SMALL HYDRO OVERVIEW/SPREADSHEET

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BACKGROUND

The two vital factors impacting hydroelectric potential are how much water is flowing past the turbine and the pressure the water is exerting on the turbine.

Flow is measured in volumes per time (gallons per minute, cubic feet per second, liters per second, etc.)

Pressure is measured in pounds per square inch (psi) or, in hydro vocabulary, is typically expressed as "head", which is measured in height (feet or meters). One foot of height = 0.433 psi

The key equation to remember is the following:

Power = Head x Flow x Gravity ***watts = meters x liters per second x meters per second squared***

where power is measured in watts, head in meters, flow in liters per second, and gravity in meters per second squared. The acceleration due to gravity is approximately 9.81 meters per second per second

For most calculations, rounding acceleration due to gravity to 10 meters/second squared is acceptable

To calculate how much hydro power is available at a site:

If you have a flow of 20 liters per second with a head of 15 meters (or if a flow of 15 l/s and a height of 20m)

15 x 20 x 9.81 = 2,943 Watts

In North America, and in some other parts of the world, we use English units.

With English units the hydro power equation becomes:

Power = Head x Flow /10 ***watts = feet x gallons per minute / 10.***

where power is measured in watts, head in feet and flow in gallons per minute.

If you have a flow of 20 gallons per minute with a head of 15 feet:

15 x 20 / 10 = 30 Watts

SPREADSHEET

Below is a hydro-power calculator using North American Units for an In-conduit application:

Inputs

Flow: (gallon/minute)	5000	[1 US gallon/minute = 0.06308 l/s = 0.00223 cubic feet/second)]
Pipe Diameter (inches)	24	
Pressure in (psi)	120	(1 psi = 2.31 feet)
Pressure out (psi)	80	(1 psi = 2.31 feet)

Results:

Velocity (feet/second)	3.55	fps	
Power (watts)	46.200	kW	theoretical maximum

Turbine/Generator Adjustment

The above calculation is the theoretical maximum power available. In the real world, we have efficiency losses in both the turbine and generators (typically 40% or so). So we need to modify the power equation to account for these losses:

Power = Head x Flow /10 x e where e = combined operating efficiency of hydro turbine and gene

Input

Turbine/generator efficiency ϵ	60	%	

Results:

Power (watts)	27.720	kW	Turbine/generator output

Annual Production

To get an idea of the amount of income/value of the electricity produced annually, put in the value of the electricity below:

Input

Value of Electricity	$0.10	$/kWh

Results:

Annual kWh produced	242,827	kWh/year
Value of KWh produced	$24,282.72	$ per year

Notes:

This spreadsheet is for illustrative purposes only. To get an accurate evaluation of your site you'll need

- pressure change profiles throughout the year
- water flow change profiles throughout the year
- detailed turbine/generator efficiencies
- more detailed pipe characteristics to determine flow (type and characteristics of pipe)
- changes in the price/value of electricity throughout the year.

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