44 - HYDROELECTRIC INFORMATION

HOW MUCH POWER CAN YOU GENERATE?

The amount of power available depends on the dynamic head, the amount of water flow and the efficiency of the turbine generator combination. To get an idea about available power in watts, ***multiply the head in feet, times flow in GPM, times 0.18 times turbine efficiency.*** *Turbine efficiency ranges from 25% to 50%, with higher efficiency at higher heads. To get a rough idea, use 0.30 (representing 30%) as a multiplier for efficiency. The Harris Pelton turbines are well suited to higher head and lower flow situations. Flow is limited by nozzle size (a maximum 1/2"). With the Harris, adjustment to variable flows is as easy as switching a valve and dialing in the alternator. Harris turbines are now available with permanent magnet (PM) alternators. This option provides up to 50% efficiency. Higher flows are accommodated by the ESD Turgo Turbines. They can have nozzles of up to 1" diameter, and provide better efficiency at low heads. The HI-Power Hydros are ideal for sites where water is available at long distances from power needs. They generate 100+ volts AC that is stepped down and rectified at the batteries. This allows the use of relatively small wire for a distance of up to 10,000 feet. They can also deliver up to 3600 watts where higher power is needed.*

Pipelines

A hydroelectric turbine operates from the pressure at the bottom end of a pipeline. This pressure, usually measured in pounds per square inch (PSI), is directly related to the head, or vertical distance from where the water goes into the pipe at the top of the pipeline, to the turbine located at the bottom of the pipeline. The pressure at the lowest point of a pipeline is equal to 0.433 times the head, (the vertical distance in feet). Pressure is important because it is a determining factor in how much power is available and what type of pipe is required. Polyethylene pipe can be used for pressures up to 100 PSI, PVC pipe is available with pressure ratings from 160 to 350 PSI and steel pipe can withstand 1000 PSI or more. Check with your local plumbing supplier for pipe ratings. Pipe diameter is very important. All pipelines will cause the water flowing in them to lose some energy to friction. The pipe must be large enough for the maximum quantity of water it will carry. The pressure at the bottom of a pipeline when water is not flowing is called **static pressure**. When water is flowing through the outlet or nozzle of the hydroelectric turbine, the pressure at the outlet is the **dynamic pressure** or running head. If you install a gate valve on the pipeline just above the turbine and a pressure gauge on a "T" fitting just above the gate valve, you will read the static pressure on the gauge when the valve is closed and the dynamic pressure when the valve is opened. The maximum power that can be delivered by a pipeline will occur when the dynamic pressure is approximately 2/3 of the static pressure. The actual flow rate of the water in a hydroelectric system is determined by the diameter of the nozzle. We will supply a turbine with the proper size nozzle for your site, depending on the head, flow, length and diameter of the pipe. We carry hydroelectric generators made by Energy Systems and Design, HI-Power Hydroelectric, and Harris Hydroelectric. Use the descriptions on the following pages to help determine which turbine will work best for your site and power requirements.

Let us help you design the system

If you think you have a suitable site, contact us and we will help you choose the best unit for your situation. Please provide us with the following information about your site when calling:

1. Head – The total vertical elevation from the place where the water enters the pipe to the point where the turbine will be located.

2. Flow – The number of gallons per minute that are available.

3. Distance – The length of pipe that will be necessary to carry the water from the pickup to the turbine. If the pipe is already installed what is the type and diameter?

4. Location – Distance from turbine to batteries.

Nozzle Selection

Power output of a hydroelectric generator is determined by the pressure of the water at the nozzle and the amount of water flowing out of the nozzle. The larger the nozzle, the greater the flow will be. The nozzle must also be sized small enough to keep your pipeline full and keep the speed of the water in the pipe below five feet per second. The **nozzle selection chart** on the next page shows water flow through various size nozzles at given pressures. Use this chart to determine what size nozzle and how many nozzles you need to accommodate the flow of water you have and to deliver the amount of power you need. A pressure gauge in the pipe feeding your turbine, installed before the shutoff valve, can help you check proper operation and diagnose problems. When the valve is shut off, the gauge will read the static pressure in pounds per square inch PSI (head in feet x .433). When the valve is turned on the gauge will read a lower (dynamic) pressure.

The difference between these two pressures represents your loss to friction in the pipe. The greater the flow, the greater your loss will be. (See pipe loss chart on the next page for PVC pipe.)

Water Flow Information for Pumping and Hydroelectric Design

Flow Through Nozzles

The chart below shows flow through various nozzles in GPM at a range of heads from 5 feet to 400 feet. Use chart to choose what nozzle size to use and how many nozzles a turbine must have to give the required flow to use all of the water available in the system.

Head		Nozzle Diameter											RPM for
Feet	PSI	1/8"	3/16"	1/4"	5/16"	3/8"	7/16"	1/2"	5/8"	3/4"	7/8"	1.0"	4" Turbine
5	2.2	-	-	-	-	6.18	8.4	11	17.1	24.7	33.6	43.9	460
10	4.3	-	-	3.88	6.05	8.75	11.6	15.6	24.2	35	47.6	62.1	650
15	6.5	-	2.68	4.76	7.4	10.7	14.6	19	29.7	42.8	58.2	76	800
20	8.7	1.37	3.09	5.49	8.56	12.4	16.8	22	34.3	49.4	67.3	87.8	925
30	13	1.68	3.78	6.72	10.5	15.1	20.6	26.9	42	60.5	82.4	107	1140
40	17.3	1.94	4.37	7.76	12.1	17.5	23.8	31.1	48.5	69.9	95.1	124	1310
50	21.7	2.17	4.88	8.68	13.6	19.5	26.6	34.7	54.3	78.1	106	139	1470
60	26	2.38	5.35	9.51	14.8	21.4	29.1	38	59.4	85.6	117	152	1600
80	34.6	2.75	6.18	11	17.1	24.7	33.6	43.9	68.6	98.8	135	176	1850
100	43.3	3.07	6.91	12.3	19.2	27.6	36.6	49.1	76.7	111	150	196	2070
120	52	3.36	7.56	13.4	21	30.3	41.2	53.8	84.1	121	165	215	2270
150	65	3.76	8.95	15	23.5	33.8	46	60.1	93.9	135	184	241	2540
200	86.6	4.34	9.77	17.4	27.1	39.1	53.2	69.4	109	156	213	278	2930
250	108	4.86	10.9	19.9	30.3	43.6	59.4	77.6	121	175	238	311	3270
300	130	5.32	12	21.3	33.2	47.8	65.1	85.1	133	191	261	340	3590
400	173	6.14	13.8	24.5	38.3	55.2	75.2	98.2	154	221	301	393	4140

Pipe Loss Chart

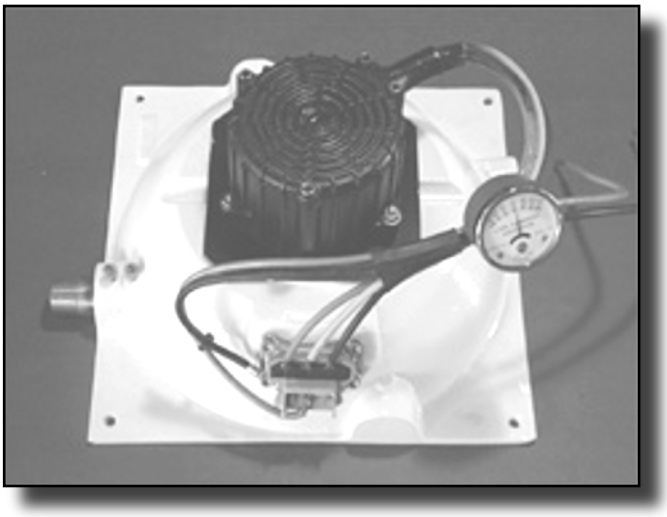
Use the chart below to determine what pipe size is required to efficiently allow necessary flow for your power need. Once you know the required flow for your system (gpm), find the head loss for various pipe sizes. Multiply the head loss number by the length of the pipe divided by 100 and you will get the loss of head for that pipe size. The actual head minus the head loss will give you the effective head in the system.

Pipe Friction Loss Chart - Head loss in feet per 100 feet of Schedule 40 PVC pipe																								
		Flow (GPM)																						
		1	2	3	4	5	7	10	15	20	25	30	40	50	60	70	80	100	150	200	250	300	400	500
PIPE DIAMETER (Inches)	1/2	2.08	4.16	8.7	14.8	23.5	43																	
	3/4	0.51	1.02	2.2	3.7	5.73	10.5	20.1	42.5															
	1	0.1	0.55	0.68	1.15	1.72	3.17	6.02	12.8	21.8	32.9	46.1												
	1-1/4	0.03	0.14	0.19	0.31	0.44	0.81	1.55	3.28	5.59	8.45	11.9	20.2	30.5	45.6									
	1-1/2		0.07	0.08	0.13	0.22	0.38	0.72	1.53	2.61	3.95	5.53	9.43	14.3	20	28.6	36.7							
	2			0.03	0.05	0.07	0.11	0.21	0.45	0.76	1.15	1.62	2.75	4.16	5.84	7.76	9.94	15.1	34.8	59.3				
	2-1/2				0.03	0.04	0.05	0.09	0.19	0.32	0.49	0.68	1.16	1.75	2.46	3.27	4.19	6.33	13.4	25.0	37.8	46.1		
	3						0.02	0.03	0.07	0.11	0.17	0.23	0.4	0.6	0.85	1.13	1.44	2.18	4.63	7.88	11.9	18.4	40.1	
	4										0.04	0.06	0.11	0.16	0.22	0.3	0.38	0.58	1.22	2.08	3.15	4.41	7.52	
	5											0.03	0.04	0.05	0.07	0.1	0.13	0.19	0.4	0.69	1.05	1.46	2.49	3.76
	6													0.02	0.03	0.04	0.05	0.08	0.16	0.28	0.43	0.6	1.01	1.53

46 - HI-POWER HYDROELECTRIC TURBINES

NEW! HI-Power LV Hydroelectric Generators

- Head Range: 40 to 400 feet
- Flow Range:5 to 400 gpm
- Maximum Power: 1200 Watts
- Efficiency: 30% to 70%
- Battery Voltage: 12V, 24V, 48V, 96V



Hi Power is now offering a low voltage brushless PM generator. This user-friendly unit requires no adjustments and is more efficient than car alternator types over a wider range of head and flow.

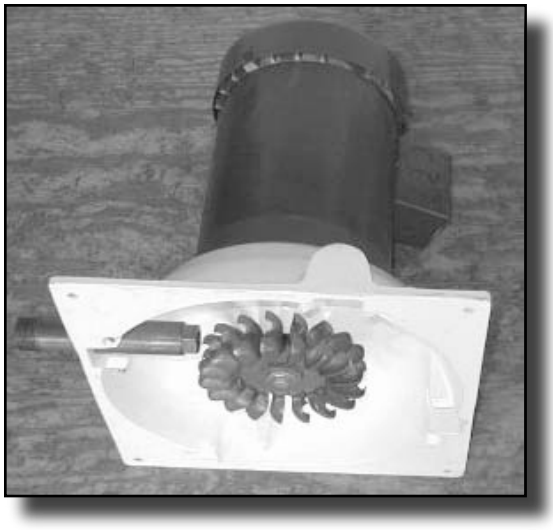
Available in 4 voltages: 12, 24, 48 and 96V, for direct battery charging or for use with power point trackers (like MX) or power supplies.

The sealed permanent magnet alternator is mounted on a Harris housing with the bronze Harris pelton wheel. The external rectifier is water-cooled and all fasteners are stainless steel. It comes with induction meter and 3 feet of 1'' flexible hose per nozzle. Order multiple nozzles for convenient adjustment to varying flows. Alternator has 2 sealed 6203 bearings which should be changed every 5-10 years, depending on use. When ordering, specify battery voltage, transmission line length and size, flow, pressure, pipe size and length.

Description	Item Code	Price
LV Hydro with 1 Nozzle	17.2005	$1,350
LV Hydro with 2 Nozzles	17.2007	$1,400
LV Hydro with 3 Nozzles	17.2009	$1,450
LV Hydro with 4 Nozzles	17.2011	$1,500
Car Alternator Upgrade Kit	17.2019	$500

HI-Power Hydroelectric Generators

- Head Range: 60 to 500 feet
- Flow Range:10 to 400 gpm
- Maximum Power: 3600 Watts
- Efficiency: 30% to 60%
- Transmission Voltage: 110V to 440V
- Battery Voltage: 12V, 24V, 48V



HI-Power Hydroelectric generators are ideal for sites where water is far from power needs (up to 10,000 feet), or when greater power is required. High transmission voltage can be sent over a mile before being 'stepped down' to battery voltage. It comes complete with step down transformer, rectifier, fuses and amp meter. Use a diversion type regulator with these units.

These hydroelectric generators use brushless alternators for reliability and versatility. They produce 110V, 220V, or 440V "wild" (unregulated) AC, which is then stepped down with the supplied transformer and rectifier. The heavy-duty brushless alternator is housed on the Harris housing and uses the Harris Bronze Pelton Wheel for flows up to 200 gpm and the ESD Turgo Wheel and housing for flows 200 to 400 gpm. Available in 4 sizes ranging from 600 to 3600 watts. The HV600 is available with 2 or 4 nozzles. The larger units come with 4 nozzles.

2 year warranty. Specify battey voltage when ordering

Description	Item Code	Price
HV 600 - 600 Watt 2 Nozzle	17.2025	$2,500
HV 600 - 600 Watt 4 Nozzle	17.2028	$2,600
HV 1200 - 1200 Watt 4 Nozzle	17.2030	$3,000
HV 1800 - 1800 Watt 4 Nozzle	17.2031	$3,500
HV 3600 - 3600 Watt 4 Nozzle	17.2034	$5,000
HI-Power Turgo Option	17.2037	$600

Harris Pelton Turbines

- Head Range: 20 to 600 feet
- Flow Range: 4 to 250 GPM
- Maximum 12-Volt Power: 700 watts
- Maximum 24-Volt Power: 1400 watts
- Maximum 48-Volt Power: 2500 watts

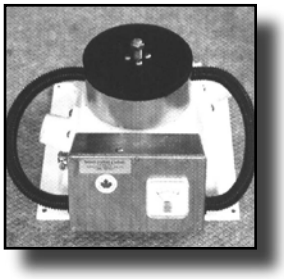
This hydroelectric battery charger uses a cast bronze pelton wheel and a heavy duty automobile alternator or a brushless permanent magnet alternator in a white powder-coated aluminum housing. They are available with one, two or four nozzles, depending on water flow and power requirements. (PVC manifold with one shut-off valve on two-nozzle machines and 3 shut-off valves on 4-nozzle machines is available) These turbines can be fitted with nozzles up to 1/2" in diameter. Each hydroelectric system is custom-built to match your site specifications. Please tell us your head, flow, pipe size and length, electrical transmission line length and battery voltage when ordering. Allow two to three weeks for delivery. The permanent magnet brushless alternator (PM) pictured above is 15-30% more efficient than the automotive alternator (HD), produces less heat and lasts longer. 1-year warranty.

Description	Item Code	Price
Harris HD 1 Nozzle 12/24V	17.1015	$1,040
Harris HD 2 Nozzle 12/24V	17.1018	$1,150
Harris HD 2 Nozzle 12/24V w /Manifold	17.1021	$1,225
Harris HD 4 Nozzle 12/24V	17.1024	$1,296
Harris HD 4 Nozzle 12/24V w/ Manifold	17.1027	$1,376
Harris PM 1 Nozzle 12/24V	17.1030	$2,080
Harris PM 2 Nozzle 12/24V	17.1032	$2,182
Harris PM 4 Nozzle 12/24V	17.1034	$2,336
Add for 48 volt operation for above	17.1036	$200

ES&D's microhydro systems employ high efficiency, precision-cast parts, and non-corrosive alloys for long life and durability. A digital multimeter accompanies each turbine for measuring output amperage. These units can be used in stand-alone, or grid-tied systems.

ES&D Stream Engine Turbines

- Head Range: 5 to 200 feet
- Flow range: 10 to 400 GPM
- Maximum Power: 1000 Watts
- Voltage from 12 to 48 VDC



ES&D hydroelectric battery chargers use a cast bronze turgo runner to drive a long-life, brushless permanent magnet alternator. A simple change of wiring in the junction box allows this turbine to charge 12, 24, or 48-volt battery systems. These turbines come with cut-to-size nozzles that can be user-set for up to 1", allowing a very large flow in low head situations. They can operate on heads as low as five feet with a flow of 40 GPM.

Description	Item Code	Price
ES&D 2 Nozzle Stream Engine	17.3241	$1,895
ES&D 4 Nozzle Stream Engine	17.3244	$2,045

ES & D Water Baby

- Head Range: 50 to 500 feet
- Flow range: 3 to 30 GPM
- Maximum Power: 350 Watts
- Voltage from 12 to 48 VDC

This new tiny turbine, a miniature version of the Stream Engine above, is ideal for sites with good head, but with very little flow. Two models are available; one for 12 to 48 volt charging and one for high voltage transmission. At 3 GPM and 100 feet of head, the Waterbaby will charge at 25 watts.

Description	Item Code	Price
ES&D 1 Nozzle Water Baby - 12 - 48V	17.3245	$1,395
ES&D 2 Nozzle Water Baby - 12 - 48V	17.3247	$1,515
ES&D 4 Nozzle Water Baby - 12 - 48V	17.3249	$1,755
ES&D 1 Nozzle Water Baby - High Voltage	17.3252	$1,495
ES&D 2 Nozzle Water Baby - High Voltage	17.3254	$1,615
ES&D 4 Nozzle Water Baby - High Voltage	17.3256	$1,855