engineers without borders uk
training

Pico Hydro Workshop

At a glance:

Community of Practice: Energy
Type: Workshop
Duration: 1 hour
Min/Max participants: 4 per group
Room/space requirements: Tables (to build turbines on)
Water (to test turbines – best done outside)

Objectives

- To build and test a small cross-flow turbine and use it to power a load.

Material written by Sam Williamson, edited by Lizzie Norris

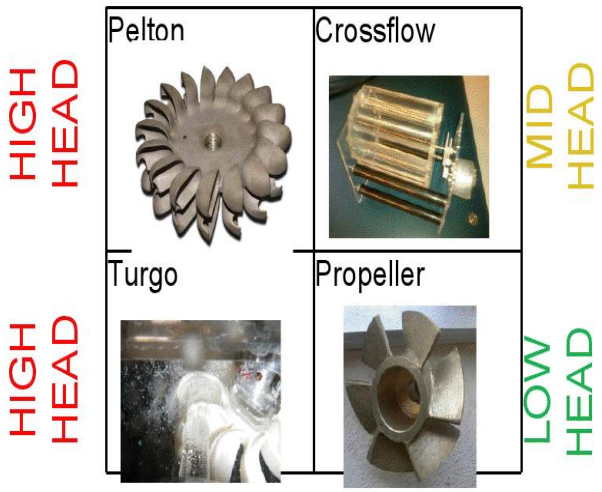
1. Introduction

Pico Hydro is the term used for the generation of hydroelectric power under 5kW. It is particularly useful in small, remote communities which have small electricity requirements and cannot be connected to the grid. Countries such as Nepal have many projects scattered around the countryside.

It is an easy source of electricity if you have a river running near your house/village; it is likely to be the cheapest way to power off-grid and is more reliable than solar or wind power.

Pico hydropower can be used to light homes, and provide power for income generating activities such as wood shops, sewing machines and computer centres providing much needed rural income.

Four types of turbines are normally used in pico-hydro projects for different head (water drop) heights.



This exercise enables participants to build a small cross flow turbine, called the firefly, and test it tout to see how it works with a simulated load.

How Do Crossflow Turbines Work?

Crossflow turbines use the change in direction of water to produce a torque on the output shaft. The water hits the blade in two places, causing it to turn. Crossflow turbines are frequently used because they are simple to manufacture with basic tools. They do not provide the greatest efficiency however they can operate to a wide range of heads and therefore power, making them very convenient.

The Firefly Crossflow Turbine

This turbine was designed and developed by Jan Portejis for use in the Philippines. Constructed from steel, it was originally attached to a car alternator and used to charge batteries. A low efficiency (~30%) but is simple to build usually locally available materials, tools and skills and can produce around 40W – enough for a couple of lightbulbs.

This Turbine

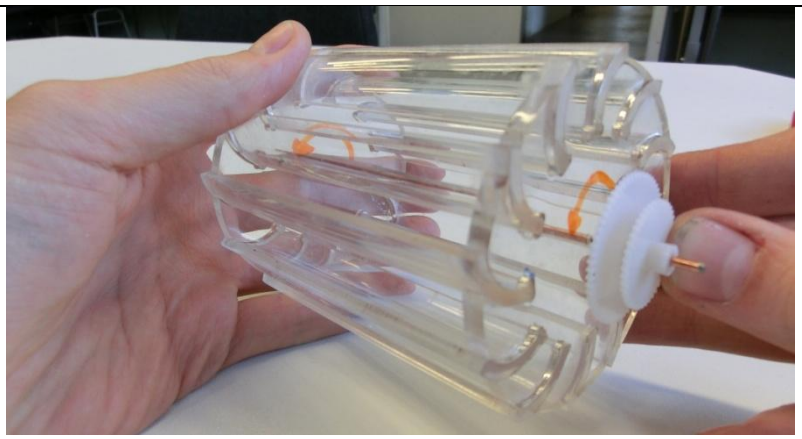
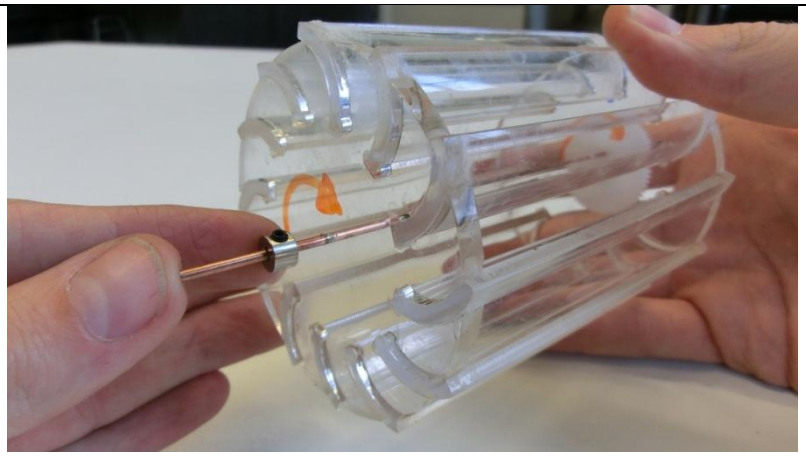
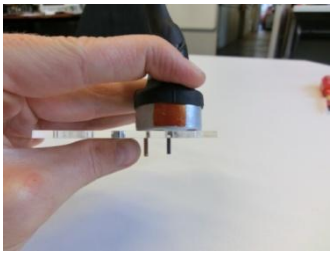
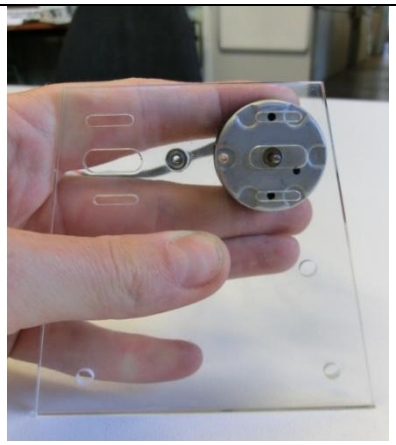
This turbine mirrors the design of the crossflow turbine however it is constructed from Perspex and is glued together. It uses a low speed motor so it can generate more volts at lower speed.

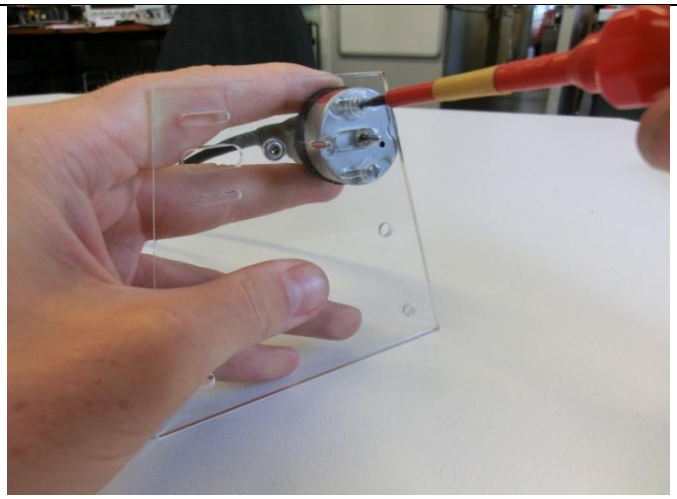
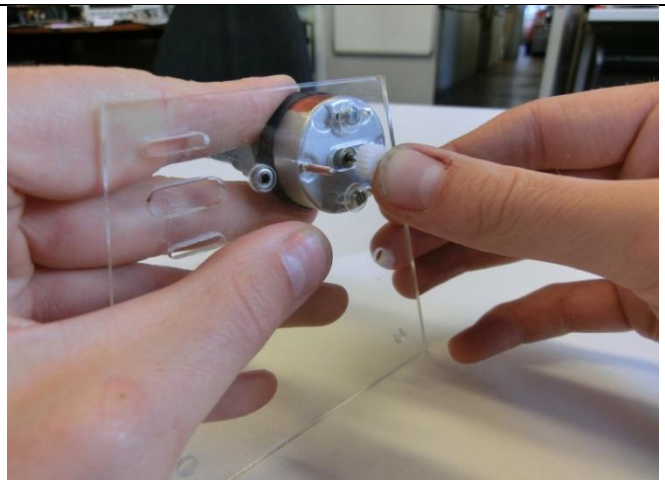
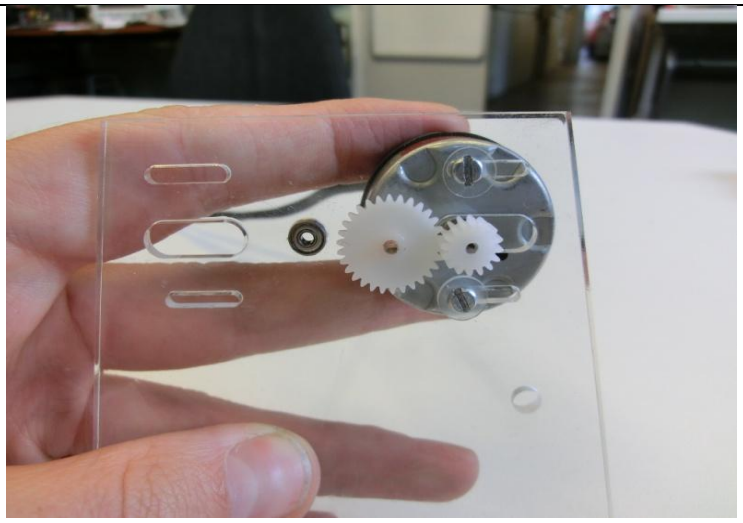
2. Typical Timetable

Below is a guideline for a typical timetable for the workshop.

	Building / Role-play / Activity (break down in steps where appropriate)
5 minutes	Introduction to pico hydropower
30 minutes	Building turbines
20 minutes	Testing turbines
5 minutes	Review of workshop

3. Step by Step Guide

Step 1 Take the 42T and 62T gear and push them on the end of the turbine shaft leaving around 5mm on the end.	
Step 2 Put the collet on the other end of the shaft. You don't need to tighten this at the moment.	
Step 3 Put the motor on the end plate with the slots in, on the side with the small stub shaft. Make sure the orange marking is facing up (otherwise the output voltage will be negative!)	 

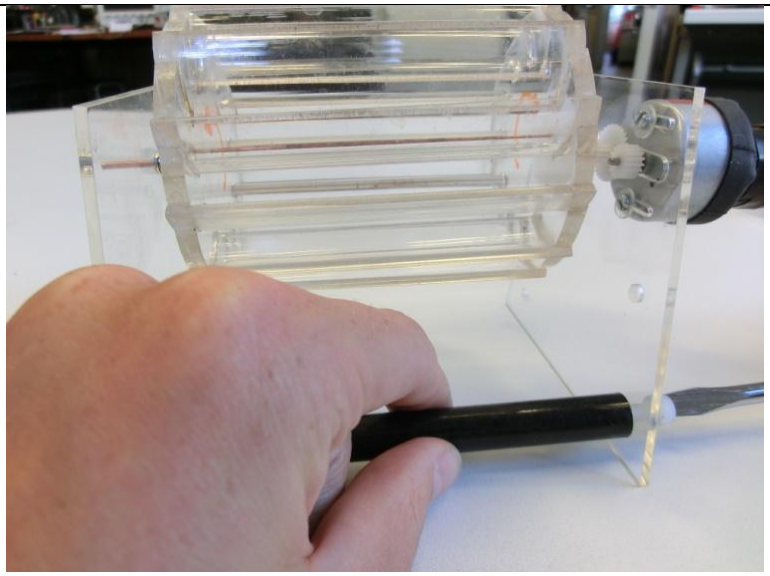
Step 4 Use the M2.5 screws and washers to attach the motor to the end plate, but don't fully tighten yet!	
Step 5 Push the 16T gear on the motor shaft	
Step 6 Put the 30/10T gear on the stub shaft, then slide the motor in so that the gears mesh. Make sure the gears turn freely! Then tighten the screws holding the motor on the end plate.	

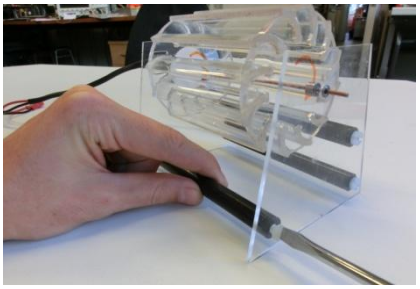
Step 7

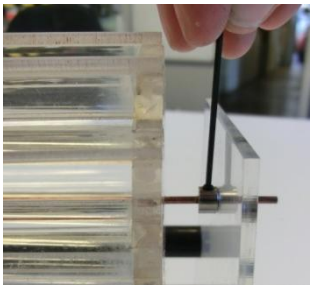
Put the turbine and shaft into the endplate with the motor on, the 42T gear should mesh with the 10T gear.

Put the other end plate on and use the plastic rods and M5 screws to attach them together.

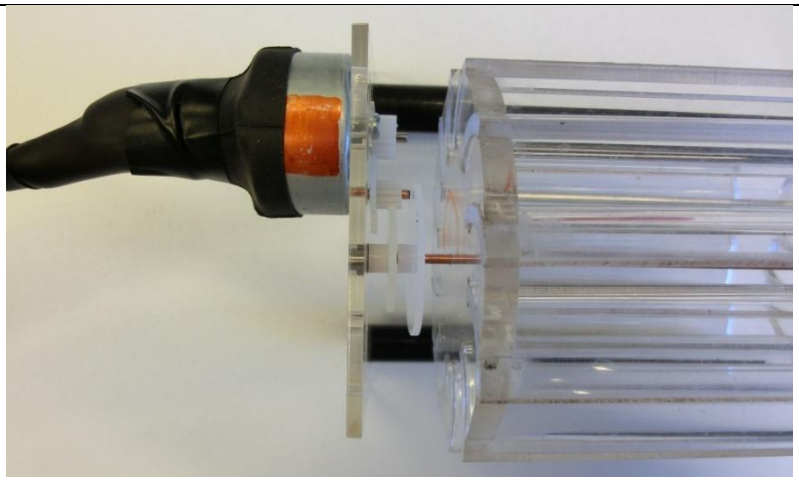
The collet can then be tightened up when it is pressed against the end plate.





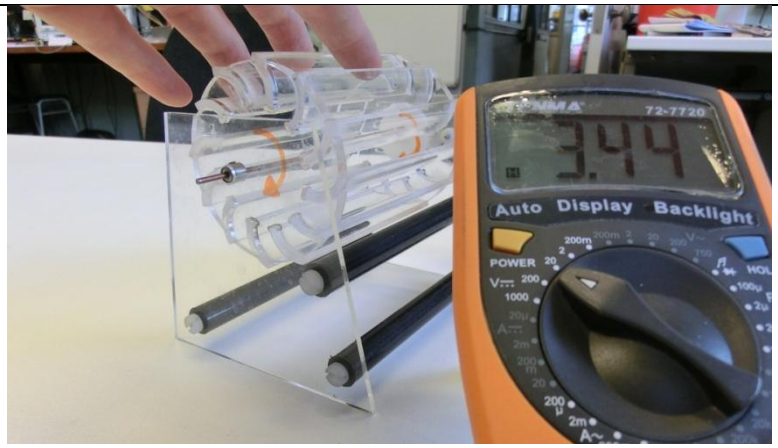


So now your gearbox hopefully looks like this!



Step 8

Connect the motor output to the multimeter, spin the turbine and make sure it produces a positive voltage!



Step 9

Attach the charging circuit to the generator using the spade clips. (red wire to red wire etc.)

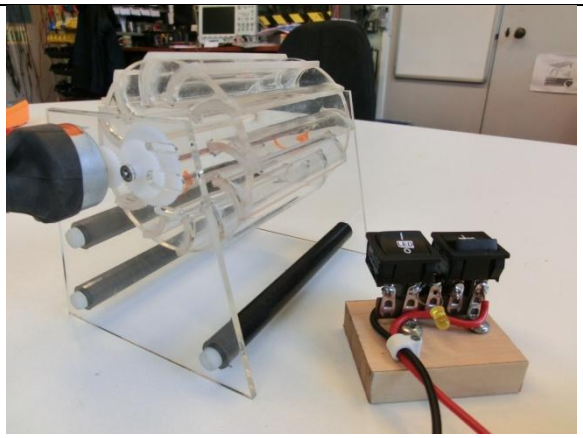
Switch the CAP switch on.

Spin the turbine by hand in the direction drawn on the turbine for 20 seconds.

Switch the CAP switch off.

Switch the LED switch on and hopefully the LED should light up!

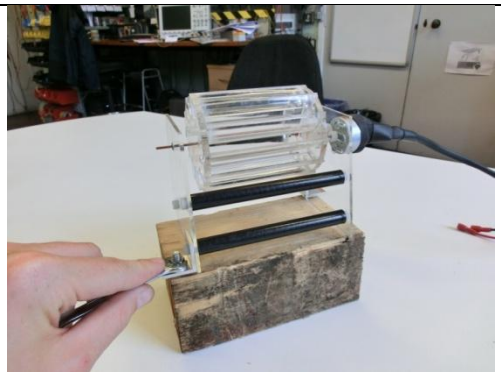
If you switch on the CAP switch, it may spin the turbine too!

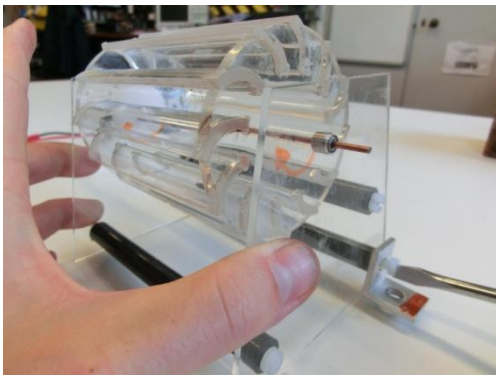


Step 10

Attach the feet on opposite corners of the turbine, by removing one of the M5 screws on each side. (Orange side up on the feet.)

Then attach the feet to the studs in the wooden block and take to the turbine test area!





Step 11

Fill up the container with 5l of water.

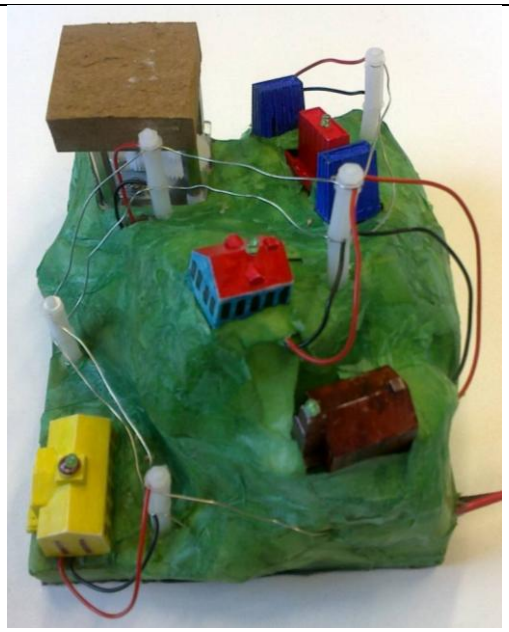
One person support the nozzle, one take the water up the ladder and one control the charging circuit.

Switch on the CAP switch of the charging circuit, making sure LED is off (!), and then pour the water through the intake.

Once all the water has gone switch off the CAP switch and take the charging circuit to the load.

Time how long the circuit powers the load – the motor will probably last the longest…

Longest time wins!



4. Materials

FOR TURBINES

1. 3mm Perspex (250mm x 120mm per turbine)
2. 6mm Perspex (80mm x 160mm per turbine)
3. 30mm (24mm ID) Perspex tube (300mm per turbine)
4. 10mm PVC rod (400mm per turbine)
5. Motor size J (1 per turbine)
6. 2mm ball bearing (2 per turbine)
7. 2mm x 150mm shaft (1 per turbine)
8. 2mm collet (1 per turbine)
9. 16T gear (1 per turbine)
10. 42T gear (1 per turbine)
11. 60T gear (1 per turbine)
12. 30/10T gear (1 per turbine)
13. M2.5 screw and washer (2 per turbine)
14. M5 nylon screw (6 per turbine)
15. Switches (2 per turbine)
16. 0.1F, 3.3V or 5V Super-capacitor (1 per turbine)
17. LED (1 per turbine)
18. 220 Ohm resistor (1 per turbine)
19. 56 Ohm resistor (1 per turbine)

1 - 4 available from www.hindleys.com
5 – 12 available from www.technobotsonline.com
15 – 19 available from www.farnell.com or uk.rs-online.com/web/

FOR TESTING

1. 50mm/2" pipe (approx 2m)
2. Funnel for pipe
3. Nozzle for pipe
4. Wood and brackets to secure turbine with
5. Gorilla bucket
6. Bricks (6)

5. Tools

Recommended Tools to construct the Turbine from:

- Small flathead screwdriver
- Large flathead screwdriver
- Multimeter

- Allen key for collet
- Water!

6. Useful Tips!

- Best results happen if the water is poured as fast as possible
- As motor can run at 0.3V this will last longest as load – LEDs drop at about 1.7V or so
- When charging the super-capacitor, be careful not to discharge it be allowing it to spin the turbine!
- 8 ready made kits and all bits needed available, in Bristol. Email sam.williamson@bris.ac.uk if you'd like to use them, or would like Sam to come and run the workshop for you.

7. Further Reading/Recommended Sources

- Microhydro Design Manual: A Guide to Small Scale Water Power Schemes, Adam Harvey et al, Practical Action Publishing
- Poor People's Energy Outlook, Practical Action
- The Firefly Micro Hydro System - http://www.microhydropower.net/mhp_group/portegijs/firefly_bm/ffbm_index.html
- Pico Hydro @ Nottingham - http://www.eee.nottingham.ac.uk/picohydro/contacts.html

8. Risks to consider (to guide a risk assessment form)

Potential Risks	Mitigation Strategy
Impact between fingers and spinning turbine	Design of turbine to reduce finger insertion, give warning about this before workshop.
Electric shock from water splashing onto electrical components	Low voltage levels (<12V) used, supervision from workshop leader during exercise, water and electrical cables kept apart. Give warning before workshop.
Falling from Step Ladder	Ladder placed on hard and level standing, All participants esp. children to be supervised on ladder.