How much power can you generate with a hydroelectric turbine?

These micro-hydro turbines require that water be piped from a higher elevation to a lower elevation where the turbine is installed. This pipeline is called a "penstock" and the elevation difference is called the "static head". The "dynamic head" is the static head adjusted for losses due to friction in the pipeline

The amount of power produced depends on the dynamic head, the amount of water flow and the efficiency of the turbine-generator combination. To get an idea of the potential power generation in watts, multiply the dynamic 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.

Dynamic Head (ft) x Flow (gpm) x 0.18
x Turbine Efficiency (use 0.40) = Output watts

Water flows greater than a single micro hydro turbine can handle can be accommodated by using multiple turbines with a penstock manifold, or separate penstocks running to each unit.

The Harris Pelton turbines use a brushless alternator and a Pelton wheel runner, and are well suited to higher head and water flows up to 250 gpm. Flow is limited by nozzle size. The Harris permanent magnet (PM) alternator provides up to 50% efficiency and is adjustable for tuning to the particular site conditions.

The HI-Power LV Hydroelectric Generator can deliver up to 1500 watts into 12, 24, or 48V battery banks.

The LV is also available with a 120V output for wire runs as long as 1000 feet and is a good solution where the generator must be far from the batteries. 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. An Iota battery charger (page 161) or the new MidNite Classic MPPT charge controller (page 125) is used to convert this high voltage down to the battery's voltage, at the battery's location

The HI-Power LV 120V unit can also be used with a PV Powered inverter for grid-tie applications without batteries. Call for more information on grid-tie micro-hydro applications.

Pipelines

A hydroelectric turbine uses the energy from the pressure at the end of a gravity-fed 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 enters the system, 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 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 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.)

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
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

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 Hydroelectric Generators

HI-Power is now offering a low-voltage brushless PM (permanent magnet) 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 100 gpm
- Maximum power: 1500 watts
- Efficiency: 30% to 70%
- Battery voltage options: 12V, 24V, 48V, 120VDC

HI-Power low-voltage hydroelectric generators are available in four voltages for direct battery charging, including the 48V and 120V units, which allow the use of smaller gauge wire between the generator and the battery. An MPPT charge controller such as the OutBack FM-60 can be used to efficiently step the voltage down for charging and regulating 12V, 24V or 48V batteries.

The sealed permanent magnet alternator is mounted on an anodized aluminum turgo housing with the 4-inch stainless steel Hartvigsen Turgo Runner. The external rectifier is water-cooled and all fasteners are stainless steel. It comes with an induction meter and 3 feet of 1-inch flexible hose per nozzle. Order multiple nozzles for convenient adjustment to varying flows. Alternator has two enclosed 6203 bearings which should be changed every 4-10 years,depending on use. Pictured with ¾-inch brass nozzle holders. 1½-inch plastic nozzle holders also available. Also available with Harris Pelton Runner by request. Base dimensions: 12" x 12". Skirt fits in 10.25". 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	**017-02005**	**$1,450**
LV Hydro with 2 nozzles	**017-02007**	**$1,500**
LV Hydro with 3 nozzles	**017-02009**	**$1,550**
LV Hydro with 4 nozzles	**017-02011**	**$1,600**
Brushless alternator upgrade kit for older Harris Hydroelectric units with brush type alternators	**017-02019**	**$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.

Fan kit is recommended when producing over 500W.

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**
Permanent magnet upgrade for older Harris units	**017-01037**	**$1,650**