Dave's Notes

F.R.E.E. WIND TEST CENTER

FERNDALE RENEWABLE ENERGY EVALUATION (F.R.E.E.)
WIND TEST CENTER

READ THIS FIRST - LAKOTA Installer/Operator Notes by Dave Cooke

In addition to reading the manual . . .
These are my personal NOTES on installing turbines and particularly LAKOTA or Longbow. They will make installations and operations easier and safer. Failure to understand some of these issues will not only make it frustrating to install but will likely result in systems problems, turbine failures, or damage to the system or yourself.
(Questions? please call me at (519-793-3290) or email david@truenorthpower.com

WARNING: STOPPING THE TURBINE (This is on Pg 34 of the manual) DO NOT leave the brake switch ON in high wind if the turbine fails to stop within 3 seconds after flipping the switch. The LAKOTA may be damaged if the brake is left ON when the blades are already in full flight and the wind exceeds about 30-35mph. Once the blades stop or slow to "slowly rotating" within a couple of seconds, then the brake may be left on indefinitely. This is a safe mode. The "BRAKE Switch" on the side of the rectifier/controller box is intended for stopping the turbine in light to moderate wind or to prevent it from starting before an anticipated storm or if you do not want the turbine to operate when you are away, such as a cottage or remote camp. It is safer to just let the turbine continue to fly, even in 50-60mph wind, than to switch the brake ON and leave it on when the blades fail to stop immediately. Either stop the turbine before the wind gets above 30mph or wait for a lull in the gusts and apply the brake for 4-5 seconds just as the wind dies briefly. If the blades stop or slow to a crawl in a couple of seconds then you can safely leave the Brake ON and it will keep them from starting up again. The blades may continue to turn, very slowly, and no damage will occur. If the blades fail to stop or slow down then immediately turn the brake switch OFF again, leave it OFF and wait for the wind to die down. The LDR load diversion regulator (LDR) and resistors are designed to safely handle over 150% of the rated power of the LAKOTA or Longbow and prevent the turbine from overheating.

1. The **"BLACK RUBBER HANDLE"** tubing on the side of the LAKOTA is **NOT A HANDLE**. Picking it up by the black tubing can stress internal wiring and lead to a short or open circuit and system failure. Pick up and carry the LAKOTA by one or both of the springs as a handle is fine. Please point this out early to others who may be helping you. Pulling on this black conduit if the connectors are not secure, can cause internal wiring to apply a twisting pressure to the brushes inside the base and result in less than 25% of one or more of the brushes to being contact resulting in low power output and eventually burned brushes or turbine if it's not corrected.

2. **Potential Cause of EARLY Turbine Failure: (Pg 23) Current 2006 turbines should be shipped with this step already done prior to shipping . . . but just in case . .** The torque ring may not seat properly on installation because the hub plate was not assembled in the proper order. This condition is easy to avoid and will

not happen if you follow the instruction in the manual. Failure to assemble the hub assembly in the correct ORDER **will** prematurely wear out the drive shaft and the vibrations **will** cause rapid wear through of the springs on the upper attachment points. The turbine may fail within days in good wind. Fit the torque ring onto the shaft by itself FIRST, with the torque key in place, and check to be sure the ring is completely seated, well into the turbine housing, **before** mounting the back hub plate. Next add some PERMANENT LOCTITE (red or the green locktite supplied with the system) to the three flat head M6 x 12 mounting screws and secure the back hub plate to the torque ring and torque the screws securely with the Allen Wench provided. If the torque ring and back hub plate are preassembled before mounting on the drive shaft the assembly may feel and sound like it has seated when in reality the seating "Clunk" you hear is the drive shaft hitting the back side of the hub plate rather than passing thorough it to allow the torque ring to seat fully. At the very least the turbine's furl mechanism can fail from this condition in a few weeks and the drive shaft will also be severely worn. If you find the torque ring is contacting the front face when seated the torque ring is the wrong one. Contact TRUE-NORTH Power Systems or AEROMAX directly for a replacement.

3. For older LAKOTAs prior to the introduction of the integrated LAKOTA Commander in Jun 2005, the second major cause of LAKOTA failure is not installing a Diversion Load or installing the wrong Diversion Load. The LAKOTA is a light weight, low inertia, high performance turbine that will not shut down in high wind unless you tell it to before the event. It is rated at 900watts but is capable of generating in excess or 1200-1600w peaks in winds above 30mph. As a result it must always have some place to put that energy or it will burn itself up from the heat being generated in the head. Energy can either be used or stored or it must be diverted to a dedicated resistor to be dissipated. I recommend all LAKOTA diversion loads be able to dissipate at least twice the rated power (ie two times 900w or 1800watts of power.) This would be 1800w at the diversion voltage of about 14.4v, 28.8v, 57.2v or up to 360v for the LAKOTA HV High Voltage turbine. The resistance and controller combinations are listed below. You can use an air heater or water heater but I'd recommend it be at least 1800w continuous dissipation capacity or you risk overheating the turbine in high wind. See Chart Below:

Dave's Notes

V O L T A G E

System	Diversion	Calc R Needed	# Resistors	Series/Parallel	Resistance	Dissipation Capacity
12v	14.4 v	0.115 ohm	two 0.25 ohm	Parallel	0.125 ohm	2kw
24v	28.8 v	0.467 ohm	two .75 ohm	Parallel	0.5 ohm	2kw
48v	57.6 v	1.843 ohm	two .75 ohm	Series	2.0 ohm	2kw
300v	360 v	68.00 ohm	two 35 ohm	Series	70.0 ohm	2kw

4. ALWAYS check the resistance/connectivity of the three phase wires at the base of turbine and the tower at least, and preferably all the way to the Rectifier/Controller, BEFORE electrically or mechanically fitting of the LAKOTA to the tower riser. This will give you confidence the system is connected, there are not shorts and the turbine is correctly wired before everything is up in the air on top of a tall tower or other structure. It's a lot easier to correct any connectivity issues at this point when everything is accessible on the ground. This chart shows the resistance you should measure across each pair of phase wires when the system is NOT connected to anything. If you find your system is not in MOD 3 (LOW) or MOD 0 (Severe) then I would change it to MOD 0. For technical reasons (an imbalance in production between windings) I recommend only using LOW or Severe settings. The Med or High settings do not offer ANY advantage over MOD 0 and will overstress one of the winding sets compared to the other two.

   My best recommendation is MOD 0 for all sites . . and only use MOD 3 for rare low wind locations and then only with the EAR (longer) blades.

All readings plus or minus 0.2 Ohms		Annual Average Wind Regime			
		10-13mph	14-15mph	16-18mph	18+mph
Stator	Unwired	Low	Med	High	Severe
12v	0.2	0.7	0.7	0.2	0.2
	0.2	0.7	0.5	0.5	0.2
	0.2	0.7	0.5	0.5	0.2
24v	0.5	1.7	1.7	0.5	0.5
	0.5	1.7	1.1	1.1	0.5
	0.5	1.7	1.1	1.1	0.5
48v	2.0	7.9	4.9	4.9	2.0
	2.0	7.9	4.9	4.9	2.0
	2.0	7.9	7.9	2.0	2.0

Be sure to use proper strain relief on the cables so the weight of the phase cables in the tower does not pull on the wires or the connections coming from the base of the turbine. There should be no stress on these wires at any time, and just as important, they should be wrapped securely in a bundle so they wiring insulation cannot be worn through by rubbing on the inside of the riser section of the tower. Quality rubber electrician's tape worked best not plastic. NOTE: the new Longbow does not have a strain relief mechanism because the "compression coupler" yaw clamps over the end of the tower and so there is nothing to connect to inside the coupler. AEROMAG is looking into how to attach a hook way inside the base of the coupler to hang a slender cable hook on but this is not available yet as of Oct 2006 shipments.

5. Do not remove cover plates or open the LAKOTA or Longbow access panels (2006 LAKOTA and Longbow have three, rear and two side brush access panels) unless instructed to by TRUE-NORTH Power Systems or AEROMAX. Doing so may damage the brushes or other wiring if not reassembled properly and this will VOID the warranty. Hint: you will need a special tool and instructions in order to get the brushes reinstalled properly.

6. ALWAYS double check torque settings or all nuts (Turbine and Tower) as a LAST ORDER of BUSINESS before a hub, spinner or blade assembly or tower is raised. It is easy to forget whether or not these things have been done correctly and completely. Better to check twice as a last order of business and know that was the last thing you did before the turbine went out of reach. Also check to ensure medium LOCTITE (blue NOT the green supplied with the hub set) is applied to all tower and guy wire threads. Buchanon connectors either side of the black hose should be as tight as possible by hand . . NO tools no loctite. No Loctite on hub/blade bolts. They all have Nylock nuts. Also, don't put loctite on the torque key or the drive shaft. You'll regret it later someday.

7. NEVER allow the turbine to "Run FREE" (ie two or more phase wires NOT connected to the Controller or Commander) in wind above about 15mph and then only for a few seconds, in order to check for faulty connections or test for a failed rectifier. ie If the three phase wires are not connected to each other, a battery or other load, a strong wind can quickly accelerate the turbine into an over-speed and the BRAKE switch may not be able to halt the blades. The LAKOTA has very high performance (efficient) blades and the alternator must be under load at all times in order to allow electromagnetic braking. If a wire comes loose or a circuit breaker or fuse trips, then the turbine has the potential to SERIOUSLY over-speed and fail by throwing a blade, and possibly causing the rest of the turbine head to self-destruct. This cannot happen to a properly installed LAKOTA/Commander installation but this catastrophic event can easily be avoided by careful attention to system integrity (all phase wires connected under windy conditions). Without a Commander you must pay careful attention to proper design and installing a diversion load controller, resistors, LDR and capacitor bank. For example, putting a 30 or even 60amp circuit breaker between the turbine DC output and the battery of a 12v system can result in the breaker tripping at a point when the turbine is producing maximum power. You need to ensure the diversion load and capacitor bank will always be part of that control circuit. If this open circuit happens it will unload the LAKOTA and this Free Flight condition will occur within a few moments in wind above 25-30mph. Blade rpm can exceed 2500rpm and tip speeds can exceed the speed of sound. This condition can be the result of improper (undersized) wire from controller to the turbine or a loose connection at the base of the tower, or not providing strain relief for the phase wires at the top of the tower causing a connector to separate inside at the top of the tower. Also, using phase wire that is too small (such as #10 or #8 of a 12v system) or a diversion load that is too small or does not have a capacitor bank or a diversion load controller that is not appropriate for wind control such as a Trace C40 charge controller on a 12 or 24 v system. With no proper diversion load a full battery bank during high wind can eventually burn the alternator. This condition will not happen to a properly wired system. A rectifier failure causes a short circuit that results in proper electromagnetic breaking not a Free Flight condition. Electrical safety demands wires be protected from overload and these circuit breakers or fuses must be sized appropriately for both the batteries AND the wire but also the turbine. The 12v LAKOTA is capable of generating up to 100amps or more in high wind and this could cause the 60amp circuit breaker to trip. Sixty amps of current flow requires #6AWG wire at least, and 100amps requires #3AWG. Use only a 100amp fuse or circuit breaker for 12v systems, 60amp for 24v and 30amp for 48v systems to protect wiring from dead short conditions on the DC power side before the batteries. Note these must be DC rated devices. DC Breakers are different than normal AC breakers and using AC breakers can result in dead shorts not an open circuit when they trip.

For complete security use the LAKOTA Commander or at least a tapered Load Diversion Regulator (LDR) controller series LDR 12-100, LDR 24-60 or LDR 48-30 is now supplied with each LAKOTA. This small circuit board is usually installed inside the old style controller with a couple of screws and provides complete voltage and current control of the LAKOTA even if the batteries, or breakers or inverter fails. You will need a minimum of 2 preferably 4 80v 10,000 micro farad capacitors in parallel for complete fail safe operations with no batteries in the loop. Use the proper resistance diversion load to assure the LAKOTA is always under an appropriate electrical load. See section 3 above.

> *Basically it boils down to this. A 24v LDR set to divert at 28.8v needs about 0.47ohm to dissipate 1300 watts or more, so use two .75 ohm resistors in* ***parallel*** *for about 0.4 ohm resistance. The 48v LDR can be set to divert at say 57.6 and needs about 1.87ohm for around 1300w dissipation so use two .75 ohm resistors in* ***series*** *for about 1.7 ohms resistance, and a 12v LDR set to divert at 14.4 needs about 0.138 ohms so use two 0.25 ohm resistors in* ***parallel*** *for about 0.125ohm*

So we've standardized on two .75 ohm 1kW (ASE 1000-.75 resistors) for 24 series and 48v parallel and two 0.25 ohms resistors (ASE 1000-.25) for 12v in parallel.

8. Handle the blades carefully. They are very stiff and strong but are also very light weight and the trailing edges or tips especially can be damaged by striking the corner of a work bench or doorway. Proper balancing measurement on installation is essential to assure smooth vibration free use. A tolerance of plus or minus 1/16th (1mm) inch is desired. 1/8th inch (2-3mm) is acceptable. Please read the manual for details on how. . . but WHAT FOLLOWS IS NOT IN THE MANUAL. DO NOT tighten the three nose cone bolts to the specified torque. Using too high torque on these bolts can crush the nose cone in freezing conditions and can also flex the front plate ever so slightly, enough to pull the blade tip out of track by as much as a half inch. The three end bolts have nylock nuts and are only there to hold the nose cone on, so they don't need to be that tight.

9. Be sure to use **RED** LOCTITE on the torque ring/hub assembly screws that fasten the torque ring to the hub back torque plate. This will ensure that that the torque ring remains well secured. Note: I've noticed that the extra strength **RED** Loctite may come in a **BLUE** container depending on supplier. This is Medium Strength removable **BLUE** Loctite can be in a RED container. You can only remove **RED** loctite with direct heatgun or propane torch. . . so you don't want to be fooled by the container colour.

10. Once mounted on the tower NEVER allow the tail to strike the ground first or allow the turbine to stand on the tail. (yes, people actually do that) The light weight tail boom provides a long lever for orienting the turbine into wind but is not designed to support any weight and levering on it can damage the yaw axis assembly if it is forced to carry any significant load from the tower or turbine being raised or lowered. The entire turbine assembly must be free of any side forces during the lift or lowering of the tower. Have someone support the boom, free of any side forces, as it leaves the ground. Also make sure the boom attachment bolt is torqued to 55ftlbs or 75 Nm before raising the turbine. Without a secure nylock nut, high frequency vibrations have been known to loosen this nut and have the tail just fall off.

11. Do not force the tail boom when pushing it into its final position. Use a quick spray of silicone or WD40 and it will normally slide in with a small amount of twisting. Pressing too hard or hammering puts undue stress on the YAW axis which again, is designed for vertical and rotational loads not horizontal. If it will not seat "home" easily with a little light oil and twisting from the tail feathers, simply ream out the excess paint from inside of the base carefully with some emery paper. Sometimes there is a burr on the end of the boom that can gouge the softer metal inside of the base casting. Simply file the rough edge of the boom or as a last resort simply cut off about 3/8th of an inch of the round end for an easier fit. This will not harm the tail boom integrity.

12. Do a SPIN and TRACKING TEST before you raise the turbine. Make sure the area around the turbine will allow the blades to rotate 360 degrees without striking anything and give one blade a gentle push to see if it moves easily. If it comes to a stop in less than ½ or one rotation then you may have one wire grounded, a failed rectifier diode or some other short in the system or the BRAKE switch may be ON. Have someone switch the BRAKE ON and OFF while you spin the blades gently. You will notice the difference if it is operating properly.

Next, with the nose cone on and the turbine free to rotate at a slight angle where the blade tip passes just above the ground, place a stake in the ground where the tip comes closest to the ground. Make sure the tail cannot move for this test. It should just rest firmly on your work bench or some other stand so the blades remain in a fixed plane. The blade tip should just miss the stake by a millimeter or 1/8th inch or less. Mark the stake at that point and without moving the rest of the turbine rotate to the next blade and see how close it comes to the mark. It should track within a 2-3 mm or ¼ inch. If it's more than that you may have over-tightened one of the nose cone bolts.

Now leave the BRAKE ON until the turbine is lifted. Once in the upright position switch the BRAKE off briefly if there is at least 8-10 mph steady wind and see if it starts up before securing the tower and all the guy wires. You might have pinched a Phase wire in the lift and shorted the system. Better to find out now and correct it before it's all tied down and secure. Until the tower is secure, only let the turbine fly for 10 or 15 seconds even if it is connected to the controller. Also, if it does not fly and there is enough wind that it should fly, then try undoing at least two of the three Phase wires completely at the base of the tower or at the controller input terminal. This takes the diodes and switch out of the circuit briefly to validate the turbine and wiring are both correctly installed. If undoing these connections allows the turbine to start up then the turbine is fine and you likely have a failed diode or some other grounded condition on the way to the Commander or fault in the Commander . . . or maybe still a short or ground on one of the phase wires at the base of the tower. Use this test anytime the turbine won't start when the wind is not too strong but it should be flying. Be prepared to touch all three wires together within a few seconds to stop the turbine from running FREE and over accelerating as described above. You may see a small spark but this is normal and not dangerous as long as you are not in a confined space with flooded lead-acid batteries nearby. In this case, DO NOT do this test until the batteries are well vented. A single spark could ignite dangerous fumes and cause a fire or explosion. Also, do not do this by hand with the high voltage LAKOTA. 12, 24 or 48 volts AC will not harm you but 100-300volts AC can. Wear non-conductive gloves.

13. Use 43lbs or 58 Nm to torque for tightening the "C-Clamp". Use a 1"x5" piece of heavy rubber, (an old inner tube will do) folded in half and placed under the clamp. Tighten securely with lock washers in place using a socket or open wrench but be careful not to over tighten and strip the aluminum base threads. The bolts are stainless and can strip the aluminum casting if you use too much pressure. To be really assured of a secure connection you can drill and tap a #6 x ½ inch metal screw through the aluminum collar into the riser. Don't forget the LOCTITE.

14. Before raising the turbine check the black hose connectors are tight at both ends. They should be strongly hand tight but not forced with a wrench or other tool. Also check the set screws on the back of the Pitch Axis attachment points (there are two) are seated and secured with some LOCTITE. If one appears to stick out farther than the other that may just be a set screw that is too long. If in doubt remove and replace with new Loctite. If it came from the factory that way it's likely fine and I wouldn't mess with it.

15. The Nylock hub nut and washer also ***may*** come with a steel lock washer that is not mentioned in the documentation. Use the plain washer and Nylock nut only. DO NOT USE the steel lock washer. Discard it. Using this lock washer may not allow the Nylock nut to be fully seated and you can encounter the recommended torque before the nylock nut is fully engaged. At least 2 or 3 threads should protrude from the Nylock hub nut to ensure the blade assembly is secure.

16. Any extra "bumpers" found in the spinner packing are for replacement during annual inspection if necessary. You will need to remove the springs to do so. Put the bumpers away in the plastic bag in dry place for later use. When removing springs remove the top hook first and don't use sharp pliers that can damage the spring.

17. When mounting the springs if they have been moved or replaced do not use a sharp pair of pliers or steel vice grips. These tools can score or dent the springs in a critical spot that can cause premature failure. Ensure the springs enter the spring posts from the back to front so that furling causes them to go further into the post not further out. Springs should have 33 wraps. Make sure they both have the same number. We have noted at least one case of miss-matched springs. Contact TRUE-NORTH Power Systems if you encounter this.

18. Don't forget to install a 3 phase AC lighting arrestor at the base of the tower where the tower wire connects to the underground cable. (Top right of photo) This will help protect your turbine, rectifier and

inverter from overload that can be caused by a nearby lighting strike. It's a small price to pay for protecting expensive inverters and charge control electronics. Not much can protect ANYTHING from a direct hit.

19. Some early turbines have been noted to have a very small clearance between the upper and lower tilt units and excess paint or coatings may cause some binding between them when the turbine tilts back. Check there is no binding by tilting the upper housing back into full furled position and see if there is any scoring of the paint on the base. This is best done while it is on the riser or a test stand before lifting. Have someone secure the base section from yawing and simple pull back on the blade assembly by grabbing onto the hub before the spinner is attached. Pull it back and forth a couple of times and check for scoring. Just removing excess paint may allow free movement. If you are scraping bare metal and there is still contact you should call TRUE-NORTH Power Systems for a consultation as to whether or not this may require a warranty replacement.

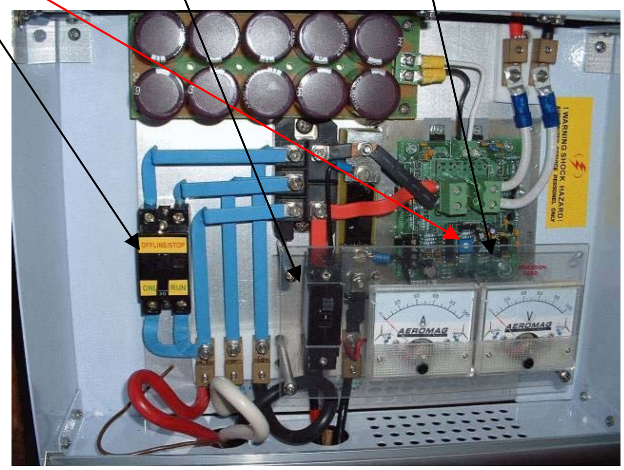
21. Always pre-fit the LAKOTA to the mast riser prior to installing the riser on the tower. It will save you the aggravation of trying to do it on top of the tower. The three "flutes" on base of the yaw shaft of the LAKOTA mounting base are designed to fit snuggly (but NOT tightly wedged) into a 2 inch pipe (2 1/8th inch ID) riser tube. If you can grab the turbine with both hands it should slide in AND out easily without binding. Forcing it will may damage the YAW axis, or make it very difficult to remove. NEVER use a hammer or heavy tool to force it on or off just tap the riser as you pull. File the flutes a little for a smooth fit. The "C" clamp is designed to hold it onto the tower not the part that slips inside. The base is aluminum casting and will crack or break if hammered.

22. Installing the COMMANDER. This is about as fool proof as you can get now. Mount it anywhere, out of the weather, where there is some clearance between the top mounted resistors for good cooling airflow. Three phase wires go to any input terminal. It does not matter which one. Get + - right (Red + Black -) to the battery and your done. If you have any other power generators connected to those batteries in parallel, (ie solar PV or gas generator for example) I'd insist on having a blocking diode (70HFR40) on the positive leg from the Commander (red wire) facing the battery. I mount it inside a standard grey switch box if it's not already mounted in the Commander. Without a blocking diode, a battery charger, solar PV system, gas generator or other source will be "seen" by the LDR and it will attempt to dissipate whatever it sees beyond the diversion voltage. Not only will this waste power but it could damage the LDR or the Commander or even the turbine. Turbines are fine if they are the only source of power. If they have to compete as a source then they are best isolated so they can push power TO the battery and not be influenced by other generating sources.

23. Setting the diversion voltage is easy with the commander. In almost any wind just isolate the batteries by turning off the Output Breaker. (NOT the BRAKE switch . . . the Circuit breaker). The green LED on the bottom right of the green LDR circuit board will glow, (or flicker in light wind). Note the Voltage on the volt meter. The ammeter will drop to zero because no current is flowing to the batteries. Use a small long shaft plane end screwdriver to turn the blue/white setting screw in the middle of the LDR until you reach the desired voltage. You can also use a digital volt meter across the rectifier output terminals to get an accurate 10th of a volt setting. The correct diversion voltage setting depends on the battery type and system configuration but generally about 0.2 to 0.4 v above full: Remember, this setting is for battery control. The turbine will fly fine at any LDR setting.

Typical LDR Diversion Voltage Settings

SYSTEM	FLOODED LEAD ACID	SEALED BATTERY
12v	14.8v	14.4v
24v	29.6v	28.8v
48v	59.2v	57.6v



24. Guy Wires. Always cut the longer guy wires first . . in case you make a mistake . . and add about 8 feet to the measurement to allow for turnbuckle "Lacing". That's where you weave the excess guy wire back and forth through the turnbuckle to prevent it from turning through vibration. Also make sure it goes through the lowest anchor attachment point at least once or twice so that you provide and extra level of security/safety in case a bolt, or attachment or clamp gives way.

25. Print the System Configuration Chart Below and keep it near the System Controller
This chart shows typical battery charging and inverter charge control settings. It show the relationships between battery state and battery voltages and helps you understand the relationship between all the various components of battery charging and how they affect one another. Note that each manufacturer of inverters, chargers and batteries may have different limits and preferred "optimum" settings but this is a start at least. Works for 12, 24 or 48v systems but the final choices you make will depend on how you want the system to behave and there is no SET SOLUTION for this that fits all systems. Standard settings are not optimum settings and optimum settings have benefits and implications you may not fully appreciate until you try them. . . *like setting the HBX mode so as to allow a deeper battery cycle will allow you to not waste PV or wind energy when the batteries are full but setting it too deep may leave you with not enough emergency backup and a shorter battery life.*

ADD YOUR OWN NOTES:

	INVERTER-SOLAR CHARGER SETTINGS								BATTERY REQMTS					DIVERSION SETTINGS			CHARGE RATES		
	Setting	Delay	System Voltage			Setting	Delay		24v Charging					Turbine	Setting	Solar PV	Outback Charger Limit AMPS		
INVERTER Setting	Voltage	Hours	12v	24v	48v	Volts	Hrs	CHARGER Setting	Lead	AGM	GEL			Diversion LOAD	Volts		110vAC Amps Set	DC AMPS @28.8v	Actual Watts IN to battery
			15.5	31	62			Equalize	31.0	No	No								
																	46	192	5,520
				30.5	61												44	183	5,280
																	42	175	5,040
			15	30	60												40	167	4,800
																	38	158	4,560
				29.5	59				29.6	29.6				Divert Exces	29.8		36	150	4,320
																	34	142	4,080
			14.5	29	58												32	133	3,840
						28.8	1.0	Bulk & Equalize	28.8	28.8							30	125	3,600
				28.5	57												28	117	3,360
																	26	108	3,120
			14	28	56												24	100	2,880
											28.2						22	92	2,640
				27.5	55						27.6						20	83	2,400
										27.6			Legend				19	79	2,280
			13.5	27	54					27.0				Equalize			18	75	2,160
						26.8	1.0	Float						Bulk-Absorption			17	71	2,040
				26.5	53									Float			16	67	1,920
									26.4		26.4			Refloat			15	63	1,800
HBX or AUX - DROP	26	2.0	13	26	52									Factory Setting			14	58	1,680
						25.6		Refloat					Battery				13	54	1,560
				25.5	51								State	12v	24v	48v	12	50	1,440
													100%	12.73	25.46	50.93	11	46	1,320
LBCI	25		12.5	25	50								90%	12.62	25.24	50.47	10	42	1,200
													80%	12.50	25.00	49.99	9	38	1,080
				24.5	49								70%	12.37	24.74	49.49	8	33	960
									Example		1000 AH		60%	12.24	24.48	48.96	7	29	840
HBX or AUX - USE	24	1.0	12	24	48				AGM or Absolyte				50%	12.10	24.20	48.41	6	25	720
								Rate of Charge	%AH	Amp	v/cell	24v	40%	11.96	23.92	47.83	5	21	600
				23.5	47			High	10%	100	2.40	28.8	30%	11.81	23.63	47.26	4	17	480
								Low	3%	30	2.35	28.2	20%	11.66	23.32	46.63	3	13	360
			11.5	23	46			Finish	1%	10	2.25	27.0	10%	11.51	23.02	46.03	2	8	240
																	1	4	120
LBCO	21																		