

## Waterwheels

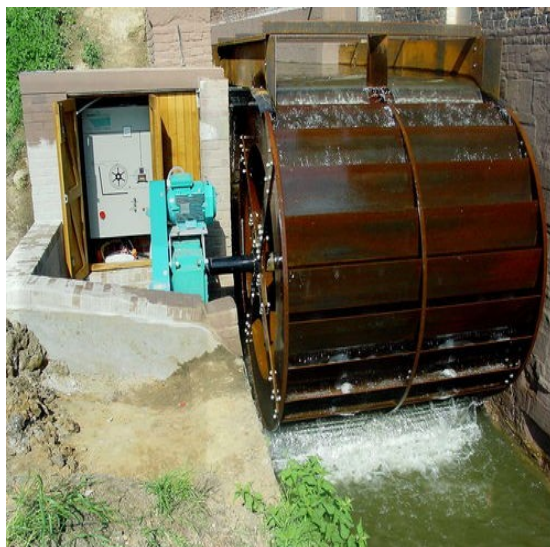
Waterwheels are a viable proposition for producing electricity for domestic purposes. They are simple to control and aesthetically pleasing. Although they run relatively slowly and require a high ratio gearbox to drive a generator, for low powers - say below 20kW - and heads below 8m, they are worth considering.

Waterwheels are often overlooked for generating electricity but can be successfully employed at many low-head micro-hydro sites and have a number of advantages over conventional approaches with turbines:

- Output reduction due to screen blockages is avoided since fine intake screens are not required.
- Part-flow performance of waterwheels can be very good without requiring complex control systems.
- Often minimal building work is required, particularly at former watermills if there is a vacant wheel pit.
- Waterwheels have obvious aesthetic benefits over turbines and provide an excellent attraction at sites where visitors are encouraged.

The principal challenge of the waterwheel is the low rotational speed, which means that significant gearing up is required to match generator speeds. However, high power gear units are now much more widely available and have improved the economics of waterwheel power schemes up to 20kW.

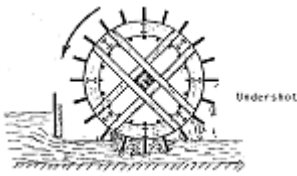
Waterwheels are incorrectly regarded as being inefficient compared with turbines. Studies have shown that waterwheel efficiency can be in excess of 80% for overshot waterwheels and 75% for breastshot waterwheels [Muller 2004]. This in combination with a superior part-flow performance and lack of fine intake screening requirements can often result in very worthwhile overall energy capture.



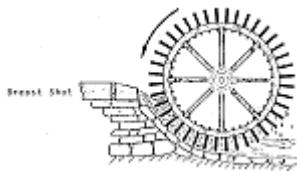
*Zuppinger and overshot wheels by HydroWatt GmbH*

## Types of Waterwheels

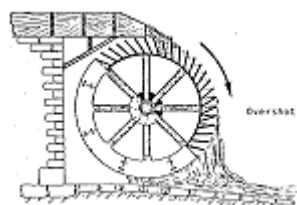
Although vertical axis wheels are common in Nepal and North India, horizontal axis wheels are more frequently to be found in Europe. There are three basic types:



**Undershot** - This is probably the oldest design. The paddles are flat and are simply dragged round by the flowing water. The undershot wheel is not the most efficient – at most 30% and has a very low output.



**Breast Shot** - The water hits the breast shot waterwheel much higher than on the undershot wheel and is more efficient. Variations on the breastshot wheel worth considering and which are capable of efficiencies of over 60% are the Poncelet, Pitchback and the modern Zuppinger wheel. Each of these has a large number of blades, usually curved to smooth the entry of water, and both rotate in the direction of the water flow at the base. The Poncelet is an undershot wheel where the water is introduced as a jet from a sliding gate at its base, and the Pitchback is a high breast shot wheel where the water is introduced well above the axel at about the 11 o'clock position. Many wheels of this type were built in the 19th century at textile mills in Northern England and Scotland. The Zuppinger is manufactured by Hydrowatt in Germany and is suitable for sites with 1 to 3m of head and 500 to 1,500 litres/s flow.



**Overshot**- This type of waterwheel can achieve an efficiency of over 80% with careful design. The disadvantage is that it must have a diameter almost equal to the head. This places an upper limit on the head at which a wheel can be practicable. The largest electricity generating overshot wheel in Europe is at Aberdulais in South Wales, operated by the National Trust. It is 8m diameter and can produce up to 20kW.



The 8m wheel at Aberdulais, Wales.

<https://www.nationaltrust.org.uk/aberdulais-tin-works-and-waterfall/features/the-waterwheel-at-aberdulais>

With care, Victorian iron mill wheels can be re-engineered for electricity generation. One of the largest, oldest grid-connected overshot wheels in operation in England is in Devon. Made in the 1850s by Willcocks & Son, Buckfastleigh to a design by Sir William Fairbairn, the 6m diameter, 3m wide wheel powered a canvas factory up until WWI. In 2015 it was reinstated for power generation and has a rated output of 9kW:



The former Brent Canvas Mill wheel in Devon, now used for domestic power generation.

At a smaller scale, many former grist and corn mills had just sufficient head and flow to turn one or two sets of grindstones. These sites lend themselves to modern overshot wheels with their their excellent low flow efficiency.



Lydia Mill: 3.86m diameter steel wheel, 70 litres/s, 1.8kW, up to 10,000kWh per year.

## Gearing Up

A number of ingenious solutions have been used with varying degrees of success.

If the power is taken from the axle of the wheel, the torque on the gearbox is high. Solutions in the past have included the use of back axle and differential gearboxes from tractors as a first stage speed step-up, then a second gearbox or belt-and-pully final speed multiplier. An elegant though more expensive solution is to use an industrial gearmotor unit. Epicyclic (sun-and-planet) gears are particularly suited to handling the low speed and high torque requirements.

Taking the power from the rim of the wheel is possible and used to be the norm for large industrial textile mills because the iron main shafts were incapable of handling the high torque.

Environmentally safe lubrication and the risk of debris becoming entangled with rim gears are two challenges that have to be addressed. Running a car wheel (complete with tyre) on the rim and taking the power off from the car wheel axle has been used for low power output systems but its long term durability is unknown.

Further reading:

[https://en.wikipedia.org/wiki/Water\\_wheel](https://en.wikipedia.org/wiki/Water_wheel)

<http://hydrowatt.de/de/en/produkte/wasserrad-ms/>