MICRO HYDROPOWER

Exercise 1 *What is micro hydropower and how does it work?*

Read the following sentences and build the correct sequence. In order to help you there's a short summary of the whole content at the beginning :

a)Hydropower is actually one of the renewable sources of energy with the advantage of a steady production. Usually when we talk about it we think of the big dams, but something is now changing and we are going oftener and oftener towards small scale applications.

	Moreover while sun is not always shining and wind not always blowing, hydropower is produced steadily around the clock.
	What is new to most people is the idea that this same concept will work on a smaller and even individual scale: we are speaking of
	Hydropower plants capture the energy of falling water to generate electricity.
	The concept of generating electricity from water has been around for a long time and there are many large hydro-electric facilities around the world.
	A turbine converts the energy of falling water into mechanical energy
	Hydropower is a renewable energy source because it is replenished by snow and rainfall. As long as the rain falls , we won't run out of that energy source
	Micro Hydropower (from *hydro* meaning water and *micro* meaning small scale). It refers to electrical energy that comes from the force of moving water used to power a household or small village.
	Then an alternator converts the mechanical energy from the turbine into electrical energy.

b)Two factors combine in giving the most of electricity production in a hydro power plant (head and flow),…

	The farther the water falls, the more power it has.
	Volume of water falling (Flow): more water falling through the turbine will produce more power. The amount of water available depends on the volume of water at the source.
	A river with twice the amount of flowing water as another river can produce twice as much energy. Flow volume is usually measured in litres per second or m^3 per minute)
	The distance the water travels horizontally is consequential only in expense of the system and friction losses. Head is usually measured in metres or feet (1 foot = 0,3048 m)
	How far the water falls (Head): generally, the distance the water falls depends on the steepness of the terrain the water is moving across, or the height of a dam the water is stored behind.
	The amount of electricity a hydropower plant produces is a combination of two factors:
	In other words, water falling twice as far has twice as much energy. It is important to note we are only talking about the vertical distance the water falls.

	Power is also ‘directly proportional’ to river flow, or flow volume.
	In fact, the power of falling water is ‘directly proportional’ to the distance it falls.

c)… and different kinds of turbine can be chosen according to the different values of such factors.

	The reaction turbine, as the name implies, is turned by reactive force rather than a direct push or impulse. The turbine blades turn in reaction to the pressure of the water falling on them.
	The power produced by an impulse turbine comes entirely from the momentum of the water (m*v) hitting the turbine runners.
	In addition to that you have also: Submersible Propeller Water Turbines. These turbines are the least efficient of the three styles, but also the simplest design
	For high head and low flow volume sites: impulse turbines are the most efficient choice.
	A propeller mounted on the front of the turbine is attached to an alternator inside the main turbine housing
	Propeller style generators work well for locations with a fast moving, relatively deep stream or river, where a water diversion system is not possible, or when mounted on a moving boat.
	For Micro Hydro systems, this translates into two categories of turbines:
	For low head and high flow volume sites: a reaction turbine is the best choice.
	Reaction turbines can operate on heads as low as 2 feet= 0,6096 metres, but require much higher flow rates than an impulse turbine.
	This water creates a direct push or impulse on the blades, and thus such turbines are called ‘impulse turbines’.
	When submerged in a fast moving water source, the propeller is rotated by the force of the passing water.

Key Exercise 1

a)Hydropower is a renewable energy source because it is replenished by snow and rainfall. As long as the rain falls, we won’t run out of that energy source. Moreover while sun is not always shining and wind not always blowing, hydropower is produced steadily around the clock.
The concept of generating electricity from water has been around for a long time and there are many large hydro-electric facilities around the world. What is new to most people is the idea that this same concept will work on a smaller and even individual scale: we are speaking ofMicro Hydropower (from hydro meaning water and micro meaning small scale). It refers to electrical energy that comes from the force of moving water used to power a household or small village.
Hydropower plants capture the energy of falling water to generate electricity. A turbine converts the energy of falling water into mechanical energy. Then an alternator converts the mechanical energy from the turbine into electrical energy.

b)The amount of electricity a hydropower plant produces is a combination of two factors:

1. *How far the water falls (Head): generally, the distance the water falls depends on the steepness of the terrain the water is moving across, or the height of a dam the water is stored behind. The farther the water falls, the more power it has. In fact, the power of falling water is ‘directly proportional’ to the distance it falls. In other words, water falling twice as far has twice as much energy. It is important to note we are only talking about the vertical distance the water falls. The distance the water travels horizontally is consequential only in expense of the system and friction losses. Head is usually measured in metres or feet*
   (1 foot = 0,3048 mt)

2. *Volume of water falling (Flow): more water falling through the turbine will produce more power. The amount of water available depends on the volume of water at the source. Power is also ‘directly proportional’ to river flow, or flow volume. A river with twice the amount of flowing water as another river can produce twice as much energy. Flow volume is usually measured in litres per second or m^3 per minute.*

c)For Micro Hydro systems, this translates into two categories of turbines:

For high head and low flow volume sites: *impulse turbines are the most efficient choice.*
*The power produced by an impulse turbine comes entirely from the momentum of the water (m*v) hitting the turbine runners. This water creates a direct push or impulse on the blades, and thus such turbines are called 'impulse turbines'.*

For low head and high flow volume sites: *a reaction turbine is the best choice. The reaction turbine, as the name implies, is turned by reactive force rather than a direct push or impulse. The turbine blades turn in reaction to the pressure of the water falling on them. Reaction turbines can operate on heads as low as 2 feet= 0,6096 metres, but require much higher flow rates than an impulse turbine.*

In addition to these you have also: ***Submersible Propeller Water Turbines****- These turbines are the least efficient of the three styles, but also the simplest design. A propeller mounted on the front of the turbine is attached to an alternator inside the main turbine housing. When submerged in a fast moving water source, the propeller is rotated by the force of the passing water. Propeller style generators work well for locations with a fast moving, relatively deep stream or river, where a water diversion system is not possible, or when mounted on a moving boat.*

***Exercise2* Comparing different models of micro hydro turbines, excerpting info from ads**

Scan through the following ads from *ABS Alaskan Inc Micro Hydro turbines catalogue* in ***Sheet1*** (http://www.absak.com/) and fill in a comparative table with the main characteristics of each turbine.

Table 1* - *Comparing Micro Hydro Turbines

Model	Type *[1]	Head (m)	Flow (lt/sec)	Best site characteristics	Output (W)	Price	Shipment	Extra needs / costs	Contact/website

*[1] Impulse, Reaction, Propeller

Sheet 1

ABS Alaskan, Inc. introduces ...

The PowerPal

Propeller Hydro Turbine

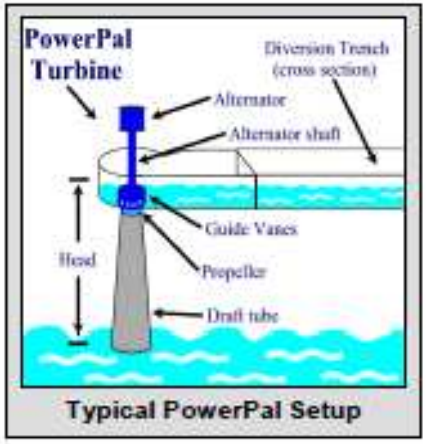
- **Power Production at 200W, 500W or 1000W (3 models to choose from)**
- **Operates efficiently on ultra low head (2 to 5ft)**
- **Designed for simple operation & low maintenance**

The PowerPal was designed for families in remote areas to produce power for their households easily and inexpensively. These units have been incredibly successful and today thousands are installed throughout the world.

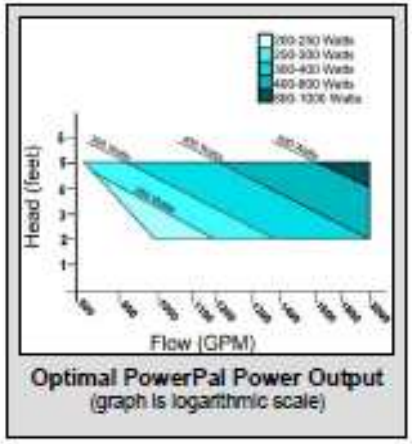
The PowerPal is a propeller turbine whose small size and light weight allows it to be installed virtually anywhere. It is the perfect hydro turbine for slow moving rivers and streams. Small, natural waterfalls or dams provide the ideal setting for the PowerPal.

Water enters the turbine from the top and drops into the propeller, spinning the blades. It exits the turbine through a sealed draft tube that is submerged in the outlet water, creating suction and increasing power production.

It can be quickly and easily moved to a new location, or removed temporarily during flooding or other adverse conditions. The PowerPal is designed to operate on a head (vertical distance between inlet water surface and the outlet surface) of 2 to 5 ft.



Typical PowerPal Setup



Optimal PowerPal Power Output
(graph is logarithmic scale)

ABS Alaskan, Inc. introduces ...

The Water Baby

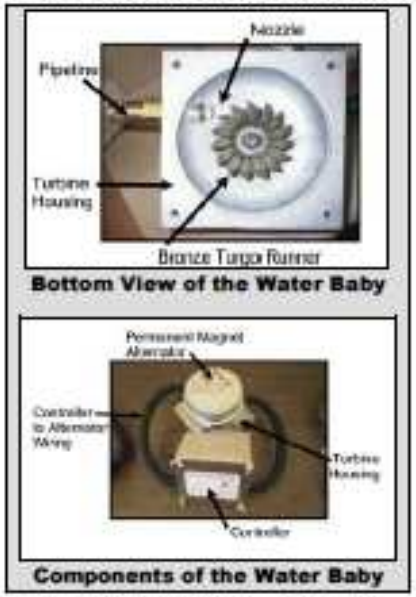
Hydro Turbine

- **Operates efficiently on ultra low flow (3 GPM)**
- **Super lightweight and compact design**
- **High quality turbine at a low price**

This turbine is a smaller ('baby') version of the Stream Engine. It is a lightweight and compact device which converts energy in water under pressure into electricity. It can operate on flow rates as low as 3 GPM, on heads from 50-500ft. To compare, 3 GPM is only slightly greater than the amount of water flowing out of a typical water faucet in your home. The Water Baby's bronze turgo runner is only 2 inches in diameter, making this one of the smallest turbines on the market. It the perfect hydro turbine for a site with low flow rate but a large 'drop' in elevation, such as a spring coming out of a hillside or a mountain stream.

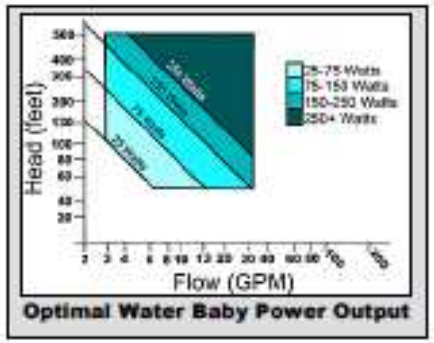
The Water Baby uses a maintenance free, highly efficient permanent magnet alternator. This alternator is specially designed to allow adjustments in output to be made while the turbine is spinning. This feature greatly simplifies optimization of power output for each hydro site.

The Water Baby comes standard with 12V, 24V or 48V DC output. It can also be outfitted with additional nozzles (up to 4) to accommodate higher flow rate. A high voltage option is also available for longer transmission distances.



Bottom View of the Water Baby

Components of the Water Baby



Optimal Water Baby Power Output

ABS Alaskan, Inc. introduces ...

The Aquair UW

Submersible HydroTurbine

- **Produces up to 100W of continuous power**
- **No pipeline or diversion channel necessary**
- **Effective operation in as little as 18 inches of water**
- **Simple installation and low maintenance**

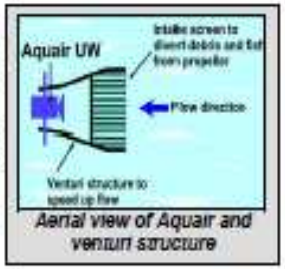
The AQUAIR UW is a propeller turbine of simple design and rugged construction. It was originally developed for use aboard seismic sleds towed behind oil exploration vessels. We like the AQUAIR UW because unlike other micro-hydro units where head, flow volume and nozzle pressure are factors, this unit simply requires *fast* moving water from a flowing stream, creek, river or sea.

The propeller is lowered into the water and held into place with a steady mount (not included). Power output is directly related to water speed, and at a flow of 6mph output will be around 60W, while at a flow of 9mph power generation will increase to 100W.

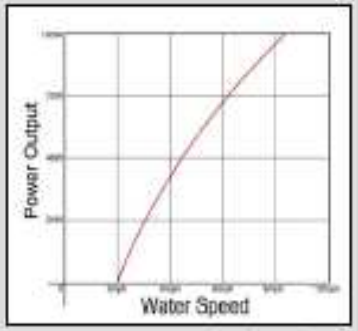
Water speed can be increased somewhat by use of a venturi pipe in the water upstream of the propeller, or by taking strategic advantage of the natural venturi effect created behind a large rock or submerged log.

The AQUAIR UW submersible generator is a rugged permanent-magnet low-speed high-output alternator sealed in an oil-filled waterproof housing.

It is ideally suited for use as an alternative power source for remote cabins when connected to storage batteries and an inverter. The AQUAIR UW Submersible Generator is warranted for three years.



Aerial view of Aquair and venturi structure



Aquair UW Power Output (In Watts)

Aquair UW with 4m of cable, heat sink and manual, all included

ABS Alaskan Inc. introduces ...

The Harris Pelton

Hydro Turbine

- **Can produce over 1.5kW of power**
- **Operates most efficiently on high head (above 25ft)**
- **Effective operation with ultra low flow (3GPM and greater)**
- **Reliable, year-round electricity at low cost**

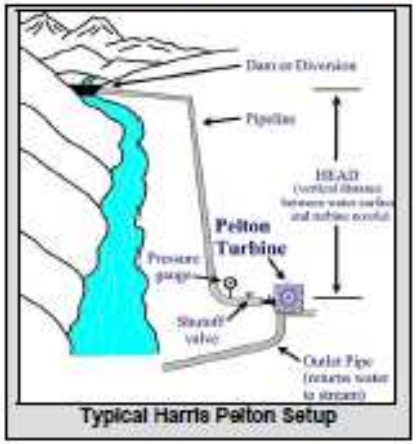
Water is collected upstream from the turbine and channeled in a pipe down to the turbine location. At the turbine, the water passes through a nozzle, where it accelerates, strikes the turbine runner, and turns a brushless permanent magnet alternator.

These turbines need very little water flow to run efficiently and produce significant power output. The standard configuration uses one nozzle, which is sized to match the water supply. Additional nozzles can be added (up to 4) with a maximum flow at each nozzle of 30 GPM.

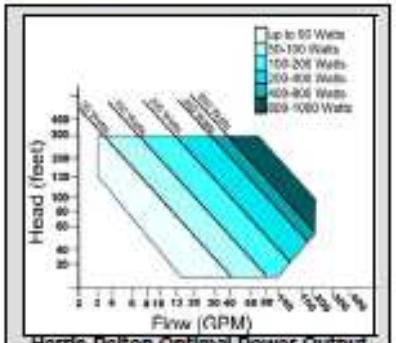
Typically, the turbine generates DC electricity – 12volt, 24volt or 48volt – which is then either stored in a battery for future use or used directly to power DC appliances. An inverter can also be incorporated into the system to convert the DC electricity to standard household AC electricity.

Close-up of the Harris Pelton Turbine runner

The Harris Pelton Hydro Turbine



Typical Harris Pelton Setup



Harris Pelton Optimal Power Output
(graph is in logarithmic scale)

ABS Alaskan, Inc. introduces ...

The Niade
Hydro Turbine

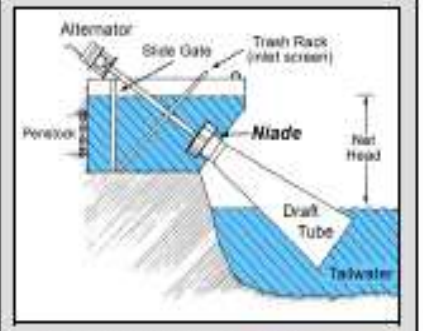
- **700 watts peak output (9 in. model)**
- **Produces power from 2 – 4 feet of head**
- **Shipped complete, easy install, no hidden costs**

The Niade is an ultra-low head propeller style turbine in a complete housing for 'drop in' installation in almost any low-head site. Like the Nautilus and Neptune turbines, it uses a 'draft tube' from the turbine to the tail water, also producing 'suction head' to maximize output. The Niade turbine is the first micro-hydro turbine in the world to produce usable power with less than 4 feet of head.

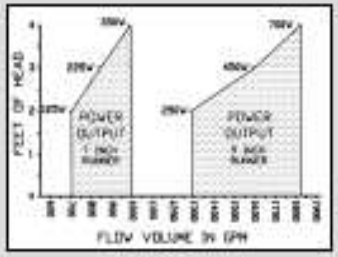
The Niade is delivered as a complete package, including the cast-iron propeller turbine and housing, draft tube, slide gate (to shut off water flowing into the turbine), a protective trash rack/inlet screen and the alternator. The complete package is ready to install, with no hidden costs or extra accessories needed.

The Niade can be lifted with a small front-end loader, or even by hand with enough man power, weighing in at 300-400 lbs. It is a rugged, durable design, intended for user installation in nearly-level sites where other turbines cannot develop enough head to produce usable power. The Niade should be installed with the housing/flume level with the surrounding land, allowing the draft tube to angle downwards into the tail race excavation. After attaching the flume inlet to your installed penstock, and backfilling the excavation to stabilize the turbine, the Niade is ready to wire into your power system.

The Niade turbine is available with either an 7 inch or a 9 inch cast iron runner. Using the 9" runner, electrical output will vary from 250 watts at 2 ft of head and 1293 GPM of flow to over 700 watts with 4 ft of head and 1828 GPM of flow. With the 7" model, the Niade will produce from 125 watts at 2 ft. of head with 704 GPM flow, up to 350 watts with 4 feet of head and 994 GPM of flow.



Basic components of a Niade hydro system



Optimal Niade Power Output

ABS Alaskan, Inc. introduces ...

The LH-1000
Hydro Turbine

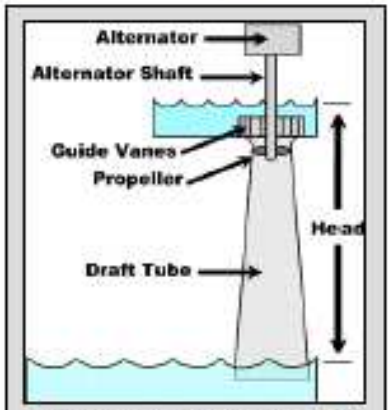
- **Produces up to 1 kW of electricity**
- **High quality turbine at a low price**
- **Ultra low head (2 ft to 10 ft)**

The LH1000 is an exciting hydro turbine that produces DC electrical power at sites with sufficient water flowing across relatively level terrain. The LH1000 uses a durable, low-head bronze propeller to produce power on a head of 2 to 10 feet. At 10 ft of head, the output from this turbine is one kilowatt, which is enough to supply the electrical requirements for an average household.

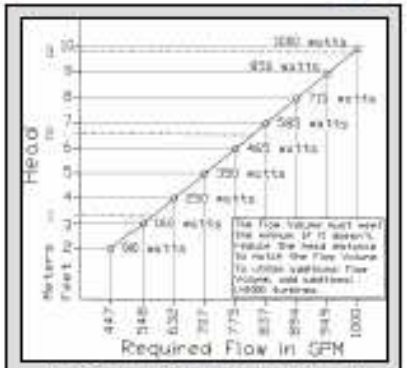
The LH1000 uses a permanent magnet alternator, which increases efficiency and performance while greatly reducing maintenance. This alternator is specifically designed for DC electrical output, eliminating the extra cost and inconvenience of an external turbine speed controller.

Water enters the LH1000 through the top guide vane assembly. As it falls through the turbine it turns the propeller, which spins the alternator, creating electricity. The water then exits the turbine through the draft tube, which is a sealed, tapered tube immersed in the tailwater. The draft tube creates a suction effect in the turbine, greatly increasing the turbine capacity.

The LH1000's light weight and small size allow for easy installation, portability, and quick removal during adverse conditions.



Basic Components of the LH1000



Optimal LH1000 Power Output
Required Water Flow Volume & Power Output in Watts for Various Head Distances.

ABS Alaskan, Inc. introduces ...

The Neptune

Hydro Turbine

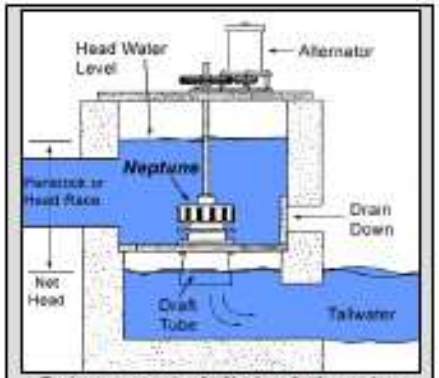
- **Produces over 2.2kW of power**
- **Very effective low head (3-10 ft) turbine**
- **High quality design and long service life**

The Neptune is a Francis-style turbine capable of tremendous power output in a compact design. It will provide power for generations on as little as four feet of head. It is essential the same as the Nautilus turbine, except that the water, whether channeled to the turbine via pipe or open canal, empties into an open chamber in the turbine. This 'open' water diversion system prior to the turbine means that the 'pressure head' is limited to the depth of the water directly above the turbine. Like the Nautilus turbine, it uses a 'Draft Tube' from the turbine to the tail water, also producing 'suction head'. The Neptune turbine is ideally suited for low head applications. For heads over 8 ft (2.5 m), the Nautilus turbine is recommended.

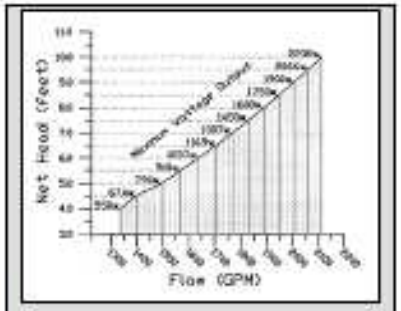
The Neptune has an expected life of over 50 years. All components are made of laser-cut stainless steel to insure smooth water surfaces that will never rust. Massive taper roller bearings and carbon/ceramic face seals will last 7-10 years between refits.

The Neptune can be disassembled and easily transported into the most areas. There are several permanent magnet alternator choices, available in both direct-coupled and timing-belt driven configurations, and with 24VDC, 48VDC, and high voltage DC output.

The Neptune turbine is available with either an 8 inch (203 mm) or a 10 inch (254 mm) stainless steel runner. Using the 10" runner (shown in graph), electrical output will vary from 550 watts at 4 ft (1.2 m) of head and 1350 GPM of flow to over 2200 watts with 10 ft (3 m) of head and 2100 GPM of flow.



Basic components of a Neptune hydro-system



Optimal Neptune Power Output
With 10 inch runner option

ABS Alaskan, Inc. introduces ...

The Stream Engine

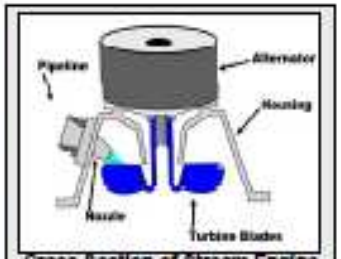
Hydro Turbine

- **Can produce over 1kW of power**
- **Operates efficiently on low head (down to 5 ft)**
- **Easy installation and low maintenance**

Water is collected upstream from the turbine and channeled in a pipe down to the turbine location. These turbines don't need a lot of elevation change to run efficiently and produce significant power output.

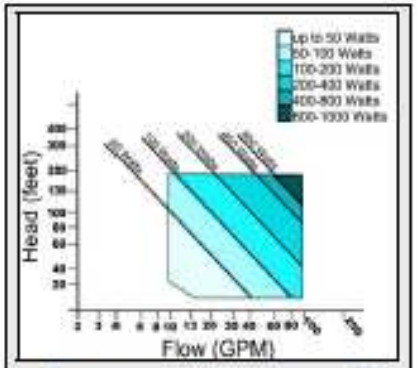
This means you'll get about the same amount of power from 6ft of head and a flow of 400GPM as from a flow of 6GPM and 400ft of head.

The Stream Engine has a brushless permanent magnet alternator driven by a 'Turgo' runner. In micro-hydro applications, the Turgo style runner is better suited to higher flow rates than the 'Pelton' runner, due to a design more efficient at removing large quantities of water from the system with minimal loses from back pressure.



Cross Section of Stream Engine
(Drawing is not to scale)

The standard configuration uses two nozzles, which are adjusted on-site to match the water supply. These turbines generate DC electricity – 12volt, 24volt, or 48volt – which is then either stored in a battery for future use or used directly to power DC appliances.



Stream Engine Optimal Power Output
(Graph is in logarithmic scale)

The Stream Engine with the Turgo runner housed in the white casing, the permanent magnet alternator on top and the controller in the foreground (silver box)

Exercise 3 *Matching sites and turbine models (in groups, plenary following)*

Read the following descriptions of potential sites for micro hydro power generation and match each of them with the most suitable kind of water turbine (see Sheet 1 Exercise 2).
Discuss with your partners and state your reasons writing a few sentences.
Could it be that any of the sites is not a suitable one for a micro power plant? Why? Explain briefly.

A) Often enough mountain huts are settled near torrents or water springs.
Suppose the water jump is 4 m with a relatively tiny sprout (0,3 minutes to fill a 1 lt bottle)

B) As water falls through mountain water ducts to reach the taps of houses in the villages, gravitational potential energy is forever lost.
By fitting small micro hydro turbines into the pipes, some of this energy could be salvaged and turned into electrical energy for single households.
We can estimate the head from 5 to 10 m at least and a pipe cross section of 60 cm.

C) At the bottom of the valley the once wild torrent becomes a river: larger, slower, deeper.
Jumps are no more than 2,50 m high but as large as the whole river bed.

D) Many towns in the Alps and in Germany (see Augsburg) have kilometres of fast running narrow water canals crossing the city centre.

E) On the Italian Appenines you can still find places where trout is bred. This kind of fish can't survive in even minimally polluted water so a constant supply of fresh and clean water is needed. This is why in trout ponds there's always running water and you often see small waterfalls of about 0,65 to 1 m high either bringing water in into or out of the pond .

F) Venice is famous for being built on the water: canals take the place of streets, boats substitute cars.
Unfortunately water in the canals is quite still and not really deep.
But as you travel by vaporetto or motor boat, instead of a romantic gondola, the relative speed of the water, which is equal to the boat one but in the opposite direction, could be worth considering for power generation.

Exercise 4 *Scanning the market for best offers and state of the art*

1. Surf the Net for any other firms manufacturing micro hydro turbines, particularly in Europe and in your own country.
2. Complete Table 1 with this additional info. Present to your fellows and compare your findings.
3. Would you change something in Exercise 3 with this updated table?

Exercise 5 *Advertising*

Design an A4 leaflet advertising the best micro turbine ever to be implemented in your local area. Remember that your aim is both to give technical info and to convince potential buyers.

Exercise 6 *Searching for potential sites*

Try to think of any other potential waterpower site in or around your town. Make a prediction about flow and head (just a rough estimate) and give a brief description of the site characteristics.
Suggest
A) the most efficient water turbine model for that site (with a detailed motivation)
B) the possible applications of the expected electrical output

Exercise 7 *In field trip measurements*

Now choose one or more real sites you can have access to (they can either be from exercise 5 or new ones) read **Sheet 2** and devise how to take exact measurements of head and flow. Discuss your notes with your group and…go!
Take your measurements and share them with your pals including photos, sketches, calculations and descriptions.
Suggest the best water turbine option too.