

## How much power can you generate with a hydroelectric turbine?

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 gallons per minute, times 0.18, times turbine efficiency. Turbine efficiency ranges from 35% to 70%, with higher efficiency at higher heads. To get a rough idea, use 0.40 (representing 40%) 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"). Harris turbines are now available with permanent magnet (PM) alternators providing 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. Transmitting the power from the generator to the battery at twice the battery voltage allows you to use 1/4 of the wire size for the same power loss. At 4 times the battery voltage, you can use 1/16 of the wire size required to transmit power at the battery voltage. The HI-Power hydroelectric generator can also deliver up to 3600 watts where higher power is needed. The LV Hydroelectric Generator and the ES&D Water Baby are a good solution for very low flow situations where the head is high enough to make some power.

### 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, the vertical drop from the top of the pipeline where the water goes into 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.

### We can help you design your 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 the following information about your site:

- 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 5 feet per second. The nozzle selection table on the next page shows water flow through various size nozzles at given pressures. Use this table 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 0.433). 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 PVC pipe loss table on the next page.)

#### Hydroelectric Power Output Estimation Formula:

**Dynamic Head (ft) x Flow (GPM) x 0.18 x Turbine Efficiency (use 0.40) = Output Watts**

## Water Flow Information for Pumping and Hydroelectric Design

### Flow Through Nozzles

The table below shows the flow in gallons per minute (gpm) through various diameter nozzles at a range of heads from 5 feet to 400 feet. Use table 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		Flow in gpm through these nozzle diameters:											Rpm for 4" turbine
feet	psi	1/8"	3/16"	1/4"	5/16"	3/8"	7/16"	1/2"	5/8"	3/4"	7/8"	1.0"	
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

### PVC Pipe Loss Table

Use the table 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 dynamic head in the system.

		Pipe Friction Loss Table – Head Loss in Feet per 100 Feet of Schedule 40 PVC Pipe																							
		Flow (gallons per minute)																							
		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	22	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		

# HI-Power

## Low-Voltage LV Hydroelectric Generators

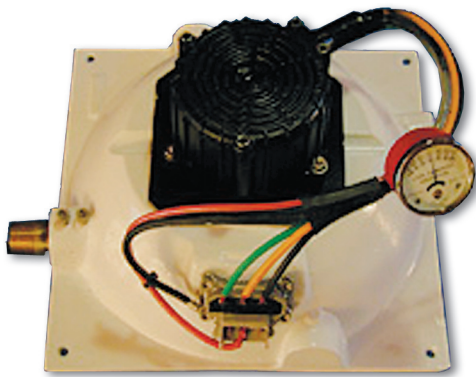
HI-Power is now offering a low-voltage brushless PM generator. This user-friendly unit requires no adjustments and is more efficient than car alternator types over a wider range of head and flow.

- Head range: 40 to 400 feet
- Flow range: 5 to 400 gpm
- Maximum power: 1200 watts
- Efficiency: 30% to 70%
- Battery voltage options: 12V, 24V, 48V, 96V

Available in the four voltages above for direct battery charging. The 48- and 96-volt units allow the use of smaller gauge wire between the generator and the battery. An MPPT charge control, like the OutBack MX-60, can be used to efficiently step the voltage down for charging and regulating 12-, 24- or 48-volt batteries.

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 an 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.



## Higher Voltage HV Hydroelectric Generators

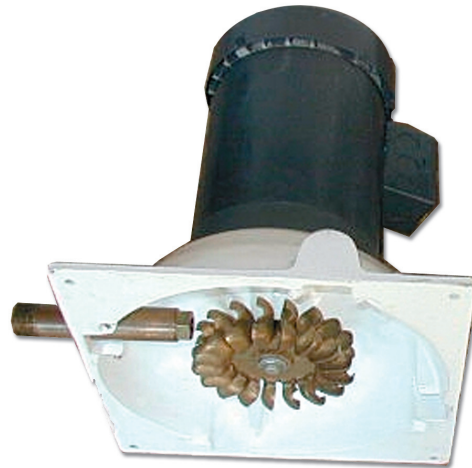
HI Power Hydroelectric generators are ideal for sites where water is far from power needs (up to 10,000 feet) or when greater power is required. High transmission voltage can be sent over a mile before being 'stepped down' to battery voltage. It comes complete with step-down transformer, rectifier, fuses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

- 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

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 of 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 battery voltage when ordering.



Description	Item code	Price
LV Hydro with 1 nozzle	017-02005	\$1,350
LV Hydro with 2 nozzles	017-02007	\$1,400
LV Hydro with 3 nozzles	017-02009	\$1,450
LV Hydro with 4 nozzles	017-02011	\$1,500
Car alternator upgrade kit for older Harris Hydro-electric units with brush type alternators	017-02019	\$500

Description	Item code	Price
HV 1200 – 1200 watt 4 nozzle	017-02030	\$3,600
HV 1800 – 1800 watt 4 nozzle	017-02031	\$4,200
HV 3600 – 3600 watt 4 nozzle	017-02034	\$6,000
Hi-Power turgo nozzle	017-02037	\$600

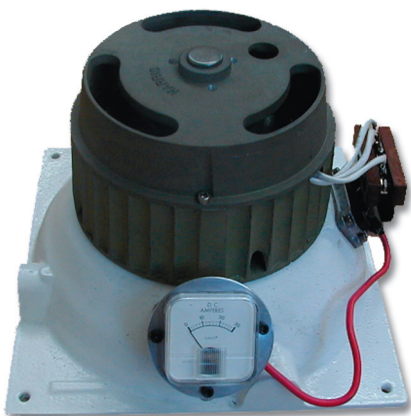
## Harris Hydroelectric

### Pelton Turbines

This hydroelectric battery charger uses a cast bronze Pelton wheel and a brushless permanent magnet alternator on a white powder-coated aluminum housing.

- 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

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. The new permanent magnet (PM) brushless alternator pictured here is 15-30% more efficient than the automotive alternator used in the past; and they last longer. Allow 5 to 6 weeks for delivery. 1-year warranty.



Description	Item code	Price
Harris PM 1-Nozzle 12/24V/48V	017-01030	\$2,300
Harris PM 2-Nozzle 12/24V/48V	017-01032	\$2,387
Harris PM 4-Nozzle 12/24V/48V	017-01034	\$2,555
Fan kit (recommended when producing over 500W)	017-01092	\$70

## ES&D

ES&D's micro hydro 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 off-grid/standalone or grid-tie systems.

### Stream Engine Turbines

ES&D hydroelectric battery chargers use a cast bronze turgo runner to drive a long-life, brushless permanent magnet alternator.

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



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	017-03241	\$3,493
ES&D 4-Nozzle Stream Engine	017-03244	\$2,795

### Water Baby

- Head Range: 50 to 500 feet
- Flow range: 3 to 30 gpm
- Max 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 Water Baby will charge at 25 watts. Comes with a selection of nozzles.

Description	Item code	Price
ES&D 1-Nozzle Water Baby – 12 - 24V	017-03245	\$1,945
ES&D 2-Nozzle Water Baby – 12 - 24V	017-03247	\$2,095
ES&D 4-Nozzle Water Baby – 12 - 24V	017-03249	\$2,395
ES&D 1-Nozzle Water Baby – 48V	017-03252	\$2,095
ES&D 2-Nozzle Water Baby – 48V	017-03254	\$2,245
ES&D 4-Nozzle Water Baby – 48V	017-03256	\$2,645