An Introduction to

Micro- Hydropower *Systems*

Natural Resources Canada
Ressources naturelles Canada

Canada

Introduction

Hydropower technology has been around for more than a century. Hydropower comes from converting the energy in flowing water – using a water wheel or a turbine – into useful mechanical power. This power is then converted into electricity by an electric generator.

Micro-hydropower systems are small hydropower plants that have an installed power generation capacity of less than 100 kilowatts (kW). Many micro-hydropower systems operate "run of river," which means that no large dams or water storage reservoirs are built and no land is flooded. The majority of these systems only use a fraction of the available stream flow to generate power, and this has little environmental impact.

Micro-hydropower provides

- an economical and renewable source of electricity
- excellent reliability and proven technology
- low maintenance costs and a long life – 20 to 30 years

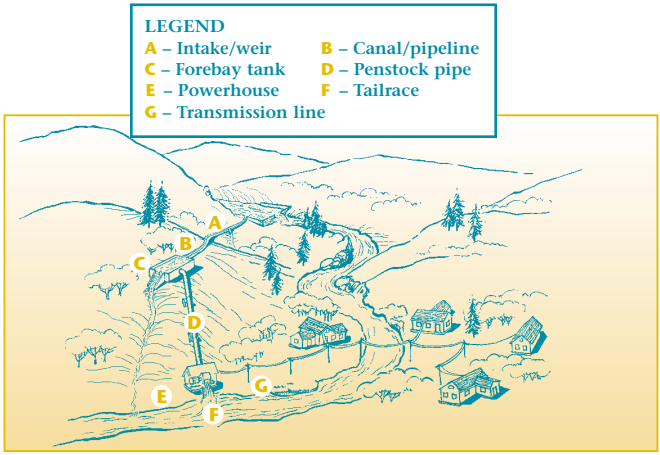
Micro-hydropower systems are ideal for remote off-grid residential homes, cottages, ranches, lodges, camps, parks, small communities and First Nations communities. These systems can also be used to connect to the grid in a net-metering arrangement.

Components of a micro-hydropower system

A micro-hydropower system may have the following components depending on the site:

- an intake or weir to divert stream flow from the water course
- a canal/pipeline to carry the water flow to the forebay from the intake

- a forebay tank and trash rack to filter debris and prevent it from being drawn into the turbine at the penstock pipe intake
- a penstock pipe to convey the water to the powerhouse
- a powerhouse, in which a water turbine (Pelton, Turgo, Francis, propeller turbines or pump-as-turbine) converts the energy of the flowing or falling water into mechanical energy that drives a generator, which in turn generates electrical power
- a control mechanism (load controllers) to provide stable electrical power
- a tailrace through which the water is released back to the river or stream
- electrical transmission lines to deliver the power to its destination



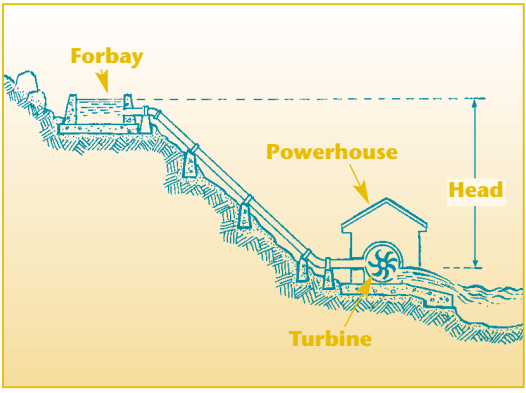
Principal components of a micro-hydropower system

Site potential

The amount of energy available from a creek, stream or river depends on the amount of water flow per second (flow rate), the height (head) from which water falls and the force of gravity. Power potential in a particular site can be calculated using the following equation:

$$P = Q \times H \times g \times e$$

P = power output in kW
Q = usable flow rate in cubic metres per second (m^3/s)
H = gross head in metres (m)
g = gravitational constant (9.8 m/s^2)
e = efficiency factor (0.5 to 0.7)



▲ *Head of micro-hydropower system*

Energy is always lost when it is converted from one form to another, and all of the equipment used to convert the power available is less than 100 percent efficient. To calculate the realistic power output from your site, you must take into account the friction losses in the penstock pipes and the efficiency of the turbine and generator; this is the efficiency factor (e).

Example:

A turbine generator set to operate at a head of 10 m (33 ft.) with flow of 0.3 m^3/s (636 cu. ft./min) will deliver approximately 15 kW of electricity.

This is given by P = Q (0.3) × H (10) × g (9.8) × e (0.5) = 14.7 kW, assuming an overall system efficiency factor of 50 percent.

Environmental issues and approvals

It is illegal to take surface water from a stream without first obtaining a water licence or other approval. Contact your provincial/territorial government offices that deal with land and water in order to determine what local permits are needed for your area.

Permits and approvals that you may need when constructing a micro-hydropower system include:

- environmental approvals (provincial/territorial and federal)
- agreement regarding the use of water (provincial/territorial)
- operating agreement (provincial/territorial)
- land lease agreements (provincial/territorial)
- permits for the use of navigable waters (federal)
- building permits (provincial/territorial)

Application

Micro-hydropower systems are suitable for off-grid power generation and also can be connected to the grid in a net-metering arrangement. Systems are available as small as 0.1 kW for battery-based systems, up to 100 kW. Micro-hydropower systems provide energy continuously, 24 hours a day. In remote locations where electricity is provided by diesel generators, micro-hydropower offers an opportunity to directly replace a fossil fuel with a renewable energy source.

System sizing

In assessing the feasibility of developing a micro-hydropower system, you should carefully examine your power and energy requirements.

The most important question in planning a micro-hydropower system is how much energy can be expected from the site and whether or not the site will produce enough power to meet your energy needs. For a stand-alone micro-hydropower system, it must be large enough to meet peak power consumption if you want to be energy-independent.

If the site's potential power output is less than you require, you could use battery-based systems to help meet consumption peaks.

The site's available head and flow rate are the major factors that limit the size of the installation, and economics will dictate the size of the hydropower site that you may want to develop.

Costs

How much will a micro-hydropower system cost? There is no standard answer to this question because costs depend on site conditions and on how much work you are prepared to do yourself. In general, with current technologies, the total cost can range from $1,500 to $2,500 per kilowatt of installed capacity, depending on the system's capacity and location. For systems that are less than 5 kW in power output, the cost per kilowatt is approximately $2,500 or higher because of the smaller size and the cost of additional components such as a battery bank and inverter.

Hydro costs are site-specific. High-head, low-flow system costs are less than those for a low-head, high-flow system because all components of low-flow systems (e.g. penstock, turbine, intake and spillway) will be smaller and cheaper.

▲ *A directly coupled Pelton turbine with a synchronous generated 8-kW system*

Generally, micro-hydropower systems have high initial development costs, but very low annual operation and maintenance costs. It has been demonstrated that hydropower can produce many times more power and energy than several other sources for the same capital investment.

Further information

If you are interested in developing a micro-hydropower system, a good place to learn the basics is Natural Resources Canada's *Micro-Hydropower Systems: A Buyer's Guide*, which will help you decide if micro-hydropower is a viable option for you. It will

- introduce you to the basics of how a micro-hydropower system works
- offer pointers on how to assess how much energy and power you need
- introduce you to the principal components of a micro-hydropower system
- outline how to determine if a micro-hydropower system makes economic sense for your circumstances
- offer some practical examples of micro-hydropower systems

You can contact one of the groups listed below for more information.

Renewable and Electrical Energy Division

Electricity Resources Branch
Natural Resources Canada
580 Booth Street, 17th Floor
Ottawa ON K1A 0E4
Fax: (613) 995-0087
Web site: reed.nrcan.gc.ca

Renewable Energy Technologies

CANMET Energy Technology Centre – Ottawa
Natural Resources Canada
580 Booth Street, 13th Floor
Ottawa ON K1A 0E4
Fax: (613) 996-9416
Web site: nrcan.gc.ca/es/etb

Or visit the following Web sites for more information:

- Canadian Renewable Energy Network: **canren.gc.ca**
- International Small-Hydro Atlas: **www.small-hydro.com**

To order additional copies of this brochure, a copy of *Micro-Hydropower Systems: A Buyer's Guide* or any other publication on renewable energy and energy efficiency, call **1 800 387-2000** (toll-free).

You can also obtain a copy of this and other publications by visiting Natural Resources Canada's Canadian Renewable Energy Network Web site at **canren.gc.ca**.

Manufacturers and Suppliers

See the Canadian Renewable Energy Network Web site at **canren.gc.ca** for a list of manufacturers and suppliers of micro-hydropower systems.

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