The LH1000

Low Head Propeller Turbine

Personal Hydropower

Owner's Manual

PLEASE READ CAREFULLY

Made in Canada
by

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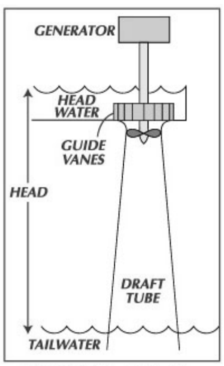
INTRODUCTION

This manual describes the **LH 1000**, which is manufactured by **Energy Systems & Design LTD**. The installer must have some knowledge of plumbing and electrical systems, as should the end-user of the system.

These machines are small, but can generate very high voltages. Even 12-volt machines can produce high voltages under certain conditions. Practice all due safety. Electricity cannot be seen and it can be lethal.

Electricity is produced from the potential energy in water moving from a high point to a lower one. This distance is called "head" and is measured in units of distance: meters (or feet) or in units of pressure: kilograms per square centimeter). "Flow" is measured in units of volume: gallons per minute – GPM (or liters per second - l/s), and is the second portion of the power equation: power [watts] = head x flow.



LH1000 Installation

The **LH1000** is designed to operate over a fixed range of heads and flows, from 0.6-3m (two to ten feet), employing a cast polyurethane propeller and guide vane assembly. The **LH1000** uses a permanent magnet type alternator. This design eliminates the need for brushes and the maintenance that accompanies them, while increasing efficiency. The **LH1000**'s output can be optimized by simply adjusting the rotor's clearance from the stator.

SITE EVALUATION

Certain information must be determined concerning your site, in order to use its potential for maximum output. Head and flow must first be determined. The other factors are plumbing specifications, transmission distance, and the system voltage. These factors determine how much power can be expected.

Power is generated at a constant rate by the **LH1000** and stored in batteries as direct current (DC). Power is supplied, as needed, by the batteries, which store energy during periods of low consumption for use in periods where consumption exceeds the generation rate. Appliances can be used that operate directly from batteries, or alternating current (AC) power (at regular domestic specifications) can be supplied through an inverter, converting DC to AC power.

Sites may vary, so carefully consider flow and head when choosing yours.

HEAD MEASUREMENT

Head may be measured using various techniques. A garden hose or length of pipe can be submerged with one end upstream and the other end downstream. Anchor the upstream end with rocks or have an assistant hold it; water should flow out the low end, especially if the pipeline is pre-filled. Once water is flowing, raise the downstream end until it stops. Do this slowly since the water tends to oscillate. When the flow has stabilized, measure the distance down to the level of water in the stream with a tape measure. This will give a very accurate measurement of that stream section. Mark the spot and then repeat the procedure until the entire distance is covered.

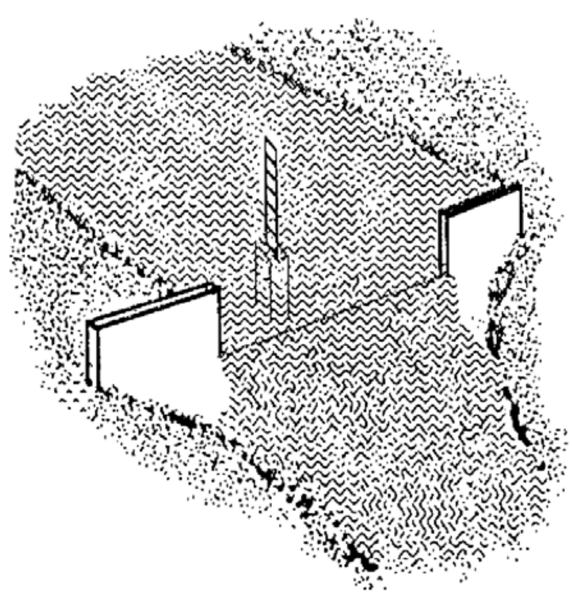
Another technique is to use a surveyor's transit. This method can also be approximated using a carpenter's level using a measuring stick or a "story pole." This technique is also done in a series of steps to arrive at the overall head. Note that with this reaction type machine, the entire head is used. No head is lost as with an impulse machine.

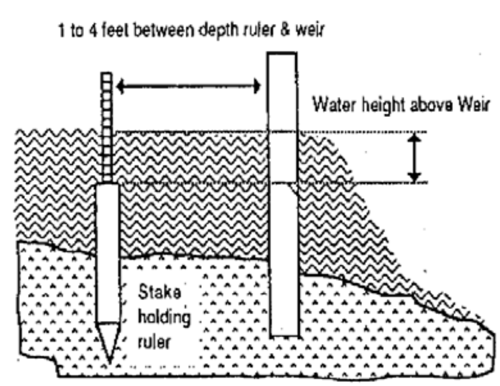
FLOW MEASUREMENT

The weir method can be used for the higher flows used with this machine. This technique uses a rectangular opening cut in a board or piece of sheet metal set into the brook like a dam. The water is channeled into the weir and the depth is measured from the top of a stake that is level with the edge of the weir and several feet upstream.

Measuring the flow at different times of the year helps you estimate maximum and minimum usable flows. If the water source is seasonally limited, you may have to depend on some other source of power during dry times (solar, wind). Keep in mind that a reasonable amount of water must be left in the stream (Don't take it all, that water supports life forms).

When head and flow are determined, the expected power output can be determined from the following chart. Keep in mind that chart values represent generated output and that actual power delivered to the batteries will be reduced by transmission lines, power converters, and other equipment required by the system. All systems should be carefully planned to maximize power output.





WEIR MEASUREMENT TABLE								
Table shows water flow in gallons/minute (gpm) that will flow over a weir one inch wide and from 1/8 to 10-7/8 inches deep.								
Inches		1/8”	¼”	3/8”	½”	5/8”	¾”	7/8”
0	0.0	0.1	0.4	0.7	1.0	1.4	1.9	2.4
1	3.0	3.5	4.1	4.8	5.5	6.1	6.9	7.6
2	8.5	9.2	10.1	10.9	11.8	12.7	13.6	14.6
3	15.5	16.5	17.5	18.6	19.5	20.6	21.7	22.8
4	23.9	25.1	26.2	27.4	28.5	29.7	31.0	32.2
5	33.4	34.7	36.0	37.3	38.5	39.9	41.2	42.6
6	43.9	45.3	46.8	48.2	49.5	51.0	52.4	53.9
7	55.4	56.8	58.3	59.9	61.4	63.0	64.6	66.0
8	67.7	69.3	70.8	72.5	74.1	75.8	77.4	79.1
9	80.8	82.4	84.2	85.9	87.6	89.3	91.0	92.8
10	94.5	96.3	98.1	99.9	101.7	103.6	105.4	107.3
Example of how to use weir table: Suppose depth of water above stake is 9 3/8 inches. Find 9 in the left-hand column and 3/8 in the top column. The value where they intersect is 85.9 gpm. That's only for a 1-inch weir, however. You multiply this value by the width of your weir in inches to obtain water flow.								

INTAKE, PIPELINE, AND TAILRACE

All hydro systems require a waterway. Even systems operating directly from a dam require at least a short plumbing run. It is important to use the correct type and size of plumbing to minimize restrictions in the flow. When possible, pipelines should be buried; this stabilizes the line and prevents animals from chewing it.

At the inlet of the plumbing, a filter should be installed. A screened box can be used with the pipe entering one side, or add a section of pipe drilled full of holes wrapped with screen or small holes and used without screen. A mesh size of about 20mm (3/4”) and smaller can be used as debris of this size and will pass through the machine. However, it is important to keep sticks out of the intake as they may become jammed in the machine. This may require a smaller mesh size.

A settling basin should be used with this machine. This is a pool of low velocity water that enables the grit to settle so that it will not enter the machine and wear the edge of the propeller and the guide vane housing.

See LH1000 installation illustration at back of manual

The turbine can be mounted in the waterway, through a 17-cm (7”) hole, with the draft tube extending to the tail waters below. Small tabs with screws are adequate to retain the machine. The draft tube is connected to the machine using rubber sleeves and hose clamps. These are standard plumbing items. PVC pipe of 150mm (6") diameter with a 4mm (0.160”) wall thickness is used between the guide vane assembly and the draft tube. Install the rubber sleeve at the lower end of the guide vane tube so as to create a smooth transition from one to the other. It is recommended to have the LH1000 in a small enclosure or under some cover to keep it dry and provide a place for auxiliary equipment. Mounting the machine in concrete is also possible (you may wish to try a temporary wood mounting first).

PIPE FRICTION LOSS - PVC Class 160 PSI Plastic Pipe

Pressure Loss from Friction in Feet of Head per 100 Feet of Pipe

Flow US GPM	**Pipe Diameter, Inches**										
	1	**1.25**	**1.5**	**2**	**2.5**	**3**	**4**	**5**	**6**	**8**	**10**
1	0.05	0.02									
2	0.14	0.05	0.02								
3	0.32	0.09	0.04								
4	0.53	0.16	0.09	0.02							
5	0.80	0.25	0.12	0.04							
6	1.13	0.35	0.18	0.07	0.02						
7	1.52	0.46	0.23	0.08	0.02						
8	1.93	0.58	0.30	0.10	0.04						
9	2.42	0.71	0.37	0.12	0.05						
10	2.92	0.87	0.46	0.16	0.07	0.02					
11	3.50	1.04	0.53	0.18	0.07	0.02					
12	4.09	1.22	0.64	0.20	0.09	0.02					
14	5.45	1.63	0.85	0.28	0.12	0.04					
16	7.00	2.09	1.08	0.37	0.14	0.04					
18	8.69	2.60	1.33	0.46	0.18	0.07					
20	10.6	3.15	1.63	0.55	0.21	0.09	0.02				
22	12.6	3.77	1.96	0.67	0.25	0.09	0.02				
24	14.8	4.42	2.32	0.78	0.30	0.12	0.04				
26	17.2	5.13	2.65	0.90	0.35	0.14	0.05				
28	19.7	5.89	3.04	1.04	0.41	0.16	0.05				
30	22.4	6.70	3.45	1.17	0.43	0.18	0.05				
35		8.90	4.64	1.56	0.62	0.23	0.07				
40		11.4	5.89	1.98	0.78	0.30	0.09	0.02			
45		14.2	7.34	2.48	0.97	0.37	0.12	0.04			
50		17.2	8.92	3.01	1.20	0.46	0.14	0.04			
55		20.5	10.6	3.59	1.43	0.55	0.16	0.05			
60		24.1	12.5	4.21	1.66	0.64	0.18	0.07	0.02		
70			16.6	5.61	2.21	0.85	0.25	0.09	0.03		
80			21.3	7.18	2.83	1.08	0.32	0.12	0.04		
90				8.92	3.52	1.36	0.39	0.14	0.07		
100				10.9	4.28	1.66	0.48	0.18	0.07	0.02	
150				23.2	9.06	3.50	1.04	0.37	0.16	0.05	
200					15.5	5.96	1.75	0.62	0.28	0.07	0.02
250					23.4	9.05	2.65	0.94	0.42	0.12	0.05
300						12.6	3.73	1.34	0.58	0.16	0.05
350						16.8	4.95	1.78	0.76	0.21	0.07
400						21.5	6.33	2.25	0.97	0.28	0.10
450							7.87	2.81	1.20	0.32	0.12
500							9.55	3.41	1.45	0.42	0.14
550							11.4	4.07	1.75	0.48	0.16
600							13.4	4.78	2.05	0.58	0.18
650							15.5	5.54	2.37	0.67	0.23
700							17.8	6.37	2.71	0.76	0.25
750							20.3	7.22	3.10	0.86	0.30
800								8.14	3.50	0.97	0.32
850								9.11	3.89	1.08	0.37
900								10.1	4.32	1.20	0.42
950								10.8	4.79	1.34	0.46
1000								12.3	5.27	1.45	0.51

BATTERIES, INVERTERS & CONTROLLERS

System Voltage

A small system with a short transmission distance is usually designed to operate at 12 volts. Larger systems can also be 12 volts, but if higher power is desired or the transmission distance is long, then a system of 24 volts or higher may be preferable. This is especially true if all loads are inverter-powered. In a 12-volt system, operating at a low power level, it may be advantageous to operate all loads directly from batteries. Many 12-volt appliances and small inverters are available. In 24-volt systems, it may also be preferable to operate the loads directly (although not as many appliances are available).

In higher power systems, it is usually better to use an inverter to convert battery voltage to regular domestic AC power. This has been made feasible with the advent of reliable high power inverters. Thousands of home power systems are in operation with only AC loads.

Sizing Battery Capacity

A typical hydro system should have about two days of battery storage capacity. This will generally keep lead-acid cells operating in the upper end of their charge range where they are the most efficient and long-lived. Alkaline batteries like the nickel-iron and the nickel-cadmium types can have a lower capacity since they can be more fully discharged without harm.

Batteries should be located outside of living space, or adequate ventilation should be provided, as a rising charge level tends to produce both hydrogen gas and corrosive fumes. Also, distilled water should be added as needed to maintain the electrolyte level.

Charge Control

A hydro system requires that a load be present so that the power has somewhere to go. Otherwise, system voltage can rise to very high levels. This situation provides an opportunity to do something with the excess power (i.e., a diversion load used for water heating).

As the batteries become fully charged, their voltage rises. At some point, the charging process should stop and the power be diverted to the dump load. The voltage set point should be about 13.5 to 14.5vdc for a 12-volt system depending on the charge rate. The higher the charge rate, the higher the voltage can go. If batteries are often in a high state of charge, the voltage limit should be on the low end of the range.

A voltmeter or a watt-hour meter can be used to monitor battery charge level. Battery voltage is roughly a function of the charge level, and varies according to the load level and charge rate. There are many commercially available monitors that conveniently display these features to the user, including the state of charge.

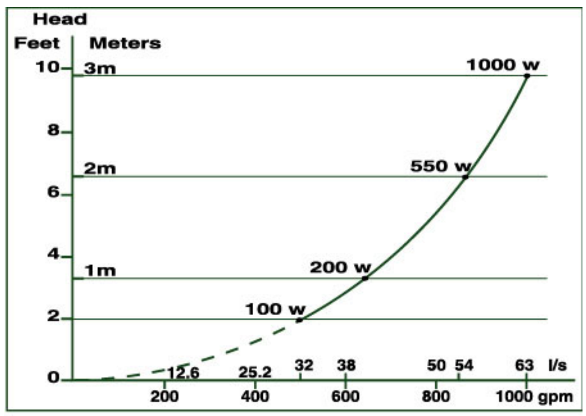
WIRING AND LOAD CENTER

Every system requires some wiring to connect the various components. Load centers are available as a complete package that easily facilitates the connection of loads and power source(s). All circuits in the system should use wire of adequate size and have fuses or breakers of sufficient capacity to carry the expected load current. Even the LH1000 must be fused since it can suffer from a short or similar fault just like anything else in the system.

Inside the "junction box", are two terminal lugs for the battery cable leads. The negative terminal lug is bolted to the box and the positive terminal lug is bolted to the clear plastic terminal block. Transmission wire ends are inserted into these two connectors (after being stripped of insulation) and then tightened.

The precision shunt installed in the junction box will give a readout of the hydro output in amperes if the digital multimeter is plugged into the jacks (color coded in the shunt body), and turned to 200m (the 9 o'clock position). A voltmeter connected to the batteries will roughly indicate the charge level, as described in "Charge Level" above, and an ammeter will indicate the output of the machine.

LH POWER OUTPUT



LH1000 Output (Watts Continuous)

DESIGN EXAMPLE

This example shows how to proceed with a complete installation. The parameters of the example site are:

-6 feet (2m) of head over a distance of 50 feet (15m)
-a flow of at least1000 GPM (63l/s)
-100 feet distance from the house to the hydro machine
-12 volt system

The first thing to do is determine the pipe size. Given that there is friction between water and the pipe in which it flows, this friction can be reduced by increasing the size of the pipe to minimize the friction to acceptable limits. Therefore, pipe size must be optimized based on economics and performance.

The pipe flow charts show us that eight-inch (approx. 20cm) diameter PVC pipe has a head loss of 0.97 feet of head per 100 feet (30m) of pipe at a flow rate of 800 GPM (50 l/s). This is about 0.5 feet (15cm) of loss for 50 feet (15m) of pipe.
PVC comes in short lengths and is glued together or purchased with gaskets.

The maximum output occurs with a flow of about 800 GPM (50 l/s). Note that with this machine, the flow is determined by the head, as there are no nozzles that can be adjusted that would change the flow.

1 foot loss/100 feet pipe = x feet loss/50 feet pipe
x = 0.5 feet (15cm) of head loss

Next, we subtract the head losses from the measured head (often referred to as static, or gross head. Abbreviated: Hg) in order to determine the actual, operating head (often referred to as dynamic, or net head. Abbreviated Hn):

6 feet head (Hg)-0.5 feet head losses = 5.5 feet (1.85m) actual head (Hn)

It is now known that the **LH 1000** will be operating at an actual, or dynamic, head of 5.5 feet (1.85m) Hn. By referring back to the output chart, it can be determined that the LH1000 can, realistically, be expected to produce approximately 400w.

COPPER WIRE RESISTANCE

Wire Gauge	Diameter Inches	Ohms per 1000'	Ohms per Mile
0000	0.460	0.05	0.26
000	0.410	0.06	0.33
00	0.364	0.08	0.42
0	0.324	0.10	0.52
2	0.258	0.16	0.84
4	0.204	0.25	1.34
6	0.162	0.40	2.13
8	0.128	0.64	3.38
10	0.102	1.02	5.38
12	0.081	1.62	8.56
14	0.064	2.58	13.6
16	0.051	4.10	21.6
18	0.040	6.52	34.4

Since we require 12 volts and the transmission distance is short, we can generate and transmit 12 volts using the **LH1000**. This **LH1000** could also be used for higher voltages like 24 and 48, and power could be transmitted longer distances. We need to go 100'(30m) with 400 watts at our site. The amperage can be determined using the formula: volts x amperage = watts. So, a 12v system usually operates at an actual voltage of about 15v, therefore: 400/15 = 26.7 amps. The machine will need to be wired parallel delta for this site.

This will be about 26.7 amps at 15 volts at the generator. Note that there will be some voltage drop in the line and 12-volt batteries require somewhat higher voltages than nominal to become charged. So the 26.7 amps must pass through 200'(60m) of wire for the distance to the batteries and back which completes the circuit. As there is friction between water and the pipe that carries it, causing losses, so there is resistance between electricity and the conductor that carries it, and is measured in units called ohms. Resistance losses should be kept as low as economics permit, just like the pipeline losses. Let’s assume that a 5% loss is acceptable at this site, resulting in the loss of 25 watts.

The formula to calculate resistance losses is I (amps) x I (amps) x R (resistance) = w (watts). We put our known figures into the formula to learn the resistance that we require in a copper conductor to achieve this.

$$26.7 \times 26.7 \times R = 25w$$
$$711 \times R = 25w$$
$$R = 0.04 \text{ ohms}$$

It has been calculated that a copper conductor with losses of 0.04 ohms over a total distance of 200 feet (60m) will result in an acceptable 5% loss. The Wire Loss Chart shows losses per 1000' (300m) of wire, so:

1000'/200' x 0.04 ohms = 0.2 ohms per 1000'.

The chart shows 2 ga. wire has a resistance of 0.16 ohms per 1000', so:

200'/1000' x 0.16 ohms = 0.032 ohms.

This is close enough to the desired level, that with a little more investigation we can determine whether this will result in acceptable power losses:

26.7 amps x 26.7 amps x 0.032 ohms = 22.8watts of loss.

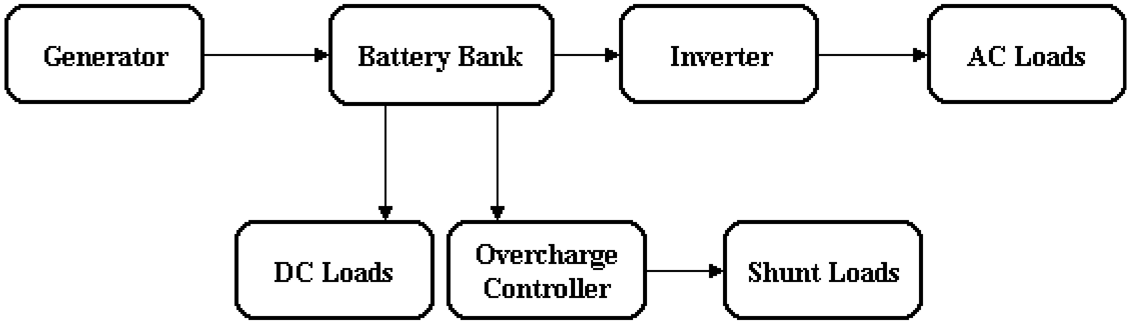
Increasing the wire size can further reduce the losses, but can also increase costs, as larger wire is usually more expensive. Resistance in a length of wire results in power loss that is seen as a voltage drop from one point in the line to another. For example, if your voltage, as measured at the generator, is 15vdc, then it could be assumed that if the voltage were measured along the line to the batteries, it would be lower as you got further from the generator: Voltage drop= I (amps) x R (ohms resistance in your circuit). So:

Voltage drop (v) = 26.7 amps x 0.032 ohms = 0.85 volts

Hence, if your generator voltage is 15vdc, your battery voltage will be 14.15vdc. Keep in mind that it is always the batteries that determine the system voltage, as they are the stabilizing force in your system. All voltages in the system will rise and fall corresponding to the battery voltage, or the battery's state of charge. At the site, we would be generating 26.7 amps continuously. Typically, a battery bank is sized to have two days storage capacity. If we choose lead acid batteries and wish to have two days of storage capacity, then we use the formula: amps x hours x days = amp/hrs capacity. So:

33 amps x 24 hrs x 2 days = 1584 amp. Hrs. Capacity

The Trojan L-16 has a rating of 6vdc and 350 amp/hr. Using these you would require at least eight batteries; there would be four strings paralleled, with each string consisting of two batteries in series to give the 12vdc system voltage we have chosen. This would give 1400 amp/hrs at 12vdc capacity, which is about two days storage. An inverter and charge controller are usually used in the system. The diagram for such a system would look like this:



OUTPUT ADJUSTMENT

For the machine to produce the highest output, the rotor height should be adjusted, so as to match the magnetic power of the rotor to the power of the waterway at the site. Since each site varies from the next, it is important to adjust the rotor for maximum output at your site. This involves raising and lowering the rotor to change or adjust the magnetic flux level until the optimum level is found.

After the machine is installed, perform a trial operation to establish a power output level. This can be determined using a digital multimeter, plugged into the output jacks in the precision shunt found in the junction box. It is recommended to keep a logbook to note any output changes in relation to settings, and to monitor long-term performance. After everything is installed, start the **LH1000** by opening the water source. Operate it long enough for the output level to stabilize and note the current (or voltage). Then shut off the water.

The **LH1000** comes with the rotor (the chrome plate) set very close to the stator (the stationary, black body of the generator). To increase this distance, and reduce the magnetic flux level, you first must, while holding the rotor stationary with the 1/4-inch rotor pin placed in the hole in the rotor's edge, loosen the smaller (7/16" head) bolt. Next, hold the rotor stationary with the pin, and tighten the larger bolt, which will force the rotor up. Each full turn of the bolt will move the rotor vertically 0.050" or 1.25 mm. If raising the rotor causes the current (or you may be monitoring the voltage in a high voltage site) to increase, then continue to do so until there is no longer an increase. If a point is reached where a decrease occurs, then the rotor should be lowered. This is done by loosening the larger bolt and then tightening the smaller one. Turning the smaller bolt causes the rotor to move vertically the same distance per turn as the larger bolt does. When you have found the best position (no increase in current or voltage), make sure the larger bolt is turned until it is tight. Now the smaller bolt should be tightened securely to lock everything in place. No further adjustments should be required unless site conditions change.

When adjusting the rotor downward, it may contact the stator. If this occurs, always adjust it upwards by at least a 1/4 turn of the larger bolt. Operating the machine with the rotor any closer than this will not result in any power increase but may damage the machine.
** Always turn the rotor by hand before starting the machine to check for rubbing and make sure you can always fit a business card in the space between the rotor and stator**. Remove the pin from the rotor edge before starting the machine.

DISASSEMBLY & SERVICE

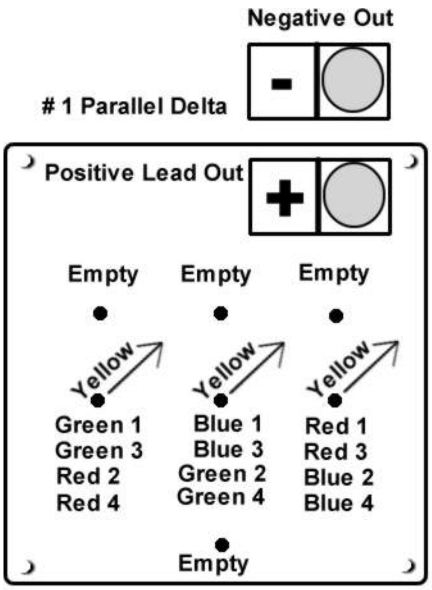
In order to remove the generator you must first remove the wiring from the terminals on the clear, plastic terminal block in the junction box. Be sure to note their position for later re-installation. An alternative is to remove the junction box from the alternator base by removing the two bolts on the bracket. Then, undo the four allen head bolts that attach the generator to the finned, aluminum base, using the allen wrench supplied with the LH1000. The four bolts are located under the generator base, and thread upward into the generator. Next, unscrew the polyurethane nose cone from the base of the unit, located inside the guide vane assembly, at the end of the shaft in a counter-clockwise or right hand direction. Proceed to remove the propeller by removing the ¾ inch (19mm) brass nut, then the washer, and finally, slide the propeller from the shaft. Now, the generator and shaft assembly may be pulled up, and out of the generator base and shaft housing. The shaft may now be unscrewed so as to remove the long turbine shaft from the generator shaft.

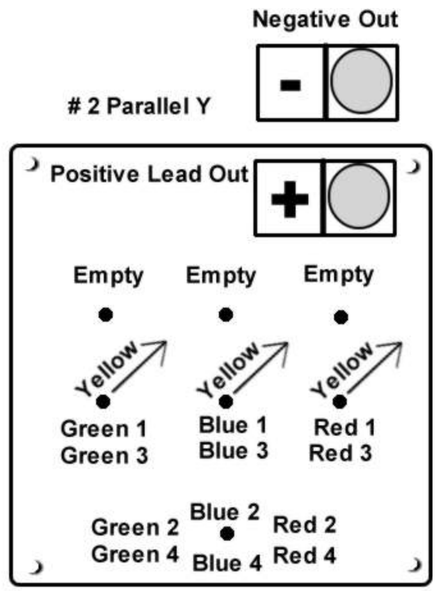
The finned alternator base can be removed from the shaft housing by unscrewing it. The shaft housing can also be unscrewed from the guide vane base. The aluminum guide vane base is attached to the polyurethane guide vane assembly with four 1/4 –20 allen head bolts that may be removed using the provided wrench and a 7/16 (11mm) wrench.

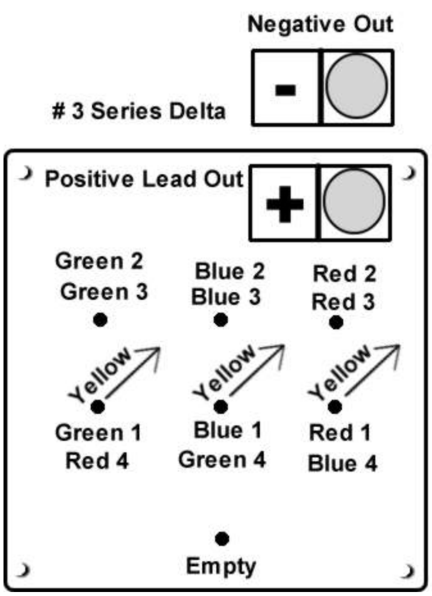
Replace bearings as soon as you notice any looseness and check the air gap thickness for any change. If they are too loose, severe damage to both the rotor and the stator can result. This machine uses three 6203 ball bearings with rubber seals, in the generator, and has a water lubricated bearing located in the guide vane base. These are a slip fit into the alternator housing and the guide vane base. .

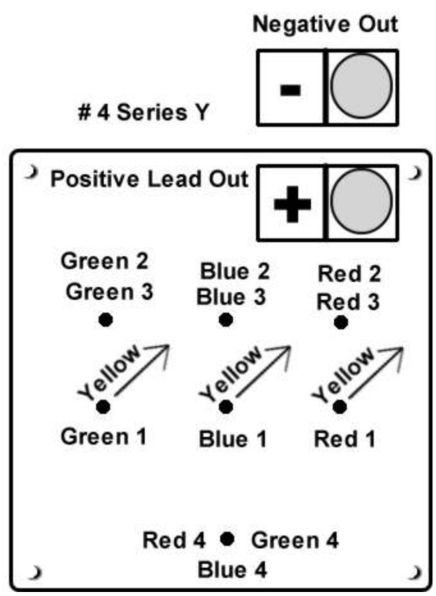
WIRING DIAGRAMS

These diagrams represent the four possible combinations of output wiring. They are in order of potential. If you find your air gap adjustment to be at a minimum and wish to try for more power, then try using the next higher combination. If you find the air gap is very large, try the next lower one. Note that there is only a small change in potential between #2 to #3.









CURRENT MEASUREMENT TECHNIQUE

A built-in shunt (precision resistance) is installed in the junction box, which allows the current to be measured digitally. This is done with the supplied DMM (digital multi meter). To measure the current produced by the generator, set the DMM scale to "DC milli-volts" or "200 m" at the nine o'clock position. Plug the leads into their corresponding color-coded jacks on the shunt in the junction box. This will give current readings from 0.1 amps to 199.9 amps. Of course, the DMM can be used for other tasks with your renewable energy system.