Systems Design Supplement

Specifications and considerations for the design, installation and operation of a Small Wind and Solar based Renewable Energy System

Release 2.5

WARNING

This document is not a design specification and should not be used as such. It is provided for information only, in order to understand what is involved in installing, owning or operating a renewable energy system. Please consult with a qualified systems designer or engineer as well as a certified electrician before attempting to operate your own design. Assembly, installation, erection, and maintenance of the WIND ARROW Turbine involves work with towers, rotating devices and electrical components, all of which can be very hazardous if attempted without proper knowledge. Prior to assembly, installation, erection or maintenance of the WIND ARROW system, individuals must read and understand the information contained in the Owner's Manuals as well as information provided by the manufacturers of other components. Also, local electrical installation standards must also be followed when operating an electrical generating system.

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Introduction

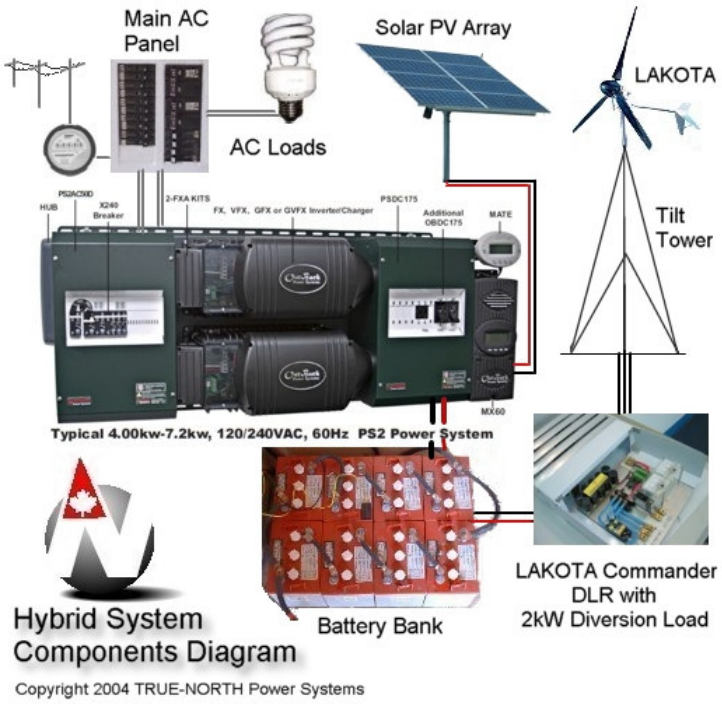
WIND ARROW Turbines are manufactured by True North Power NG and marketed world-wide through Dealers around the world. TRUE-NORTH Power NG is the Canadian Distributor of WIND ARROW Turbines and is also the Canadian Warranty Service Center and the World Training Centre for True North products.

TRUE-NORTH Power NG also operates the FREE Wind Test Center at Ayr, Ontario where they test turbines, blades, towers, inverters, controllers, batteries and other renewable energy components. The purpose of this supplement is to educate and inform designers and installers on the specifications and considerations for implementing a WIND ARROW based wind and solar personal power generation capability.

This supplement will cover turbine, tower, inverters, batteries, and some PV Solar, as well as turbine and electrical standards that may apply. It also addresses local municipal, provincial and federal issues that may or may not apply to the installation of personal renewable energy generation systems. This guide is for systems designers, installers and local municipality, environmental or electrical standards/utility authorities to understand the installation and operation of a typical WIND ARROW based renewable energy system.

Any Trademarks or manufacturer specifications are the property of their respective companies or agencies.

A typical solar/wind Hybrid, WIND ARROW based system consists of a single turbine on a 45-75 ft freestanding or guyed tower, feeding a 12, 24 or 48volt battery bank with a 1-4 kilowatt inverter that produces either pure sine wave or modified sine wave I20v 60 Cycle AC power. Such a system might also use from 4-6, 80-200watt Photo Voltaic (PV) solar panels connected to the battery pack through an MX60 charge controller and PV combiner box. Charge control and system monitoring equipment must also be used to regulate the turbine generated energy to ensure that the batteries are not overcharged during high winds when there is low demand for energy from the system and the batteries are full. A battery monitor and/or the inverter monitors inverter use and energy demand, and will shut down or divert the loads at preset voltage points. This protects the batteries from being damaged by being over or under charged. Remote applications may also employ a gas or diesel backup generator that is controlled by the inverter/controller combination. This paper describes each of the main components, their specifications and operational limitations as well as installation ideas and other systems design criteria.
The following graphic shows the typical system components in relation to each other. See also last page.



Turbine Overview

The WIND ARROW is a 3 Phase "Y" alternator with a very advanced controller that provides "Active Flight Control" (AFC). The AFC controller has a small microprocessor onboard that actively monitors the turbine's rpm and power available and extracts the most energy it can for a given wind speed without stalling the rotor, but without the use of a mechanical furling system.

Desert applications may use a clear helicopter tail rotor leading-edge tape to protect from sand and dust abrasion.

Specifications: WIND ARROW Turbine

- Rotor Diameter 2.090 metres (82.3 inches)
- Swept Area - 3.43 square metres (36,9 square feel)
- Weight – 16.5 kilograms (~36.5 pounds)
- Rated 1000 watts power output at 12.9 metres/second (46,4 kph) (28.8 mph)
- Peak 1300 watts power output at 1 7,0 Metres/second (61+ kph) (38+ mph)
- Start-up wind speed - 2,8 metres/sec (10 kph) (6 mph)
- Charging 1 ampere at 12 volts at 4.0 metres/sec (14.5 kph) (9 mph)
- Charging may exceed 100 amps at 12 volts above 38mph for 12v systems, >60Amps for 24v systems.
- Aerospace grade, uni-directional carbon fiber
- Anodized Aluminum body with all stainless steel hardware
- 8 pole, 36 slot, 3 phase alternator
- Rare-earth neodymium iron boron permanent magnets.
- 4 Field adjustable settings to match performance to low, medium, high or severe wind regimes (Consult your Authorized True North Dealer or TRUE-NORTH Power NG for details first). Opening the case or access panels may VOID your warranty.

Performance

The WIND ARROW will produce between 100-250 kWhrs per month or more depending on the wind regime, height of your tower, time of year and the optimization setting of the turbine. A 24 volt turbine can exceed 60 DC amps output (in excess of 1400w) above 30-35mph.

WIND ARROW TEST DATA: Actual test data from June 2008 Test Unit 1

The following data confirms WIND ARROW performance claims are below actual performance. This factory standard turbine is rated at 950w at 25 mph and has been installed on the first FREE Wind Test Centre tower since 14 May 2008. Official test data will be published in September 2008

Noise

The typical small wind turbine has earned a reputation for being noisy. This comes from sideward furling designs and generally low efficiency or badly designed blades. The WIND ARROW turbine however, is 'virtually silent" throughout it's normal operating range of. There are no instrumented sound test data other than a hand held sound meter that does not measure above ambient noise. Downwind you may be able to hear a slight swishing should but in most cases the wind in the trees or normal ambient sounds exceed the blade noise of a WIND ARROW. In very high winds above 30-40mph, the wind itself makes more noise

than the turbine from 30-40 feet away. Visit *the TRUE-NORTH Website under KNOWLEDGE to listen to audio recordings of similar blade performance.*

The sound of the turbine when heard from downwind within the tower height the quiet swishing sound cannot be heard over normal conversation. Thirty to forty feet upwind of the tower (at the anchor points) it is difficult to hear any sound from the turbine above the ambient sound in a quiet country setting. Typically at 15-20mph wind, the sound of the leaves rustling in the trees at makes more sound than the WIND ARROW.

Vibrations produced by the alternator can be felt in the tower if you place your hand on it, but these vibrations will also remain silent unless attached to a structure without isolation mounts. Properly isolated acoustically, the WIND ARROW vibration noise will not be amplified by the structure. Generally it is not recommended that any turbine be attached to a solid structure, roof or building without proper acoustic isolation. On a single family dwelling that can be as simple as using heavy rubber pressure hose between the attachment points with the bolts running laterally through the hose. On commercial buildings a special acoustic isolation compound is placed between attachment points and then alternative lightning grounding is then provided around the acoustic isolation mounts.

Maintenance

The WIND ARROW turbine should provide years of maintenance free operation if inspected annually for wear and tear. This is normally an annual visual inspection to look for excessive wear in the head or blades. The blades should be handled annually to determine of there is any "play" in the rotor plane which might indicate bearing wear or a loose hub nut. Other turbines that use the same SKF bearings (made in France or Italy), have been shown to exceed 10 years of life "without noticeable bearing wear". SKF specifications indicate these bearing are rated for 18,000 rpm. The WIND ARROW normally operates around 500-800 rpm.

Desert or marine/ocean applications should inspect the blades leading edge carefully for dust or sand abrasion and look for corrosion on the body and attachment hardware. All WIND ARROW components are stainless steel or coated aluminum castings and should not corrode. True North tower couplers are also galvanized with stainless bolts and should not show signs of rust or corrosion.

In severe desert operations, a helicopter tail rotor leading edge tape is recommended on the blades. This might need to be replaced annually depending on the severity of the environment. This tape is only supplied if the application requires it. Normally the carbon fiber blades offer years of maintenance free operations. If they become dirty or soiled from pollution or a dusty- environment, they can be cleaned with any mild detergent and water.

Electrical Safety Accreditation

There are few if any small wind turbines sold in North America that are known to carry a UL, CUL, ETL or CSA electrical approval rating. WIND ARROW is inspected by Intertek in Canada and will have an cETL (note the C in the 8 o'clock position. This approval sticker is similar to the one below for inverters, and is equally recognized as the CSA or UL(c) designations.

All OutBack inverters, cabinets, switches and circuit breakers carry this Electronic Testing Labs ETL (C) and (US) label, and this one for grid-tie inverters showing they conform to UL Standard 1741, which is required in Canada. Even though WIND ARROW turbines are individually inspected by the Electrical Safety Authority (ESA) Ontario and your local electrical authority may require their own safety inspection. Individual

components such as the turbine, control boxes or circuit breakers etc, that do not carry one of the approval emblems below must be individually inspected in site and approved by ESA. In Ontario, you will need to submit a "Site Plan" and electrical schematic and the inspector will then review this material and issue a "Low Voltage Report" and approval of your installation subject to the provincial Electrical Safety Code and an on site inspection by a field inspector after the system has been completely installed. You will not be authorized to turn the system on or operate it until this inspection is passed. You may be wise to visit with or talk to this final inspector prior to having him or her do the inspection to ensure that your implementation of the plan will satisfy them. The plan submission/approval will be charged something approaching $200 (depending on travel time which is included their fees) and the final approval may cost the same or more. This on-site inspection cost will often be estimated in the plan approval because they will know the equipment and layout being reviewed. Here are some samples. These plans can be hand drawn or done by computer and submitted by fax or e-mail to the ESA.

In addition to the ETL designation Canadian electrical safety inspectors will be looking for these accredited laboratory approval stickers on each and every component used, or it will have to be inspected and approved locally at your cost. Below is a summary of their application. Each mark is equally acceptable.

In operation for more than a century, Underwriters Laboratories Inc. is an independent nonprofit organization that writes and tests products for safety and certifies them. UL has developed more than 800 standards for safety, and millions of products and their components are tested to UL's safety standards.

UL's web site is at http://www.ul.com . Information about UL standards can be found at http://ulstandardsinfonet.ul.com .

In any of these standards look for compliance with **UL 1741:** Standard for Inverters, Converters, and Controllers for Use in Independent Power Systems or **UL 1778:** Uninterruptible Power Supplies

If a product is UL listed, you know it has passed UL's stringent tests for electrical safety. For example, the chassis is grounded to the round pin on the power cord, so that if the hot lead of the power cord accidentally shorts to the chassis, the current will go to the building's safety ground — and not through someone touching the chassis.

The Canadian Standards Association (CSA) is a nonprofit association serving business, industry, government and consumers in Canada and the global marketplace. Among many other activities, CSA develops standards that enhance public safety.

A Nationally Recognized Testing Laboratory, CSA is very familiar with U.S. requirements. According to OSHA regulations, the CSA-US Mark qualifies as an alternative to the UL Mark.

Here are some areas where CSA standards are applied:

- Canadian Electrical Code, Part III-Outside Wiring
- Electrical Engineering Standards
- Electromagnetic Compatibility

The ETL Listed Mark is an alternative to the CSA and UL marks.

ETL Testing Laboratories has been conducting electrical performance and reliability tests since 1896. Intertek Testing Services (ITS) acquired ETL from Inchcape in 1996. ITS is recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL), just as Underwriters Laboratories (UL), Canadian Standards Association (CSA) and several other independent organizations are recognized.

ITS tests products according to nearly 200 safety and performance standards. The ETL Listed Mark and C-ETL Listed Mark are accepted throughout the United States and Canada when denoting compliance with nationally recognized standards such as ANSI, IEC, UL, and CSA.

This certification mark indicates that the product has been tested to and has met the minimum requirements of a widely recognized (consensus) U.S. product safety standard, that the manufacturing site has been audited, and that the applicant has agreed to a program of periodic factory follow-up inspections to verify continued conformance.

If the mark includes a small “US” at 4 o’clock position and and/or “C” at the 8 o’clock position, it follows product safety standards of United States and/or Canada, respectively.

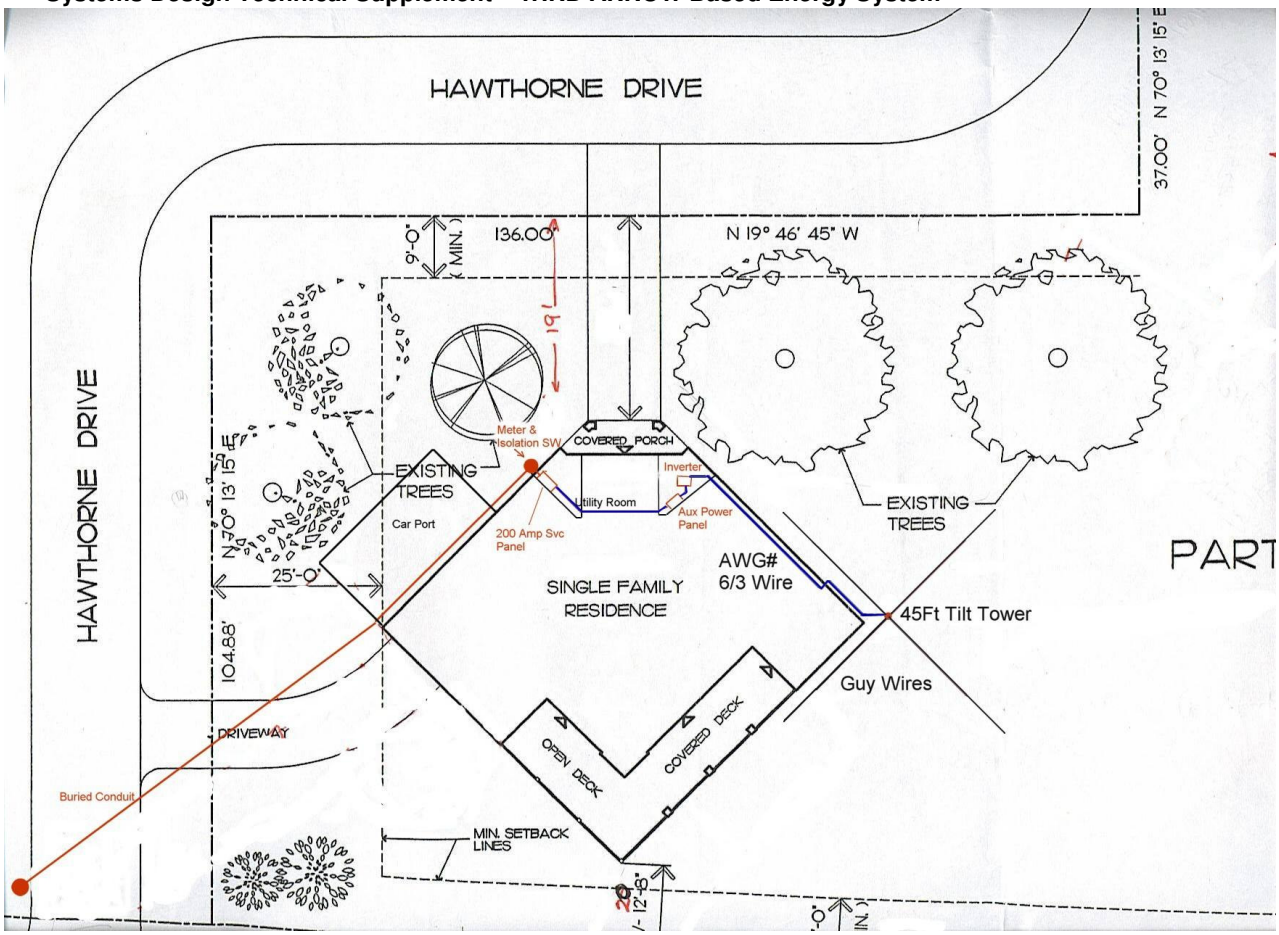
What is the CE mark, and what is its purpose? CE mark is for European installations and is not generally accepted in North America if that is the only standard mark on a piece of equipment.

The European Commission describes the CE mark as a "passport" that allows manufacturers to circulate industrial products freely within the internal market of the EU. The CE mark certifies that the products have met EU health, safety and environmental requirements that ensure consumer and workplace safety. All manufacturers in the EU and abroad must affix the CE mark to those products covered by the "New Approach" directives in order to market their products in Europe. Once a product receives the CE mark, it can be marketed throughout the EU and other jurisdictions without undergoing further product modification.

An important document related to CE is the **Declaration of Conformity** (D.O.C.). Basically it's a piece of paper which a company authority must sign to say that the device meets the requirements of the Directive. The D.O.C. must include a list of any standards used to justify the claim of compliance with the Directive. You’ll see the Declaration of Conformity packed with certain products, either separately or as part of the operation manual.

If a product is stamped CE, the product does not emit excessive radiation (microwave or RF), and is not overly sensitive to picking up radiation.

Example of a Site Plan.



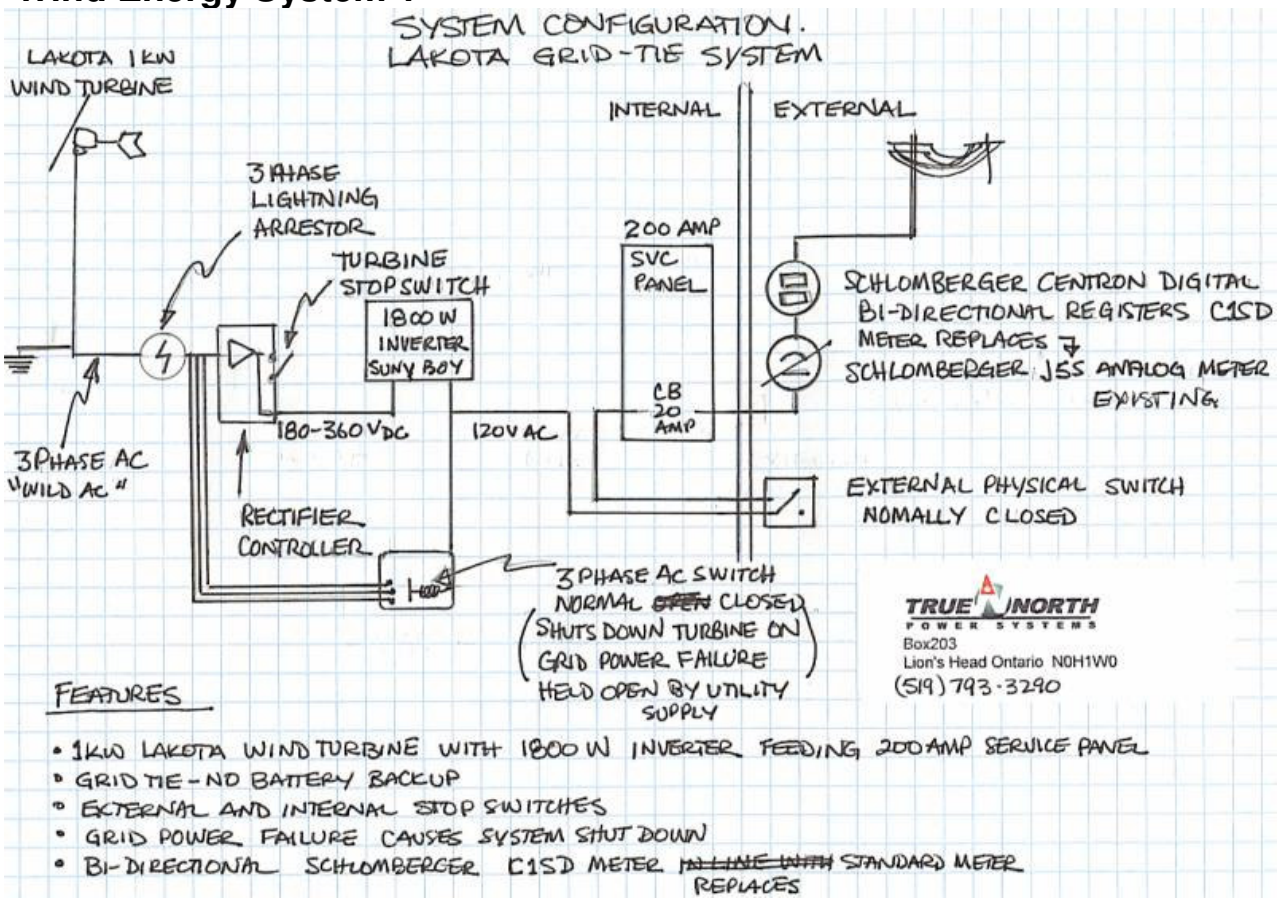
The following system configurations have been submitted and approved by the Ontario Electrical Safety Authority (ESA) There are two basic options:

1. **Grid connected:** using inverters that use both wind turbine and/or solar plus utility power to keep a battery bank charged. This configuration does not feed power into the utility and has a voltage controlled resistive diversion load to dissipate any excess wind generated energy that cannot not be used or stored. When utility power is lost only wind turbine energy is available to charge the batteries. The essential loads are the only loads connected to the batteries, through an essential loads panel that is connected to the main panel for the sole purpose of using utility power to charge the batteries when available. That is, the inverter's charge control system uses power from the grid to charge the batteries as needed.
2. **Grid-tied:** using inverters that are “grid interactive” and will match phase and voltage with utility power, to allow current flow through a bi-directionally registering utility meter. This configuration will automatically disconnect itself in a few milliseconds if it detects a power failure or voltage or frequency anomaly. When consistent power is restored for at least 5 min it will reconnect. This configuration must also feature a physical, accessible and lockable system isolation switch on the exterior of the building near the utility meter. The purpose of this switch is to isolate the inverter from the utility for safety should a lineman wish to work on the nearby power grid, and not have to shut down the turbine.

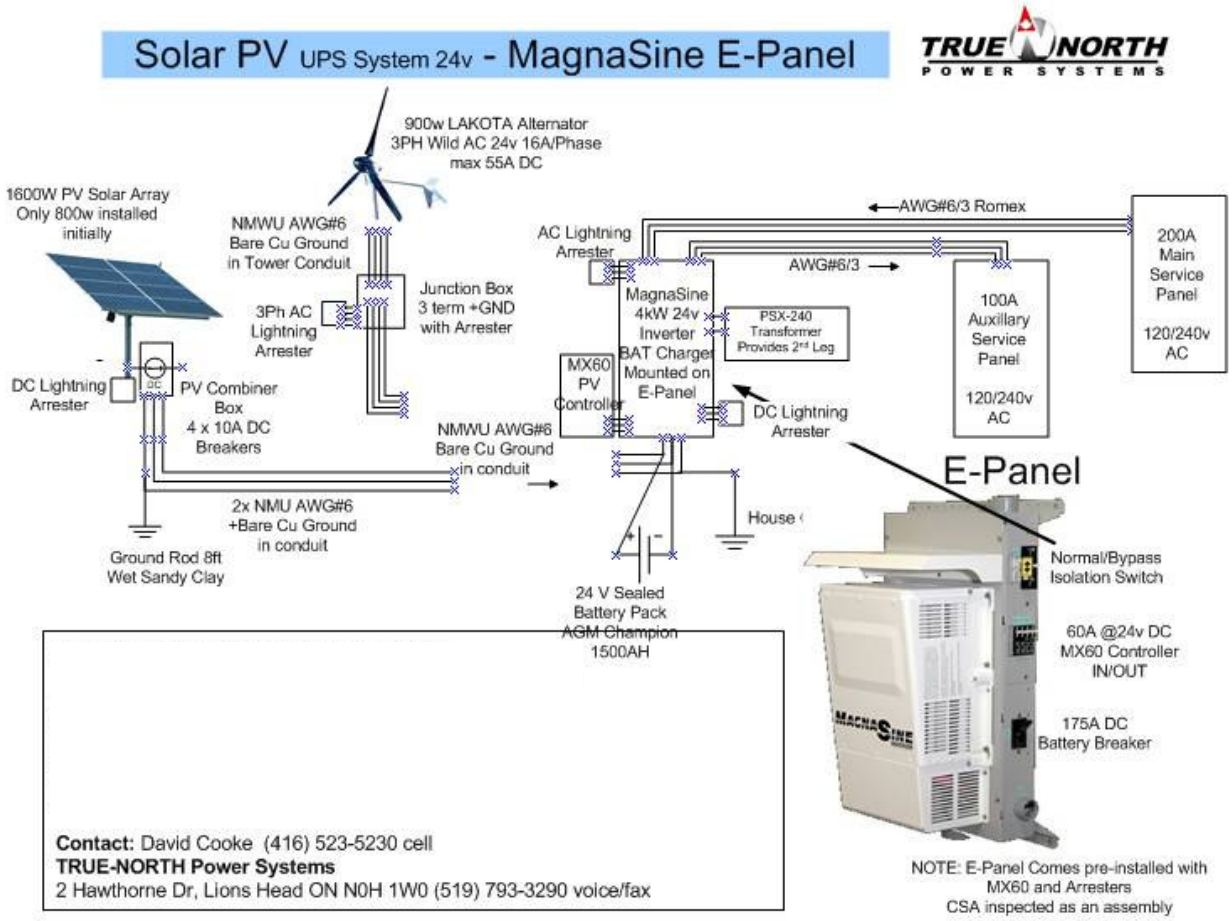
The attached diagram shows configurations 1 and 2a 2b.
The difference with system 2a is that there is no exterior isolation switch and no bi-directional meter.

We refer to the two main configurations with options as:
Wind Energy System 1 - Grid tie no batteries . . . the one you have already seen
Hybrid Wind and Solar Energy System 2a - Battery Backup No Grid-Tie
Hybrid Wind and Solar Energy System 2b - Battery Backup Grid-Tied

Wind Energy System 1



Wind Energy System 2a and 2b

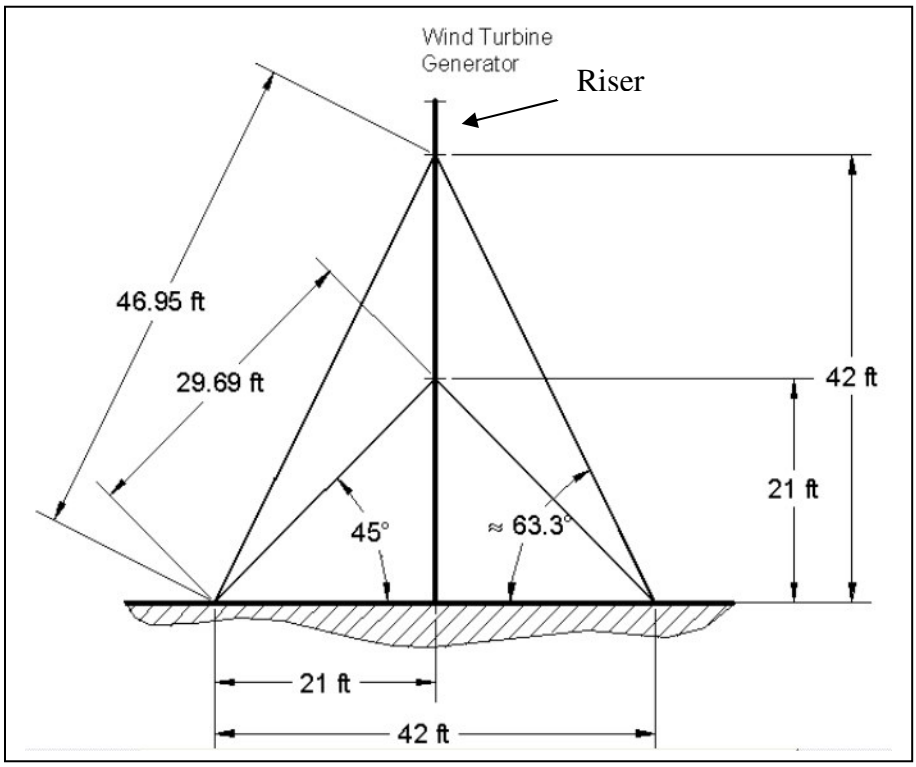


Tower Engineering Design and Equipment Safety Accreditation

The WIND ARROW can be mounted on any 1meter riser mast of standard 2 inch water pipe or galvanized structural steel pipe if the lateral forces on the top of the riser that can withstand a 200 lb side load. This is 2,5 times the operational maximum expected aerodynamic lateral force exerted by the WIND ARROW turbine in predicted 100 mph wind.

Report # 990016 AEROMAG Wind Turbine Tower analysis 8-10-99 was prepared by Robert C Burgi of Burgi Engineering Inc. Columbia Falls Montana. His report FEA Analysis determined the tower support reaction loads for a 47 ft tower made with 2inch Schedule 40 pipe and AEROMAG steel couplers. Report No. 03-1001 Aeromag Wind Turbine Tower Analysis dated 15 Mar 03 provides engineering analysis of the 3inch tilt tower by Upstream Design 3945 Bonstead Rd, Clay NY 13041. The complete reports are attached as Annex A.

The 3inch AEROMAG 47-52 ft Load Transport Tower consists of base, two steel couplers and the “Mast Riser” that the turbine is mounted on. The 18 foot sections of Allied SS-40 3" pipe (2 7/8th in OD) are designed to hold up under 100 mph wind with gusts to 120mph and a thrust load of 80 lbs. from the turbine at the top of the 40 inch riser. Forces on the tower under these conditions are estimated at 49.92 lb/Ft^2. Conducting wires pass down the centre of the tower pipe and exit the base of the tower to go underground to the house and the controller. Three wires from the turbine conduct "Wild AC" from the turbine to the controller and are usually AWG 6/3 or AWG 8/3 or Tech90 grounded cable in a weather-proof exterior plastic casing. This may also be pulled through a buried or elevated metal or plastic conduit for safety. The turbine base commutator allows for 360 degree rotation without twisting the conducting tower wire running down the center of the tower. See tower manual for details.



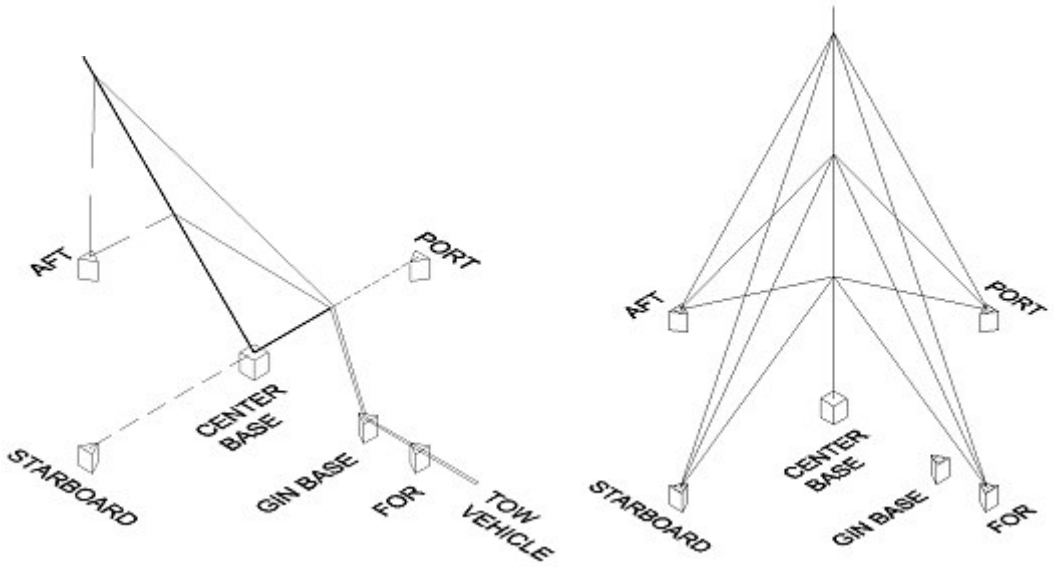
CRITICAL CAUTION

Older LAKOTA tower manuals contain a phrase on pg 27 that can be misunderstood and will lead to a tower failure on lifting. It says "make sure that the continuous loop is **free to side** thus allowing simultaneous and unhindered loading on both couplers"

This *freedom to slide* will result in a coupler failure on lifting. What they mean is, it must be free to slide until the tensions equalize on both couplers. Then it must be fixed so it cannot slide.

What it should say is that "Once the tension is equalized the continuous loop must not be allowed to slip during the lift".

This is critical to a safe lift.



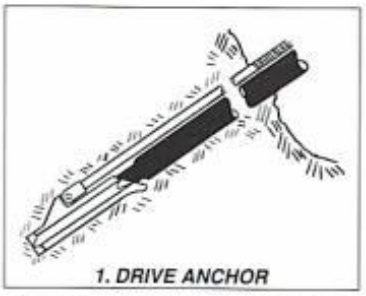
We do not recommend lifting with a tow vehicle but rather a hand winch or electrical winch is preferred. Difficulties in communications, guy tension, and the inability to "feel" the guy tension with the vehicle can result in tower failure, damage or injury. The 12v portable winch provides the best control during lifting.

TRUE-NORTH Power NG has been investigating and using the Williams, Manta Ray, Tie back and Anchor System which uses a steel cable and anchor that is driven into the soil or bolted to rock. These devices are significantly cheaper than concrete, are less obtrusive and invasive to the landscape and may prove to be the desired solution for most applications. Call Martin Hodgson VP Anchoring, (800) 265-3322.

MECHANICAL SOIL ANCHORS

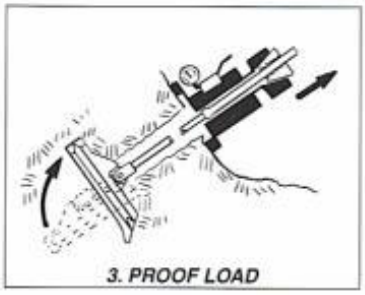
MANTA RAY EARTH ANCHOR SYSTEMS

Manta Ray Anchors are driven into the ground using conventional hydraulic or pneumatic breakers which are readily available worldwide and easily portable. The driving operation causes no disturbance or displacement of the soil. Unlike drilled and grouted anchors, the Manta Ray actually compacts the soil around itself in a clean, safe and simple operation.



1. DRIVE ANCHOR

2. REMOVE STEEL



3. PROOF LOAD

Once driven to the proper depth, the driving tool is removed and the rod or tendon that is attached to the anchor is pulled to rotate the anchor into position and load it against undisturbed soil, like a toggle bolt. This loading operation is carried out using the anchor locker which provides a direct readout of anchor capacity and proof loads the anchor immediately. Grouted anchors can not offer this feature.

MR-SR

MR-1

MR-2

MR-3

MR-4

MR-88

There are six **Manta Ray Anchors** with light to heavy duty holding capacities. All anchors are made of galvanized ductile iron, can be driven with the drive steel set (except the MR-88) and can be tested to the desired holding capacity with the load locker.

The anchors are designed to utilize solid steel rods as load carrying members.

MANTA RAY ANCHOR COMPONENT SPECIFICATIONS

ANCHOR	MANTA RAY ANCHOR STRUCTURAL RATING SAFETY FACTOR 2:1		RECOMMENDED ANCHOR ROD			MANTA RAY ANCHOR STANDARD PACKAGING		
			PART NUMBER AND DIAMETER	WORKING LOAD TO YIELD				
	Lb	kN		Lb	kN	Quantity	Lb	Kg
MR-SR	20,000	89	**R61-06 - 3/4"	33,000	147	2 per Box	45	20
MR-1	20,000	89	R61-06 - 3/4"	33,000	147	4 per Box	54	25
MR-2	20,000	89	R61-06 - 3/4"	33,000	147	4 per Box	31	14
MR-3	10,000	45	**B8S-05 - 5/8"	11,250	50	6 per Box	36	16
MR-4	8,000	36	B8S-05 - 5/8"	11,250	50	6 per Box	28	13
MR-88	5,000	22	**B8S-04 - 1/2"	9,000	40	6 per Box	13	6

Williams Anchor Rods are fully threaded and can be field cut and coupled.

**Anchor Rod Lengths: R61-06 - Up to 40 Feet Black
B8S-05 and B8S-04 - Up to 20 Feet

Recommend galvanized rods be cut to size prior to galvanizing to insure good nut fit.

8

Inverter Power Management Panels

The OutBack Inverter Power Management System is made by OutBack Power Systems Inc. Arlington Washington www.outbackpower.com . Their inverters can be wall mounted indoors or out as required. The "Half-Rack" or “PS2 Panel” shown below consists of two 2.0 or 3.5 kW inverters feeding DC power from batteries through a 175Amp DC panel to an Essential Loads Panel 120V AC panel to the desired loads.

Typical 4.0kw-7.2kw, 120/240VAC, 60Hz Off Grid PS2 Power System

OutBack Power Management Panels are modular and can be fitted with a single 2kW continuous power inverter or up to four 3.5kW continuous power inverters and transient peak load of over 12kW in 120 or 240V AC. The system is programmable and controlled or monitored by the MATE System Control that can be wall mounted remotely or connected to a remote computer via RS232 port or via standard Cat V computer cable. All enclosures are grounded and secured to the wall via a metal back plane. The mounting also provides for the MX60 Charge Controller for a Photo Voltaic PV Array combiners. Note that the PV Combiner box is normally mounted separately near the array and feeds the MX60 through an appropriate circuit breaker on the DC panel.

Trace Inverters have been well recognized for years as a quality supplier of inverters of all types and sizes. The company was purchased in 2000 by Xantrex along with a number of other inverter companies including ProSine and Portawattz among others. When this happened a number of their key engineers left and formed OutBack. As well another new inverter company created by ex-Trace employees called MAGNUM was announced in Feb 04. OutBack is located just down the street from Xantrex in Arlington Washington and both companies now compete head to head with well engineered equipment. Which product to use depends on the installation. For now, the chief distinction is that Outback power panels are more integrated and modular. Both OutBack and Xantrex can be grid tied. Either company’s equipment can be connected to the grid or run fully off grid if the customer desires independent power generation. Some examples of Xantrex/Trace installations.



Ontario Electrical Code Considerations

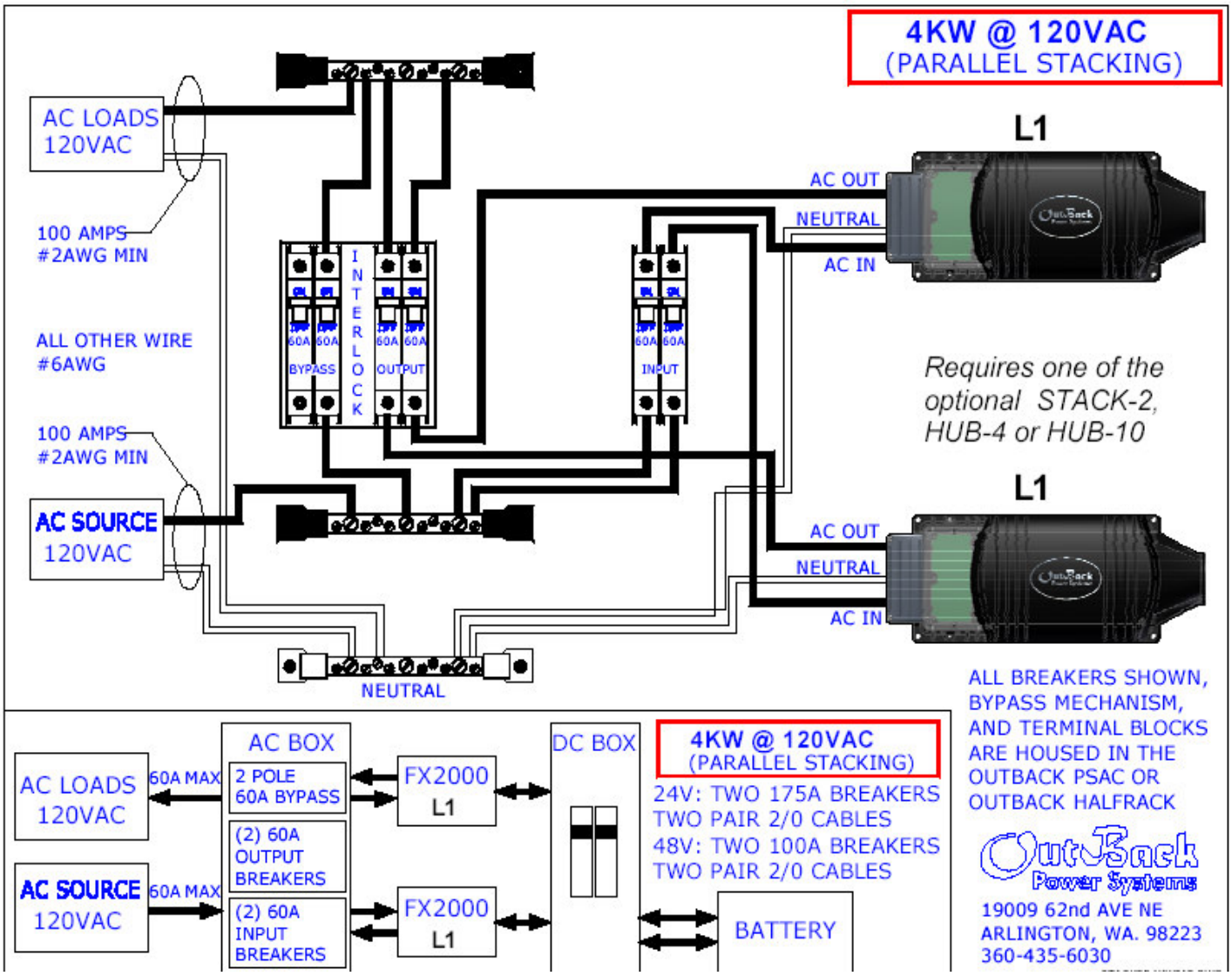
The Ontario Electrical Code does not include specific requirements for Wind Turbines. Inspectors may attempt to apply the solar/renewable energy section requirements and there are some issues here. For example; In the US, solar arrays call for a "Ground Fault Protection" Circuit which is common for solar charging systems but is not required in Canada. In Canadian code, Solar PV arrays only require an ON/OFF or circuit breaker circuit isolation switch to disconnect the array from the controller if desired or in case of a current overload. This is done automatically by the WIND ARROW AFC Controller because installing an ON/OFF switch between the battery and the turbine would result in an open circuit and unloaded turbine that could damage the alternator. An open circuit to the batteries would eave the turbine to “free wheel” without load. Instead the proper solution for shutting down the turbine is to switch the turbine AC leads off by shorting them at their rectifier/controller panel using the “BRAKE Switch”. This will produce an electromagnetic braking effect, that stops the turbine within a couple of revolutions and is the only correct way to stop an alternator powered turbine with a fixed pitch blade array. Check your WIND ARROW manual for other cautions when using the turbine BRAKE Switch.

The Ontario code requires that turbine power be able to be shut off from the grid should linemen wish to service the lines within the neighbourhood circuits. This is done automatically by the inverter line voltage monitoring circuits but the code still requires an external physical switch for safety. This isolation should not shut down the inverter but simply isolate the renewable energy system from incoming power and allow the wind/solar power system to continue to supply backup power to the home. There are still some issues around how this is done correctly. Safety authorities raise concerns about an effect called "Islanding" where two neighbouring wind/solar power systems remain live on the grid because each sees the other as "valid power in the grid" and continue to stay connected. Both the Trace Grid tied Xantrex SW series and Outback series of inverters have "anti-islanding" circuitry that will recognize the loss of valid grid power even if neighbouring power systems are still momentarily live shortly after the loss of utility grade power.

Load control of the battery’s energy is provided by the OutBack Master inverter which also controls the other Slave inverters if installed. Additional inverter capacity is added as needed and turned off or to standby mode when the demand is not there. This reduces inverter idle power and makes the whole system operate more efficiently.

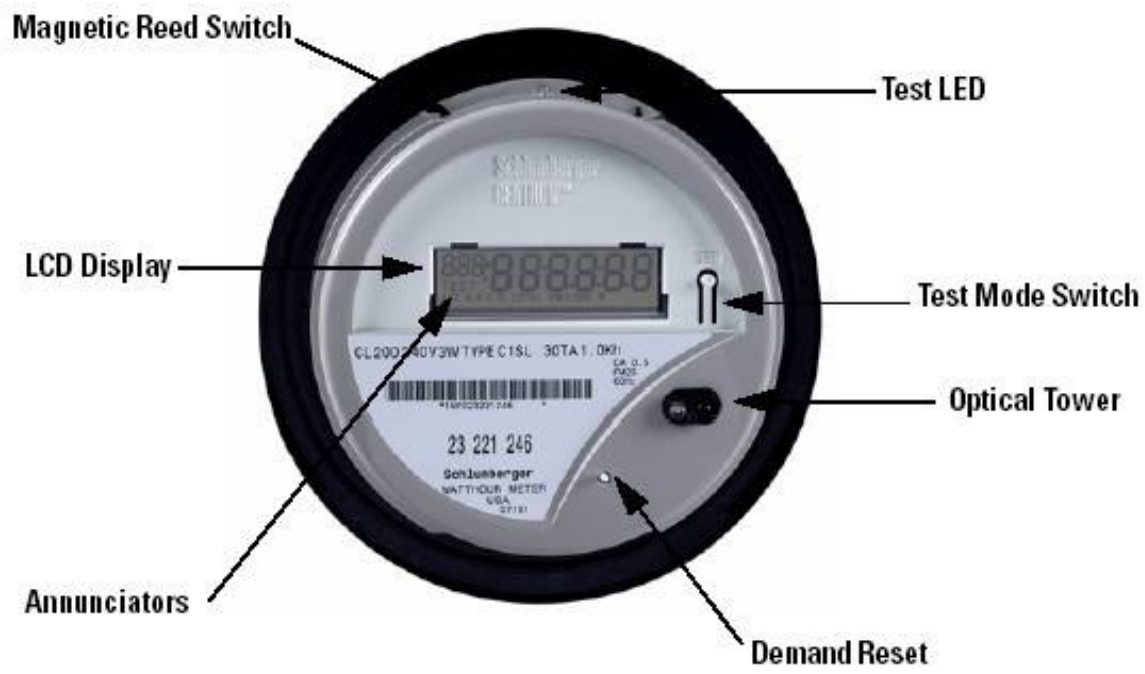
In addition, the Power Panel can be fitted with a 240v AC OutBack X-240 auto-transformer installed in the AC side with or without an auxiliary fan. The fan increases the X-240 output to 6kVA continuous power.

See installation manual for details. All Outback Power Panels contains this diagram on the back of the panel cover. If you examine it closely you will see that there is a complete system layout and description of how OutBack inverters and power panel components fit in the over all design.



Energy Metering Regulation and Net Metering

All forms of metering and measurement are Federal jurisdiction and electrical meter suitability and calibration is governed by Federal regulations. Electrical utilities will only accept bi-directional metering with Federal approval. TRUE-NORTH Power NG is working with Schlumberger (Regina Office) to acquire and test a new digital bidirectional Watthour meter called Centron C1S which also has a remote monitoring capability. This remote sensing programmable unit was first available Aug 03 for testing at the FREE Wind Test Centre and a special test rig (Configuration 1 above) was prepared for residential testing with the cooperation of Hydro One Networks Net Metering office. Results are expected take some years to become standard across all jurisdictions. Burlington Hydro for example, does not require a special bi-directional digital meter but Hydro-One Networks does, It was over $650.Now we are told they are FREE exchange.



For now, most net metering customers will be required to replace their existing uni-directional meter with a bi-directional meter that is Federally approved and will need to do so at their own expense (likely $600-800 installed)

A note on Net Metering value. We do not recommend Net Metering in most situations.
Net metering for residential generators is new territory for most utilities and as such there are few if any established processes and regulations. The residential generator is still seen as a net cost to utilities and there are many agencies, from nuclear power plants, to provincial legislatures, to safety authorities involved in the whole jurisdiction of electrical power generation. As a result, none of these diversified interests owns the problem completely and we can expect that this may continue for several years, before there is any encouragement for private generator operations.

Even though private generation is a net positive for the system, the perceived value for the utilities if a few customers who are pushing a few electrons back and forth to the grid is limited. For the consumer, the expense and general hassle involved is outweighed by the piece of mind that can be achieved by generating and using your own power, without the help or interference of regulators who don't yet see value in their connection to the gird. The best advice for the next few years is to avoid net metering and simply use or store the energy you produce yourself. If you really don't like the idea of dealing with battery maintenance in your home, you can get sealed batteries. Should you actually produce more energy than you can use sometimes, then simply divert it to heat your home or hot water tank and it won't be wasted. The utility will never pay you for excess power and they will attempt to "roll over" or write off any of that banked energy you haven't used at the end of a billing period. As it is now, customers will simply lose any excess banked energy each billing cycle.

Being energy independent means taking responsibility for your own production and use of electricity and that independence is lost to some degree when you connect to the grid. Your best solution for independence is to be isolated from the grid. The most useful is to be grid-connected but not grid-tied. That way the utility does not have any say in how or when you use your system as long as it is installed according to electrical code. If you still wish to be grid-tied be prepared to meet the requirements and pay for the extra equipment and inspections and accept responsibility for any and all problems the utilities identify.

Most electrical utility companies do not have clear guidelines for Net Metering although some provincially owned operators are beginning to publish new regulations and Grid-Tie requirements. Ontario is made up of Hydro One Networks and many more local municipal utilities such as Toronto Hydro, Markham Hydro, Vaughn or Burlington Hydro etc. Each of these companies is at various stages of defining how they will accept Net-Metering customers.

Most utilities seem to be looking at how they can make money from accepting Net Metering customers because they do not have an interest in the overall production of energy, only in its distribution. Likewise, major generators do not care about distribution savings because they do not have any interest in this aspect. Distributors prefer to work with a few larger commercial producers and find it too much trouble to deal with individual residential customers, due to economies of scale.

So far, the administrative costs of controlling residential access to the grid make such connections bureaucratically prohibitive rather than technically simple as it is. However, there remains the ability for the government to legislate such access and cut through the red tape, if it can be shown that privately owned and properly installed wind and solar power is of net benefit to a more distributed power generation system. Considering the true cost of electricity production and distribution it is estimated that every dollar spent on local production and consumption from renewable resources is worth several times the investment over public utilities. Every kilowatt produced and consumed locally saves a multiple of kilowatt hours of energy production and distribution costs. Production of locally consumed energy distributes the power management costs to the individual and reduces the system production capacity requirements. With this in mind, TRUE-NORTH Power NG is still making the case to Ontario and federal legislators that bureaucratic barriers should removed to provide private power generation owners with strong financial and connectivity incentives to install and operate their own systems. In the meantime, we are not there yet and do not recommend net metering connections as an economic or operational alternative.

Batteries, Energy Storage and Diversion

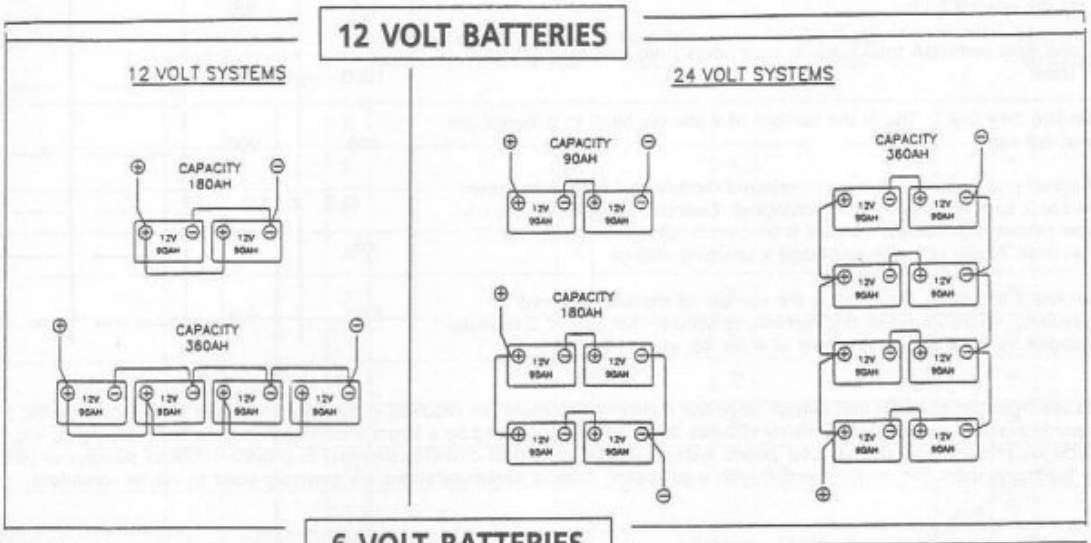
The typical system installation for residential use may have eight 6v batteries wired in two parallel banks of 4 batteries in series. (See examples below) Recommended wiring should be 2/0 cable for 24-48v systems where battery/inverter wire runs of less than 2-6 feet. For runs longer than 10 feet 4/0 cable connections are recommended, and especially for 12v systems where currents can be quite high.

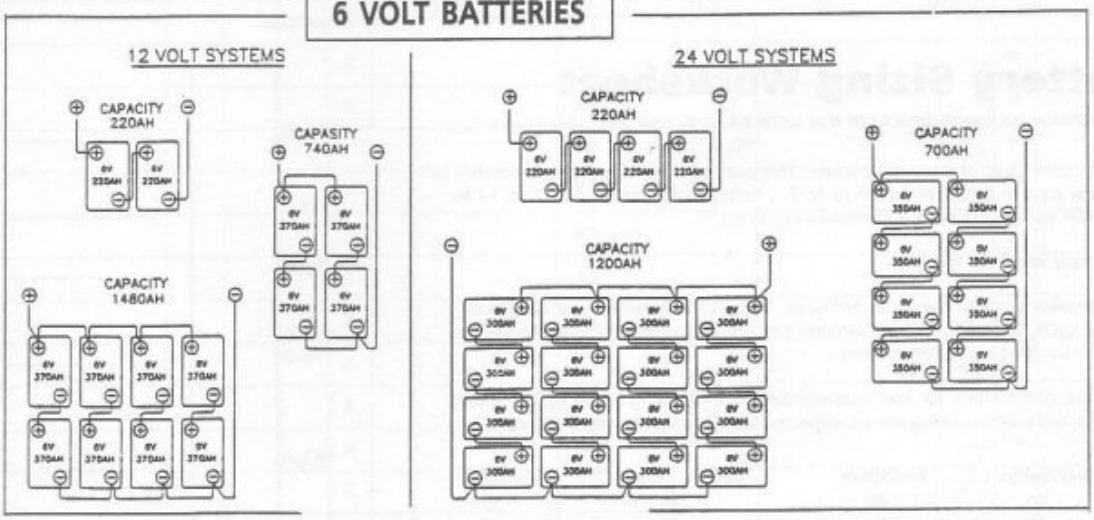
Energy generated from wind or solar must be used or stored, or it must be diverted to some resistive load to dissipate the energy and protect the generator. Both wind turbines and batteries can be damaged if left to overcharge a battery bank. Once the battery voltage reaches a predetermined level (usually 28.8 volts DC for a 24v battery bank) it must be diverted to a resistive load or the batteries will eventually overheat, boil dry and become permanently damaged. A solar charge controller such as the Trace™ C40 C-60 or Morningstar™ TS-45 or TS-60 can be employed in parallel with the WIND ARROW AFC Controller and battery connections to control the charge rate of the solar panels. In older LAKOTA systems you needed a 70HFR40 diode on the positive leg to the battery to protect the turbine rectifier and LDR from being back fed by large solar PV currents. This feature is not part of all controllers. Check with the supplier. While Morning Star and Trace systems can work fine with Solar PV products they are not to be used for controlling WIND ARROW turbines because they are not designed to handle the fast voltage fluctuations of wind and they control battery voltage by dumping energy from the batteries. More importantly the WIND ARROW has no mechanical furling system and there are other controllers capable of safely stopping the turbine in case of high winds. The AFC control system takes energy from the turbine before going to the batteries if it is not needed. Solar charge controller systems may also employ a battery temperature sensor for controlling regular equalization battery charging when the charge rate needs to be temperature limited.

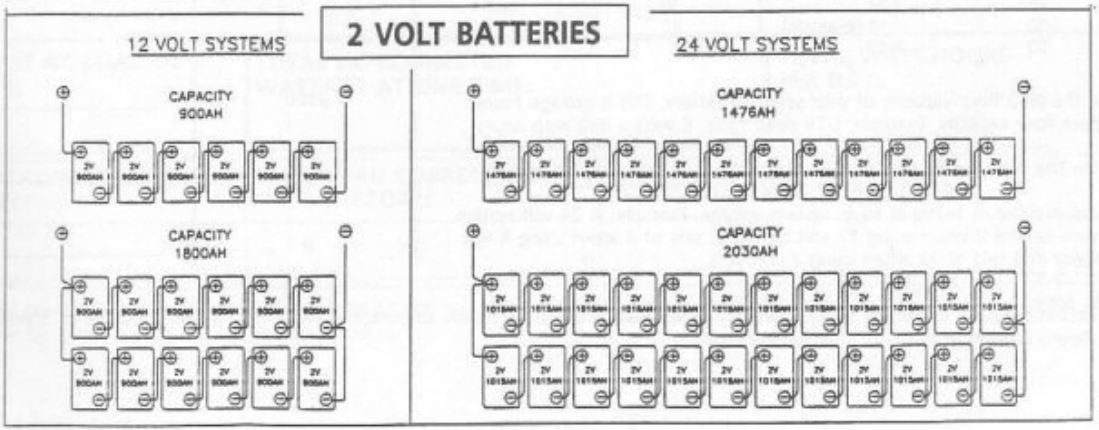
An additional, PV charge controller, the OutBack MX--60 or equivalent is required for PV Solar panel voltage management. The MX-60 employs a Maximum Power Point Tracking (MPPT) technology to control the current flow from PV arrays that may produce higher voltage than the battery bank, such as charging a 24V battery bank from a 48V PV array. The MX 60 can also be connected to the MATE™ system controller and display to allow monitoring from up to 1000 ft away. It also includes an opto-isolated RS232 port for connection to a remote PC for data collection and monitoring.

Battery Installation and Wiring

Batteries may be wired in either series or parallel configuration. When a battery is wired **in series** the positive terminal is wired to the next battery's negative terminal. This increases the voltage while maintaining amperage of the two batteries. With **parallel** wiring the positive terminal is wired to the next battery's positive terminal, and the negative to the next negative. This arrangement increases amperage while maintaining voltage. One common mistake is to believe that both amperage and voltage will increase when wiring batteries together. It will not; only one value will increase with respect to the arrangement. A battery bank may combine both series and parallel wiring configurations. Series strings of batteries are used to achieve the correct voltage, then a number of these series strings are attached in parallel to increase the amp hours of the total battery bank.







Battery Sizing and Battery Types

Normally stand-alone or utility inter-tie systems require battery storage. The turbine and solar modules charge the batteries during windy or daylight hours and the batteries supply the power to the inverter when it is needed. Utility inter-tie systems may supply power directly to the Utility grid. The two most common types of rechargeable batteries used are lead acid and alkaline. Lead acid batteries have plates made of lead, mixed with other materials submerged in a sulfuric add bath. Alkaline batteries can be either nickel cadmium or nickel-iron batteries. They have plates made of nickel submerged in a solution of potassium hydroxide. Nickel cadmium has a high cost and environmental problems related to disposal. Nickel based batteries are not recommended in some situations. Although they have proven to be very reliable, most PV modules do not have a high enough peak power voltage to charge them adequately. Gel type or glass mat batteries are sealed units and require no maintenance or vented enclosure. They are generally 2 to 3 times the cost of lead acid and have a lower power density and shorter life. Sealed deep-cycle lead-acid batteries are maintenance free. They never need watering or an equalization charge. Sealed batteries require very accurate regulation to prevent overcharge and over discharge, either of these conditions can drastically shorten their lives. Sealed batteries are recommended whenever the Indoor storage space cannot be vented or for remote unattended applications, or on sailboats for example, where spillage would be dangerous. In 2004, the FREE Wind Test Centre demonstrated the LAKOTA HV (high Voltage) with the SMA-America “Windy Boy”, a Grid inter-tie inverter system that does not use batteries. Instead a sophisticated electronic power management system feeds power to the general house circuits and any excess energy is sent to the grid with compliance to UL1741. The operational limitation of 5min wait time for reconnect however means the UL1741 compliant inverters are very inefficient in wind under 12-15mph.

Battery Size

The size of the battery bank required depends on the storage capacity required, the maximum discharge rate, the maximum charge rate, and the minimum temperature at which the batteries will be used. When designing a power system all of these factors are looked at and the one requiring the largest capacity will dictate battery size. Temperature has a significant effect on lead-acid batteries. At 40°F they will have 75% of rated capacity, and at O°F their capacity may drop as low as 50%. The storage capacity of a battery, that is, the amount of electrical energy it can hold, is usually expressed in amp-hours. If one amp is used for 100 hours then 100 amp-hours have been used. A battery in a wind or solar power system should have sufficient amp-hour capacity to supply needed power during the longest expected period of calm or cloudy weather but in most homes this amount of energy is simply impractical. Using the Load Calculator HTML Sheet, add up all the normal house loads to achieve a monthly and daily average load in kWhrs. Now, with a system voltage of say 12, 24 or 48v you can determine the average AMPS needed to supply these loads. This rate of use of power is what determines the battery size in Amp Hours (AH). Please refer to your workshop notes for details. A lead-acid battery bank should be specified about 20% larger than this amount, but a Ni-Cad battery can be sized to exactly this amount. If there is a source of backup power such as a standby generator with a battery charger, the battery bank does not have to be sized for worst-case weather conditions.

Lead-Acid Batteries

Lead-acid batteries are the most common in renewable energy systems because their initial cost is lower and because they are readily available nearly everywhere in the world. There are many different sizes and designs of lead-add batteries, but the most important designation is that they are deep-cycle batteries. Shallow cycle batteries, like the starting batteries in automobiles, are designed to supply a large amount of current for a short time and they will stand mild overcharge without losing electrolyte. But they cannot tolerate being deeply discharged. If they are repeatedly discharged more than 20% their life will be very short. Deep cycle batteries are designed to be repeatedly discharged by as much as 80% of their capacity. Even though they are designed to withstand deep cycling, these batteries will have a longer life if the cycles are shallower. All lead acid batteries fail prematurely when they are not recharged completely after each cycle. Letting a lead-acid battery stay in a discharged condition for days at a time can cause a permanent loss of capacity.

Always use extreme caution when handling batteries and electrolyte. Wear gloves, goggles and old clothes. Battery acid will burn skin and eyes and destroy cotton and wool clothing. The quickest way to ruin lead acid batteries is to discharge them deeply and let them stand dead for an extended period of time. The positive plates change from lead oxide when charged to lead sulfate when discharged. If they remain in the

lead sulfate state for a few days, part of the plate does not return to lead oxide when the battery is recharged. The parts of the plates that become 'sulfated' no longer transfer or store energy efficiently.

Batteries that are deeply discharged and then only charged partially on a regular basis can fail in less than one year. Check your batteries on a regular basis to be sure they are getting cycled properly. Use a hydrometer to check the specific gravity of your lead-acid batteries. If batteries are cycled very deeply and then recharged quickly, the specific gravity reading will be lower because of incomplete mixing of electrolyte. Check the electrolyte level in wet-cell batteries at least four times a year and top-off each cell with distilled water. Do not add water to discharged batteries. Electrolyte is absorbed when batteries are very discharged. If you add water at this time and then recharge the battery, electrolyte will overflow and make a mess. Keep the tops of your batteries clean and check that cables are tight. Do not tighten or remove cables while charging or discharging. Any spark around batteries can cause a hydrogen explosion inside, and ruin one of the cells, and harm you. It is a good idea to do an equalizing charge when some cells show a variation of 0.05 specific gravity from each other. This is an intentional, long steady overcharge, bringing the battery to a gassing or bubbling state. Do not equalize sealed or gel type batteries.

With proper care, lead-acid batteries will have a long service life and work very well in almost any power system. Unfortunately with poor treatment lead-add battery life will be very shorter.

BATTERY WARRANTIES DO NOT COVER DAMAGE DUE TO POOR MAINTENANCE

Charge Control and Energy Management

All renewable energy systems with batteries require some form of charge control to protect the generators (wind or solar), the batteries and the loads. Loads normally are protected by switches and circuit breakers but batteries and generators need to be connected at all times and therefore the energy flow needs to be regulated. This is normally done by limiting the current in PV systems and or diverting the energy from the turbine to an alternate “Diversion Load”, usually a resistor of some kind. The new WIND ARROW AFC controller there is no need for a diversion load because the AFC will shut the turbine down safely in case of high winds or no load detected.

C-40

The charge controller like a Trace C-40 should only be used for solar PV systems not LAKOTAs. For the AFC Controller, it must be matched to the voltage and power of the load and the turbine and connected to the proper battery bank with a blocking diode. At 48volts the maximum current from each turbine is about 25-30Amps while a 24 volt system can produce as much as 60Amps in high wind. As a result you must size the wires, the circuit breakers and the AFC controller to match the maximum expected current.

For Solar PV arrays the Outback MX 60 is recommended but the older Trace C-40 C-60 series can also be used. Trace “Dump load” controllers come with small jumpers to select the voltage under either charge control or load control. Dump loads are usually operated under charge control mode. The charge controller bulk/float voltage is then set to the battery manufacturers recommended level. Each manufacturer is

different so check with their specifications before setting it. Also, sealed batteries are never “equalized” so there are usually special settings for them to inhibit the equalize charge feature.

Solar Installations

Solar panels cells are wired in series or in parallel depending on voltages (the same way batteries are) and connected to the battery bank through a PV Combiner box connected in series with a current limiting charge controller. This combiner box simply collects solar panel power leads and contains a circuit breaker for each panel or group of panels being used. The PV array can also employ Ground Fault Protection circuit for failure management This is often co-located next to or can integrated with the PV Combiner box but the GFPS in not a required element in Ontario and most other jurisdictions in Canada.

Most 100-180W PV modules employ a 10-15amp over current circuit breaker. Modules less than 80 watts may use 6-8 amp breakers. Charge control for PV is normally done in series with the PV output to the battery bank using a charge controller like the Trace C-40 C-60 or the Morningstar series. More sophisticated charge controllers like the OutBack MX60 use Maximum Power Point Tracking (MPPT) technology to squeeze extra charge out of low wattage power production when there is not a lot of direct sunlight.

The generic schematic on the next page is an example of how Solar PV is integrated with a wind turbine.

Maximum Power Point Tracking

Maximum Power Point Tracking (MPPT) technology is used in PV charge control to match the charging amps from panels to the level needed to allow current flow to the batteries for a given voltage. When solar panels are not fully lit and the battery bank is near full charge the higher battery voltage will not allow current flow from the panels until the sun becomes stronger. As a result the energy landing on the panels is not delivered to the batteries.

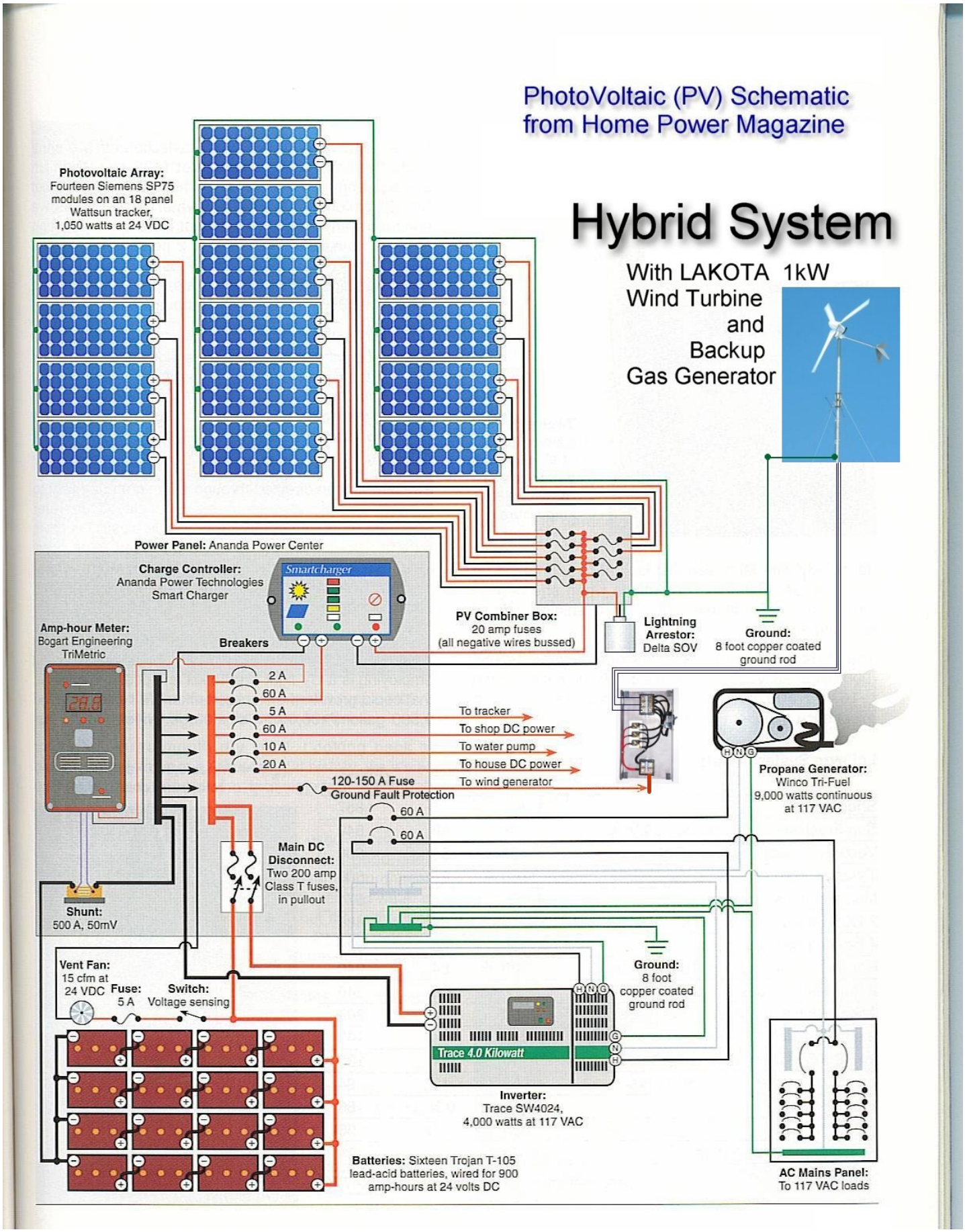
MPPT charge controllers will arbitrarily boost that voltage and maintain the charge flow by reducing the wattage available from the panels. Less energy will flow under low these light conditions, but because some energy does flow MPPT charge controllers can transfer up to 30% more energy than if the panels were connected without an MPPT controller.

As an example, a 75W panel connected directly to a 12 volt battery bank sitting at 13.5 volts in a low state of charge will only begin charging if the voltage from the panel is above 13.5 volts. This effectively allows only 53 watts of energy to flow from the panel and the remaining 22 watts is unavailable. The MPPT circuit will boost the required voltage and, in addition, MPPT controllers like OutBack MX60 will allow the use of array voltages higher than the battery bank so smaller wire can be used and also allow combining of different voltage panels in the same system.

EXAMPLE

- A MPPT takes a 75w panel at 17 volts and 4.4 amps and **converts it**, to **5.77 amps** at **13 volts**. You still have 75 watts total, (Actually, about 72 watts, because they are only 97-99% efficient but it may be more if you have fresh snow reflection). A fully discharged battery at 10.5 volts, you would get nearly 7 amps at 10.5 volts out of the MPPT into the battery.

- A MPPT **tracks** the maximum power point, which is going to be different from the STC (Standard Test Conditions) 20oC. Under cold conditions, say -10oC a 75 watt panel might actually put out as much as 80 watts - but if you don't have some way of *tracking* that power point, you won’t get it. Under hot conditions, the power drops - you lose power as the temperature goes up.


PhotoVoltaic (PV) Schematic
from Home Power Magazine
Hybrid System
With LAKOTA 1kW
Wind Turbine
and
Backup
Gas Generator
Photovoltaic Array:
Fourteen Siemens SP75
modules on an 18 panel
Wattsun tracker,
1,050 watts at 24 VDC
Power Panel: Ananda Power Center
Charge Controller:
Ananda Power Technologies
Smart Charger
Smartcharger
Amp-hour Meter:
Bogart Engineering
TriMetric
Breakers
PV Combiner Box:
20 amp fuses
(all negative wires bussed)
Lightning
Arrestor:
Delta SOV
Ground:
8 foot copper coated
ground rod
2 A
60 A
5 A
60 A
10 A
20 A
To tracker
To shop DC power
To water pump
To house DC power
To wind generator
120-150 A Fuse
Ground Fault Protection
60 A
60 A
Propane Generator:
Winco Tri-Fuel
9,000 watts continuous
at 117 VAC
Main DC
Disconnect:
Two 200 amp
Class T fuses,
in pullout
Shunt:
500 A, 50mV
Vent Fan:
15 cfm at
24 VDC
Fuse:
5 A
Switch:
Voltage sensing
Ground:
8 foot
copper coated
ground rod
Trace 4.0 Kilowatt
Inverter:
Trace SW4024,
4,000 watts at 117 VAC
Batteries: Sixteen Trojan T-105
lead-acid batteries, wired for 900
amp-hours at 24 volts DC
AC Mains Panel:
To 117 VAC loads

WARNING

Assembly, installation, erection, and maintenance of the WIND ARROW Wind Turbine and PV Solar electric panels and controllers involves work with towers and electrical components, both of which can be very hazardous if attempted without proper knowledge and training. Prior to assembly, installation, erection or maintenance of the WIND ARROW Turbine, individuals must read and understand the information contained in the Owner's Manual as well as information provided by the manufacturers of other components and local electrical installation standards that must also be followed when operating an electrical generating system.

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