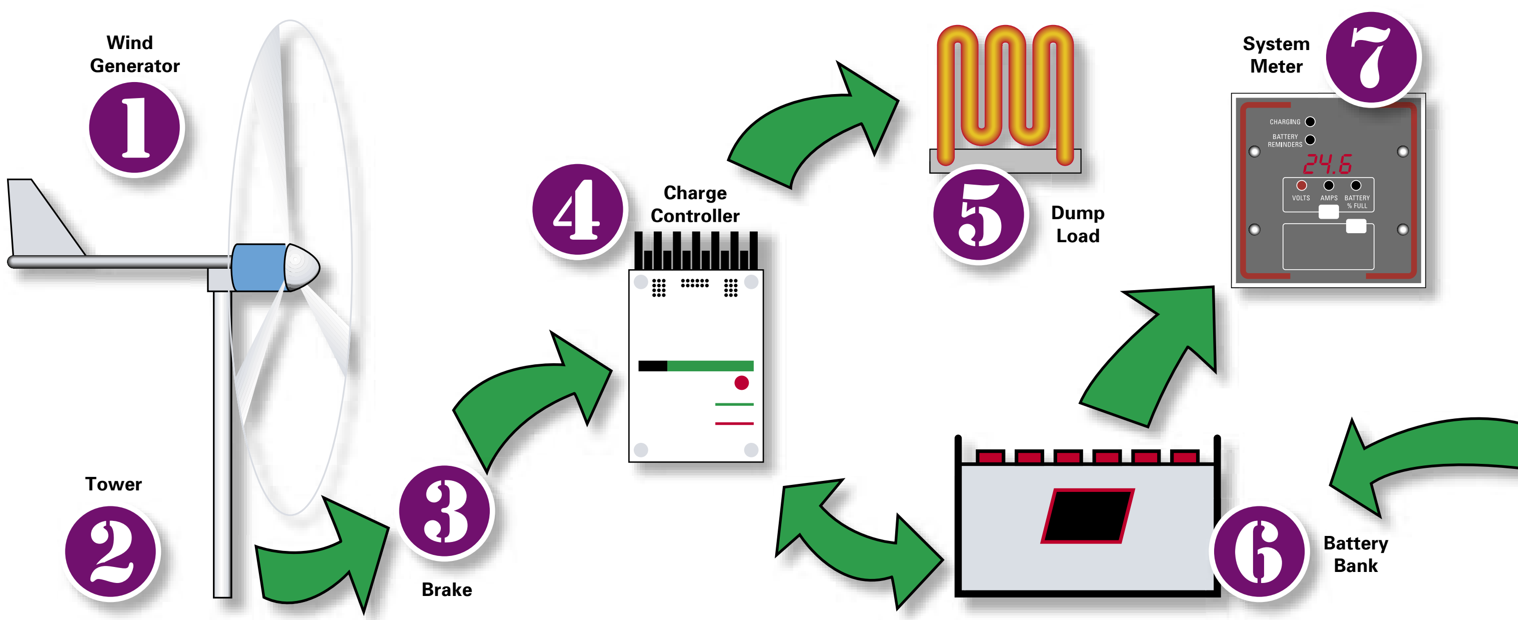
A wind-electric charge controller's primary function is to protect your battery bank from overcharging. It does this by monitoring the battery bank—when the bank is fully charged, the controller sends energy from the battery bank to a dump (diversion) load.

Many wind-electric charge controllers are built into the same box as the rectifiers (AC-to-DC converters). Overcurrent protection is needed between the battery and controller/dump load.

In batteryless grid-tie systems, there is no controller in normal operation, since the inverter is selling whatever energy the turbine is generating. But there will be some control function in the case of grid failure, and there may be electronics before the inverter to regulate the input voltage.

GRID-TIED WIND-ELECTRIC SYSTEM WITH BATTERY BACKUP

Connecting a wind-electric system to the utility grid with battery backup gives you the best of both worlds. You have the unlimited capacity of the grid at your disposal, and you can send your surplus wind energy to the grid. When the grid is down, you can still use your system, within the limitations of the battery bank and turbine. Wind-electric systems can be a much better match for utility backup than solar-electric systems, since many grid outages are caused by high winds. The drawback is that this is the most expensive type of wind-electric system you can install.



5 Dump Load *AKA: diversion load, shunt load*

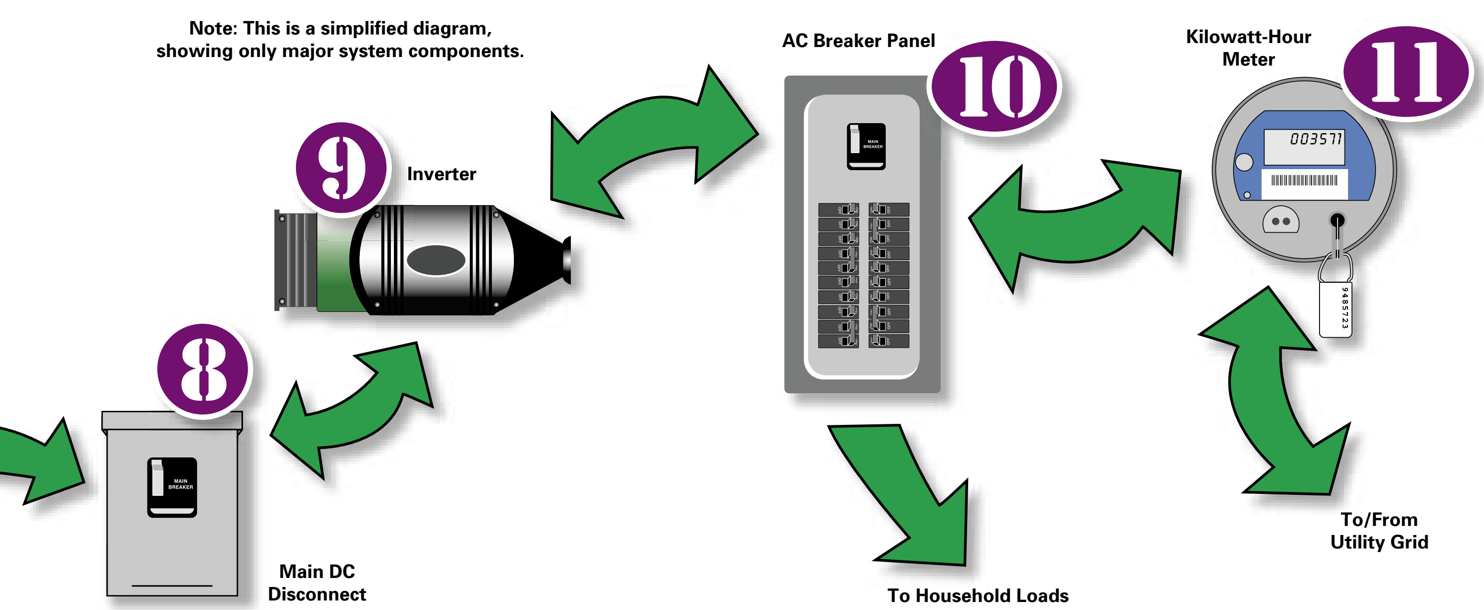
Solar-electric modules can be turned off—open circuited—with no damage. Most wind generators should not run unloaded. They will run too fast and too loud, and may self-destruct. They must be connected to a battery bank or load. So normally, a charge controller that has the capability of being a diversion controller is used. A diversion controller takes surplus energy from the battery bank and sends it to a dump load. In contrast, a series controller (commonly used in PV systems), actually opens the circuit.

A dump load is an electrical resistance heater, and it must be sized to handle the full generating capacity of the wind generator used. These dump loads can be air or water heaters, and are activated by the charge controller whenever the batteries or the grid cannot accept the energy being produced.

6 Battery Bank *AKA: storage battery*

Your wind generator will produce electricity whenever the wind blows above the cut-in speed. If your system is off grid, you'll need a battery bank—a group of batteries wired together—to store energy so you can have electricity when it's not windy. For off-grid systems, battery banks are typically sized to keep household electricity running for one to three calm days. Grid-intertied systems also can include battery banks to provide emergency backup during blackouts—perfect for keeping critical electric loads operating until the grid is up again.

Use only deep-cycle batteries in wind-electric systems. Lead-acid batteries are the most common battery type. Flooded lead-acid batteries are usually the least expensive, but require adding distilled water occasionally to replenish water lost during the normal charging process. Sealed absorbed glass mat (AGM) batteries are maintenance free and designed for grid-tied systems where the batteries are typically kept at a full state of charge. Sealed gel-cell batteries can be a good choice to use in unheated spaces due to their freeze-resistant qualities.



7 System Meter

AKA: battery monitor, amp-hour meter, watt-hour meter

System meters can measure and display several different aspects of your wind-electric system's performance and status—tracking how full your battery bank is, how much electricity your wind generator is producing or has produced, and how much electricity is in use. Operating your system without metering is like running your car without any gauges—although possible to do, it's always better to know how much fuel is in the tank.

8 Main DC Disconnect

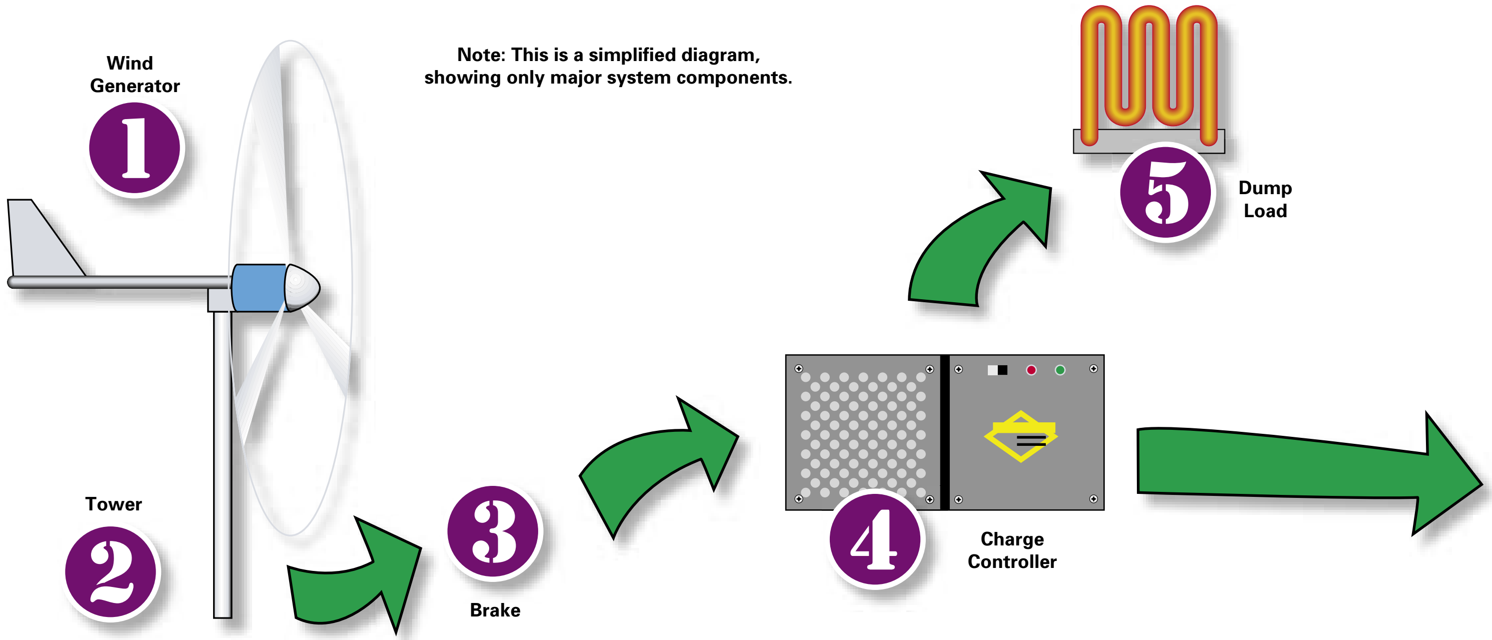
AKA: battery / inverter disconnect

In battery-based systems, a disconnect between the batteries and inverter is required. This disconnect is typically a large, DC-rated breaker mounted in a sheet metal enclosure. This breaker allows the inverter to be quickly disconnected from the batteries for service, and protects the inverter-to-battery wiring against electrical fires.

BATTERYLESS GRID-TIED WIND-ELECTRIC SYSTEM

Connecting to the grid without batteries is the most cost-effective and environmentally friendly way to go. You eliminate batteries, which are costly, require maintenance, and carry a significant efficiency penalty. The only drawback of batteryless systems is that when the grid is down, your system shuts down. But in most grid-serviced areas, utility outages are only a few hours a year—a small inconvenience to endure for the efficiency, environmental friendliness, and thriftiness of these systems.

Batteryless grid-tie systems may see increased performance (sometimes dramatically) from the wind turbine compared to battery-based systems. This is because the inverter's electronics can match the wind's load more exactly, running the turbine at optimum speed, and extracting the maximum energy.



9 Inverter

AKA: DC-to-AC converter

Inverters transform the electricity produced by your wind generator into the AC electricity commonly used in most homes for powering lights and appliances. Grid-tied inverters synchronize the electricity they produce with the grid's "utility grade" AC electricity, allowing the system to feed wind electricity to the utility grid.

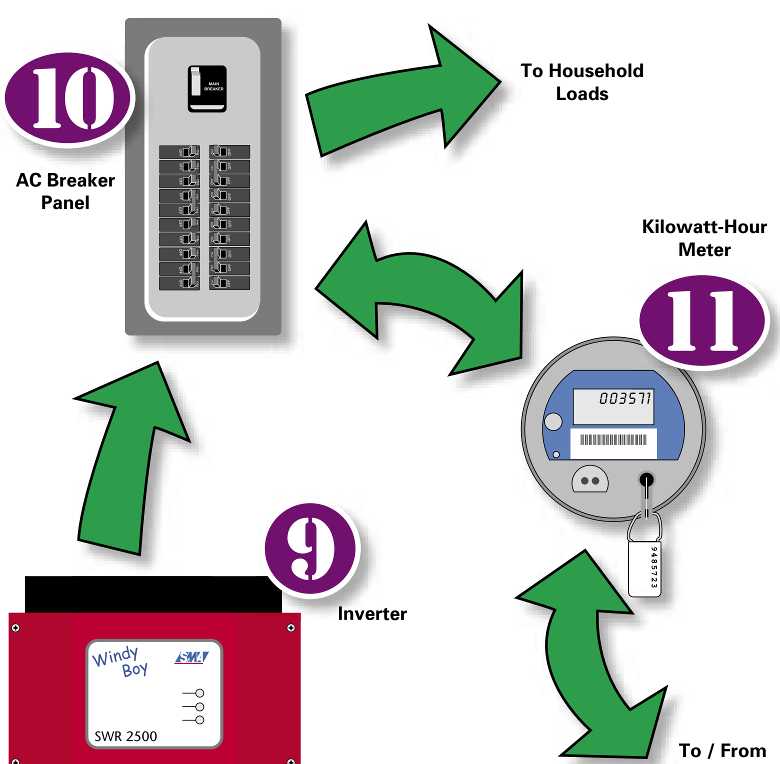
Grid-tie inverters are either designed to operate with or without batteries. Battery-based inverters for off-grid or grid-tie systems often include a battery charger, which is capable of charging a battery bank from either the grid or a backup generator during cloudy weather.

10 AC Breaker Panel

AKA: mains panel, breaker box, fuse box

The AC breaker panel, or mains panel, is the point at which all of a home's electrical wiring meets with the "provider" of the electricity, whether that's the grid or a wind-electric system. This wall-mounted panel or box is usually installed in a utility room, basement, garage, or on the exterior of the building. It contains a number of labeled circuit breakers that route electricity to the various rooms throughout a house. These breakers allow electricity to be disconnected for servicing, and also protect the building's wiring against electrical fires.

Just like the electrical circuits in your home or office, an inverter's electrical output needs to be routed through an AC circuit breaker. This breaker is usually mounted inside the building's mains panel. It enables the inverter to be disconnected from either the grid or from electrical loads if servicing is necessary. The breaker also safeguards the circuit's electrical wiring.



11 Kilowatt-Hour Meter

AKA: KWH meter, utility meter

Most homes with a grid-tied wind-electric system will have AC electricity both coming from and going to the electric utility grid. A bidirectional KWH meter can simultaneously keep track of how much electricity you're using and how much your system is producing. The utility company often provides intertie-capable meters at no cost.

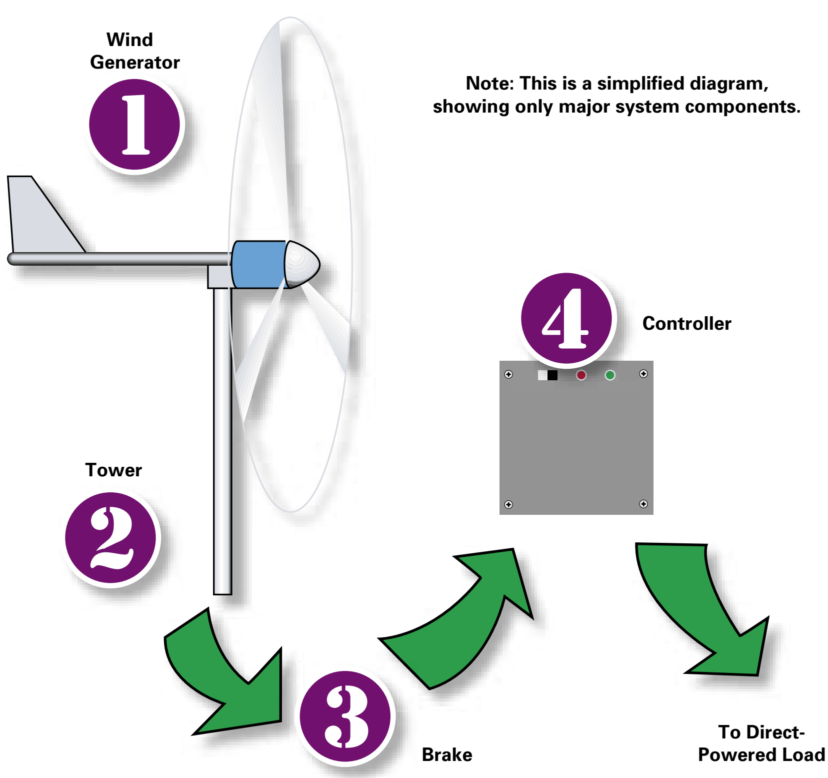
12 Backup Generator *AKA: gas-guzzler, "the Noise"*

Off-grid wind-electric systems can be sized to provide electricity during calm periods when the wind doesn't blow. But sizing a system to cover a worst-case scenario, like several calm weeks during the summer, can result in a very large, expensive system that will rarely get used to its capacity, and will run a huge surplus in windy times. To spare your pocketbook, go with at least two sources of energy. Wind–PV hybrid systems are often an excellent fit with local renewable resources. But a backup, fuel-powered generator still may be necessary.

Engine-generators can be fueled with biodiesel, petroleum diesel, gasoline, or propane, depending on the design. Most generators produce AC electricity that a battery charger (either stand-alone or incorporated into an inverter) converts to DC energy, which is stored in batteries. Like most internal combustion engines, generators tend to be loud and stinky, but a well-designed renewable energy system will require running them 50 to 200 hours a year or less.

DIRECT-DRIVE BATTERYLESS WIND-ELECTRIC SYSTEM

These are the least common wind-electric systems, typically used for water pumping. A turbine is matched to a pump, often through an electronic controller. When the wind blows, water is pumped to an elevated tank, a stock-watering tank, or directly to the land to irrigate. These systems can be simple and cost effective in the right situation. Direct-drive systems are also used for heating, which can be a good match, since it's normally colder when it's windy. But heating is a big load, so large turbines are needed.



Do It Right & Harvest the Wind

If you want a simple, reliable, maintenance-free renewable electricity system, buy solar-electric modules. Wind-electric systems are not for the faint-of-heart, and will probably never be a simple "appliance" that you can install and forget about. These are spinning machines in a very harsh environment. You don't expect your car to operate without maintenance, and you choose and drive it carefully to avoid accidents. The same is true of wind-electric systems—the renewable energy systems that take the most maintenance, and have the highest potential for problems. Wind-electric systems are very satisfying when they work, but very disappointing (and visible) when they don't.

Don't buy cheap equipment, and do buy a tall tower! Buy the best turbine for your site, regardless of price, and put it on the tallest tower possible. Investing in quality up front will pay off in the long term. Almost all of the disappointment I hear about from wind energy users is related to buying lightweight equipment for heavy-duty sites, or installing equipment on towers that are not well above surrounding obstructions.

If you do it right, wind energy can be the most satisfying of the renewable energy technologies. There's nothing quite like watching a wind generator spinning, filling up your battery bank or sending energy to the grid. When the wind blows, you may need to button up your overcoat, but you'll get a warm feeling, knowing that the wind is working for you.

Access

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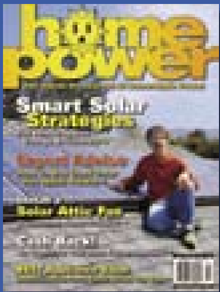

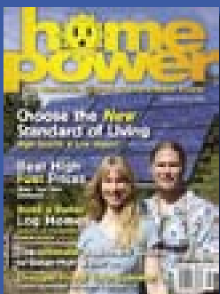

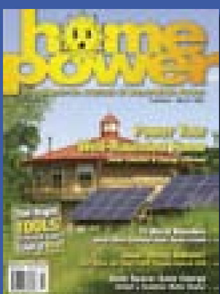

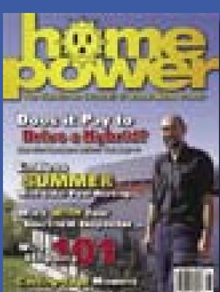

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