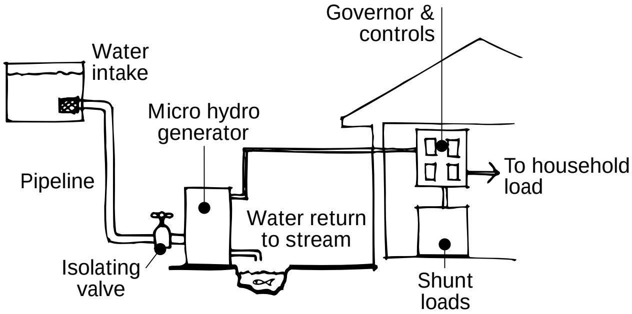
micro hydro systems

Micro hydro units convert the energy of flowing water into electrical energy. The energy produced by them is renewable and the process does not emit polluting gases.

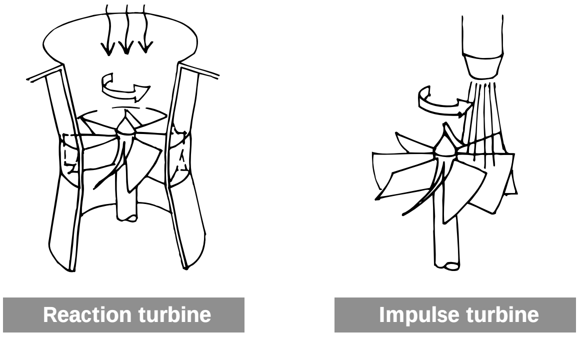
Typical micro hydro system

Domestic micro hydro generators used in stand alone power systems can be DC units, designed to charge a battery bank, or AC units designed to supply the household loads directly.



In micro hydro systems water turns a wheel or a runner (like a propeller) to rotate a turbine and produce electricity. The wheels come in different shapes and sizes depending on the site and the type of turbine.

There are two types of micro-hydro turbines: impulse and reaction.



Impulse turbine wheels run freely in air. Water is directed onto the runner by jets and then drops away, its energy depleted. Impulse turbines are usually installed on sites with heads greater than ten metres and are the most common type of turbine installed in a domestic system.

Micro hydro system with impulse turbine.

Reaction turbine runners rotate fully immersed in water in a sealed case. After passing the turbine the water continues to the waterway via a pipe. These are usually installed in low water head applications.

With a suitable water source micro hydro may be the most cost effective form of renewable electricity. For an AC unit, the cost of electricity produced over the lifetime of the unit should be cheaper than extending the mains power grid or installing other stand alone systems. Unfortunately, as Australia has only a small number of areas where micro hydro is suitable, it is estimated that micro hydro is installed in only about two percent of stand alone power systems.

It may be illegal to interfere with a watercourse without prior approval

Micro hydro power is best where water supply is continuously available. Where supply is seasonal it may still be cost effective to install micro hydro as a stand-alone system. This will depend on whether the cost of installing the system is offset by the savings made during the period when the creek is flowing. Another renewable system, or a generator, will be required when water is not available.

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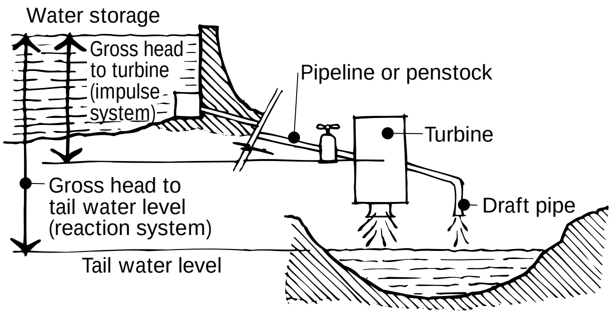
DESIGN AND SITING

The amount of energy in water is dependent on the available head and the flow.



Depending on the type of turbine, the water may be discharged direct to the tail water or through a pipe.

Gross head for a micro hydro system.

The static head (or gross head) is calculated from the vertical distance in metres between the water intake of the system and the point where the water enters the generator. For reaction turbines the static head includes the vertical distance from the turbine to the bottom of the draft pipe where the water is released back into the creek.

The static head can be determined by using good topographical maps but it is best to seek the advice of a micro hydro expert.

The dynamic head is used to determine the amount of water power available. This allows for friction losses that occur in pipework (penstock) between the water intake point and the micro hydro generator.

The smaller the diameter of the penstock, the higher the friction between the water and the walls, and the greater the energy loss. The physical length of the penstock contributes to the frictional loss. To calculate the dynamic head, the total frictional loss in the penstock is converted to a head loss in metres, and subtracted from the static head.

To minimise head losses the penstock diameter should be as large as possible. The cost of larger pipes must then be included in the final cost/benefit analysis.

Flow is the rate at which water is moving through the pipe and is measured in litres per second (L/s). It is more difficult to measure than the head. A trained micro hydro designer can use a number of techniques to determine the actual flow. This will generally take some time and could involve building a small temporary weir on the creek.

The amount of water power available is determined by the following formula:

WATER POWER = HEAD x FLOW x GRAVITY

Gravity is the acceleration due to gravity and is approximately 10 m/s^2. So a system with a dynamic head of 10 metres and a flow rate of 5 litres per second could provide 10 x 5 x 10 = 500 Watts of water power.

The power formula demonstrates that a site with high head might only need a small flow while a site with a high flow might only need a small head. While a micro hydro unit can operate with as little as two metres of head, most units used in domestic situations will require at least ten metres head. Designing and installing the pipe work for a site with less than ten metres head can be very difficult.

The efficiency with which generators convert water power to electrical power can range from 30 percent to 70 percent. It is generally not practical or cost effective to install a unit that produces less than 100 Watts of electrical power (continuous).

INSTALLATION

It is essential to obtain approval from local and state authorities before undertaking any modifications to water courses or significant use of water.

When installing a micro hydro unit it is important not to damage the local environment.

It may be illegal to interfere with a watercourse without prior approval. You may also be charged water usage fees even though the water is returned to the waterway.

As a general rule, no more than 50 percent of the minimum seasonal flow should be taken from the water source to feed the micro hydro. This is subject to local conditions. Always seek expert advice before planning an installation.

Variations could include:

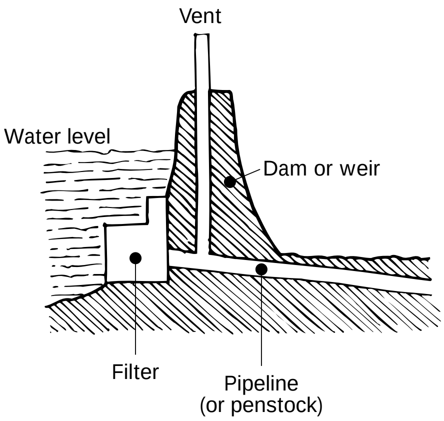
> **A spring fed dam**, where the overflow pipe is used for the hydro and the flow into it is identical to that from the spring.

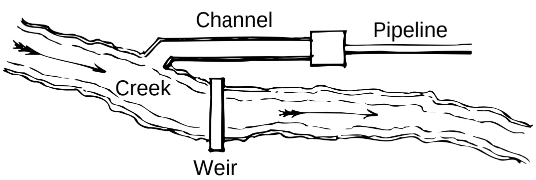
> **A steep site** with a very low flow creek at the point of intake but where the seepage into the creek is continuous along the whole length. In this case the missing water has little or no effect on the local environment.

Good design of the intake point is critical to avoid damage to the creek and to minimise maintenance.

Clogging of the intake by debris, leaves and silt will lead to under performance or even failure of the system. Careful design can eliminate this problem.

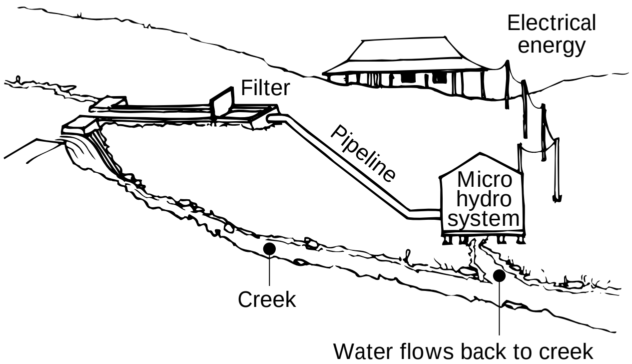
Intake design can vary greatly and must suit the local terrain and water flow. It must include some form of filter to prevent leaves, sticks, etc. entering the penstock. These could block inlet valves on the micro hydro generator or even damage the wheel.





Some examples of intake points:

Use a weir or dam where the intake pipe or penstock is installed at a specified height in the weir. Ensure that intake has a mesh filter to catch leaves and debris as the water flows through the mesh into the intake pipe.



Install a wheelie bin beside (or in) a creek with the intake pipe mounted near the top of the bin. The bin collects the debris and will require occasional emptying.

Use a channel beside the creek to which the penstock is connected.

The penstock should be buried in the ground to avoid damage to the pipe and prevent water being heated by the sun, which effects pressure. In steep terrain where this may be impractical, lay the pipe on top of the ground and cover it with vegetation.

The penstock can be either pressure pipe or poly pipe depending on the design requirements for the site.

The penstock must be installed so that it is always falling. Failing to do this can result in air locks and lead to poor system performance.

The design of the penstock must include a mechanism to avoid damage to the penstock pipe should the intake be blocked and a vacuum form. This can be achieved by installing a shepherd's crook air vent at the intake point.

A valve should be installed just above the turbine to allow the water to be turned off when maintenance is required. Valves should always be opened and closed slowly. Opening the valve slowly allows the turbine to build up speed. Closing the valve slowly prevents water hammer occurring, which could damage the pipes.

Micro hydro unit with shelter.

The micro hydro unit should be housed in a basic protective shelter that will not be covered by water in periods of flood.

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DC MICRO HYDRO GENERATORS

DC micro hydro generators are generally in the 100 Watt to 3000 Watt range and can be designed to suit all sizes of battery banks. Batteries will be required if a constant supply of flowing water is not available.

A typical 750 Watt DC micro hydro generator will cost around $3,000. The cost of installing the penstock and wiring will be highly dependent on the location. For the cost of other system components. **[See: Batteries and Inverters]**

DC generators usually measure no more than 0.6m by 0.6 m by 0.6 m and weigh 20 to 30 kg.

The alternating voltage and current they produce are rectified to charge batteries at the correct voltage, similar to charging a car battery. The rectifier is generally mounted on the micro hydro unit and feeds DC power to the cable connecting it to the batteries.

DC systems will require a regulator/controller to ensure that the batteries are not overcharged. This should be located near the batteries.

To overcome power loss in the cables the micro hydro unit needs to be located as close as possible to the battery bank. If it is installed a long distance from the batteries the AC output can be rectified to a high DC voltage to minimise the current flow in the cable. A maximiser (similar to that used in PV systems) can then convert the higher DC voltage to the required battery charging voltage.

Micro hydros always produce power when turning. If the batteries are fully charged then excess power is redirected into a dummy load, usually an electrical element. The dummy load can get very hot and should be positioned where it will not be touched accidentally.

AC MICRO HYDRO GENERATORS

AC domestic micro hydro generators are usually between 300 Watts and 5 kW in output but some systems include a 10 kW or 20 kW turbine.

A 5 kW AC unit will cost around $10,000. As for DC generators, the cost of installing the penstock and wiring will be highly dependent on the location.

The turbine units are generally no greater than 0.8m long by 0.8 wide but their height and weight vary depending on the size of the alternator required. The maximum height for a 20 kW unit would be about one metre.

AC units feed directly into the wiring system of the house, supplying the loads directly.

The system will include a controller that ensures that the output is always 240V AC and 50 Hz, identical to grid power.

The controller maintains the correct voltage and frequency by feeding excess power directly into dummy loads as in the case of the DC unit.

ADDITIONAL KEY REFERENCES
Australian Renewable Energy Website, http://renewable.greenhouse.gov.au
Platypus Power http://www.netc.net.au/platypus/
Rainbow Power Company http://www.rpc.com.au/
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