

# **A Community Guide to Small Waterpower Development**



***Affordable, Reliable Power –  
Stable, Sustained Investment***

**[www.owa.ca](http://www.owa.ca)**



Is it any wonder that here in Ontario we use the term “hydro” interchangeably with “electricity”? Hydro or waterpower was responsible for the electrification of the province. It is the energy engine that built Ontario’s original economic prosperity. It has been providing reliable, affordable electricity for more than a century.

In countless towns and cities across the province, the very identity of the community is inextricably linked with the generation of electricity from falling water. There are more than one hundred and twenty (120) hydroelectric facilities across southern Ontario – over two hundred (200) in the province.

There are approximately two thousand (2000) dams in Ontario that are currently not supplying hydroelectricity, but are serving alternative purposes (flood control, navigation, water management, etc.). Taking advantage of these existing resources and retrofitting for the future is a great opportunity for long term prosperity at a community level.

Community based waterpower is a fantastic opportunity to participate in developing clean energy. Not only is waterpower a great way to improve the environment, it is also an opportunity for communities to come together and benefit economically. A more diverse energy mix developed through local community involvement will benefit us all.

Whether you are taking the first steps in developing a new project or whether you are thinking about participating in an existing project in your community it is essential that you have the right decision-making tools. This guide has been developed to help local communities make these decisions.

## ***The Basics***

### **WHAT opportunities are there?**

Community waterpower projects require local people involved in supporting, initiating, developing, operating and/or benefiting from the development. Community projects are very diverse and come in many shapes and sizes. Community based waterpower projects help decarbonize, decentralize and democratize our electricity system.

One of the strengths of waterpower development is that every project is slightly different, and can be tailored to each community’s needs and context.

# President's Introduction

## **WHY is community waterpower important?**

Community waterpower projects create social, political, environmental, economic and technological benefits by:

- strengthening local economies;
- building community participation, resilience & empowerment;
- involving communities in creating a sustainable low-carbon future;
- directly and significantly reducing a community's carbon footprint;
- developing renewable energy industries, technology, jobs and training.

## **Always Engage your Community**

### **Why?**

People form the foundation of a community renewable energy project and community support is critical to success. Getting people on board with the project vision will build a base of champions in the community and, ultimately, these people may become an investor base.

### **What?**

Gauge the level of support, identify and recruit active members, identify partner organizations, educate the public about renewable energy options, build a groundswell of supporters.

### **How?**

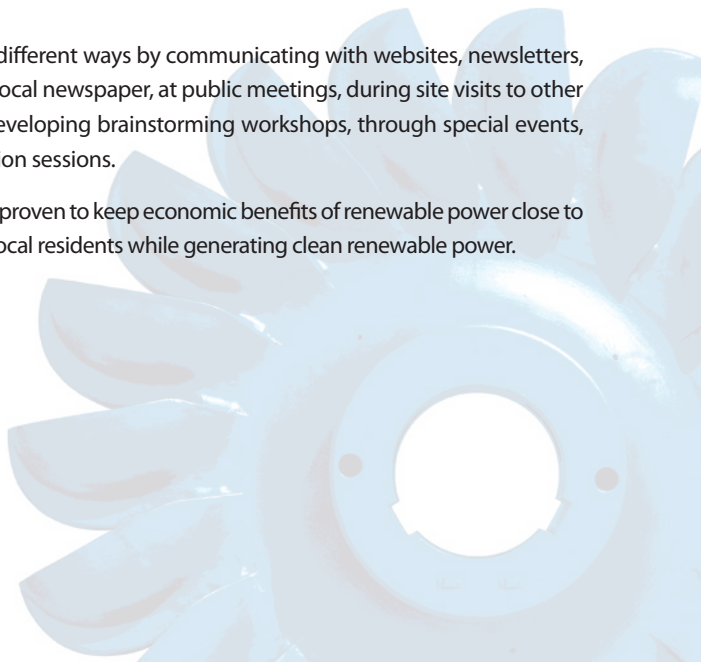
Engage your community in many different ways by communicating with websites, newsletters, on street stalls, with articles in the local newspaper, at public meetings, during site visits to other community renewable projects, developing brainstorming workshops, through special events, celebrations, and drop-in information sessions.

Community based waterpower has proven to keep economic benefits of renewable power close to home, improving quality of life for local residents while generating clean renewable power.

Sincerely,



Paul Norris  
President  
Ontario Waterpower Association



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## Introduction

Ontario's original economic prosperity was fueled by the province's first source of renewable energy – waterpower. At one point, there were more than five hundred (500) operating hydroelectric facilities across Ontario. In fact, until the early 1950's all of the province's electricity came from falling water. Today, waterpower accounts for approximately one quarter (1/4) of the electricity generated and remains the backbone of a reliable, durable system.

In Ontario there has been renewed interest in renewable energy development. Waterpower is one of those "renewables" and "small hydro" has been of special interest in particular. There are a significant number of small sites with the hydraulic potential to support generation. This guide has been designed to assist those with an interest in developing a small waterpower project and for participants in the Feed-in Tariff Program (<500 kW) in particular and has been prepared by the Ontario Waterpower Association (OWA). Our goal is to provide you, the reader, with relevant information about waterpower in an easy to understand format.

We welcome all comments and suggestions to enhance future versions. Please provide your comments to [info@owa.ca](mailto:info@owa.ca).





*Fletchers Horsefarm, Waterford Ontario -  
Greenbug Energy Micro Hydro Facility (7.3 kW)*

## **1.0 Ontario's Electricity System**

### **1.1 How does Ontario's electricity system work?**

Ontario's electricity system is characterized by its diversity. Multiple energy sources provide electricity to Ontarians. Until the early 1950s, almost all of these needs were met by waterpower. In the decades that followed, the province turned to fossil fuels, nuclear energy and, now, alternative renewable sources including wind, biomass and solar energy. Waterpower currently accounts for approximately one-quarter of Ontario's installed capacity for electricity generation.

#### ***What is a transmission system and how does it work?***

Today we have a very large transmission system – a web of wires, towers and transformers – that moves and distributes the electricity. This is a very sensitive and complex process that involves precise attention to many interconnected details. The quantities of electricity being generated in different ways and at different locations must be balanced with how much electricity is needed where, and when.

#### ***What is renewable energy and why is it important to us?***

Renewable electricity is made from an energy source that can remake or replace itself. The energy of flowing water is such a source. So is the movement of the wind, the rays of the sun and the heat of the earth.

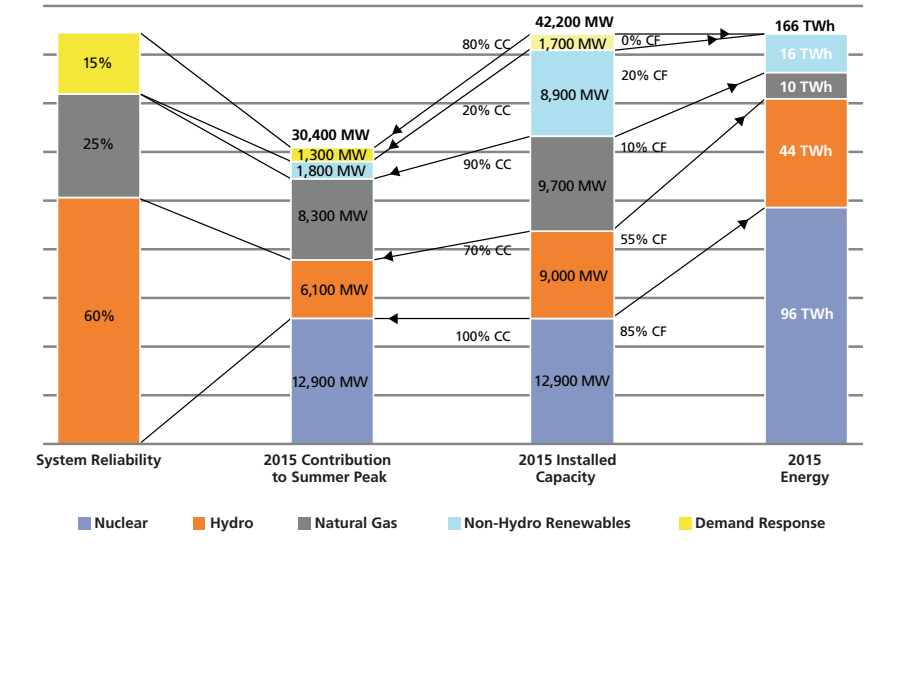
In contrast, coal, nuclear energy, and natural gas are not renewable resources. They do not replenish or re-make themselves. They must be mined, refined, transported and one day they will be gone. Renewable energy is also important because it creates very little greenhouse gas emissions and so helps reduce one of the causes of global climate change.



*Waterpower’s role in Ontario’s electricity system*

Waterpower plays a particular role in the province’s energy system mix. It provides base-load and peak-load generation. This means that, depending on the type of facility, waterpower can provide a constant supply of electricity, generate power in response to increases in demand, or store excess electricity at times of low demand (e.g. at night). As explained by the IESO, generation technologies within Ontario’s supply mix deliver differing “products” to the reliable operation of the province’s electricity system. For example, as shown on the graph below, the “capacity”, measured in megawatts is similar between nuclear, natural gas, waterpower and other renewables. The bar on the far right, however, shows the difference between the “energy” from these sources. As a rule of thumb, it takes 2 MW of wind and 5 MW of solar to produce the same amount of electricity as 1 MW of waterpower. In addition, the two left bars show that waterpower and natural gas provide the bulk of the essential “reliability” services to the system. For example, waterpower led Ontario’s recovery from the 2003 blackout because of its unique ability to restore the grid to operation without relying on the external transmission network.

*Figure 1: Comparison of Electricity Sources*

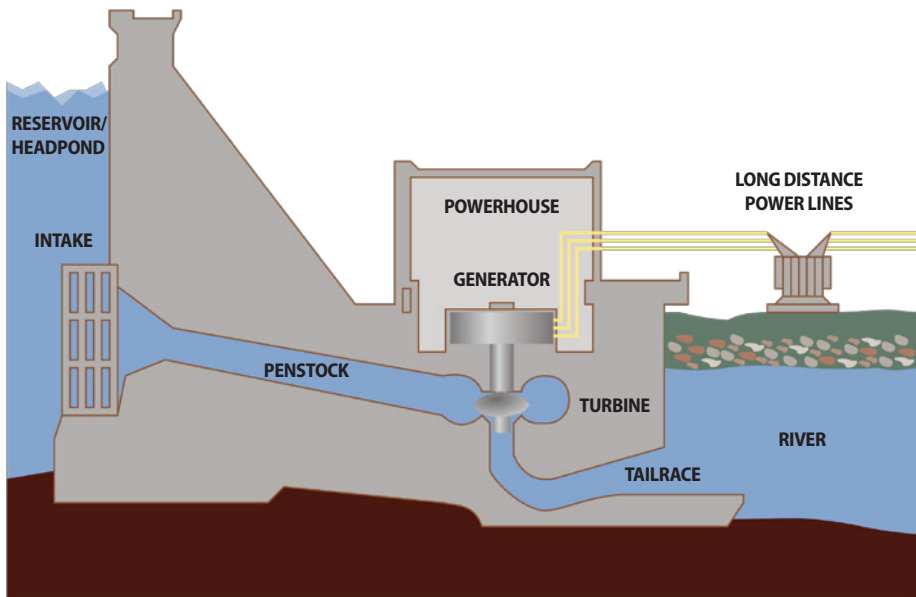


## 2.0 An Introduction to Waterpower

### 2.1 How does waterpower work?

Waterpower generation harnesses the energy of moving water. When water flows downhill the force of gravity changes the potential energy to kinetic energy. The higher the hill, or drop, the more kinetic energy is created. The first step in changing the kinetic energy into electricity is to divert the water from the main water body (e.g., the river), direct it through an intake pipe into the penstock, and then into a powerhouse containing a turbine(s), a generator, and controls. The momentum (kinetic energy) of the flowing water forces the blades of a turbine to move. The turning of the blades causes a shaft to spin and this, in turn, spins the rotor of a generator. When the rotor in the generator is spun, an electromagnetic field and electricity is generated.

*Figure 2: Hydroelectric Facility*



*Definitions of these key features are as follows:*

1. **Reservoir or Headpond:** Area of the waterbody immediately upstream of the intake. The elevation of the headpond is used to calculate the head available for the project, and in turn, the amount of energy the project can produce.
2. **Dam:** A structure constructed to create a reservoir or maintain a headpond at a certain level, and direct water into the power plant intake.
3. **Spillway/Sluiceway:** An opening in the dam that allows water to pass without going through the plant. This is done to maintain environmental flows important to the ecology of that section of the river. It also helps to manage higher flows during the spring or during very heavy rainfall events.
4. **Intake:** A structure, generally made of concrete, that is the opening through which the water leaves the headpond and goes into the power plant trashrack to keep debris from entering the plant.
5. **Penstock or Tunnel:** A penstock is a pipe or tunnel that carries the water from the intake to the powerhouse.
6. **Powerhouse:** A building containing the generating equipment, control room, electrical switches etc.
7. **Turbine:** The part of the generating equipment that water flows through to rotate the blades and spin the generator shaft.
8. **Generator:** The part that converts the mechanical energy from the spinning shaft into electrical energy using magnetic fields.
9. **Draft Tube:** A pipe that discharges the water from the turbine to the tailrace.
10. **Tailrace:** An open canal that returns all the water originally diverted from the river back to the original river course.
11. **Switchyard:** A fenced in area containing the transformer that converts the electricity from the generation voltage to the transmission voltage. It is from here that the electricity is connected to the transmission line, which then takes the electricity to homes and businesses.

## **2.2 What are the different types of waterpower facilities?**

Different types of waterpower structures suit different locations for reasons including: terrain, amount of water available, environmental values, construction and operating costs, local demand, and economic viability.

Waterpower facilities can be characterized by the degree to which they involve water storage. The four main types are:

1. Run-of-river
2. Run-of-river with modified peaking
3. Reservoir storage and cascade systems
4. Kinetic waterpower

Although electricity cannot be stored, the water storage (or reservoir) of waterpower facilities is electrical generation capacity that can be activated almost immediately to respond to sudden changes in demand.

### **Run-of-River**

A run-of-river facility uses only the natural flows in the river, as they are available, for generation. Therefore, the flow in the river is either passed through the plant, or partially released around the plant if the flow exceeds the capacity of the plant to use all of it.

### **Run-of-River with modified peaking**

Many run-of river plants allow for limited storage of water over the course of the day or days. This allows the plant to produce more electricity during periods of high demand i.e., during the day/work week, and save water during periods of low demand i.e., at night/weekends. This type of plant can provide electricity service to the system, but with limitations imposed by the amount of storage and flexibility available (generally through a headpond).

### **Reservoir storage and cascade systems (peaking)**

These are waterpower projects that use reservoirs to store water from periods of high flow, such as during the spring. The stored water is then used to generate electricity during low flow periods such as during the winter or summer. Reservoirs may be managed specifically for waterpower production at the site and may also serve a series (or cascade) of facilities downstream. Note that this type of management regime is also used for purposes other than electricity generation (e.g., flood control).

### **Kinetic hydro**

Kinetic water power systems are an emerging technology in Ontario. Turbines are placed in the river and use only the existing flow to generate electricity – there is no head involved. Kinetic systems produce less energy per unit volume of water and are generally used for small scale projects such as a remote cottage or resort.





## **3.0 Resource Access and Site Viability**

### **3.1 Resource Access**

In Ontario, the ability to develop a waterpower facility is premised on access to the beds and banks of the river, creek or stream over which water flows rather than to the water itself. In most instances in Ontario, the development of a waterpower project involves access to Crown land. Proponents must consider the interests of riparian owners, backshore owners, and other related interests that may be impacted by a proposed development.

#### **Provincial Crown Land**

For waterpower projects located in whole or in part on provincial Crown land, the Ontario Ministry of Natural Resources and Forestry is the first point of contact. For small projects, the Ministry has aligned their application process for access to Crown land with the Feed-in Tariff application.

#### **Federal Crown Land**

Proponents should consult the Dominion Waterpower Act and Dominion Waterpower Regulations for waterpower projects with Federal land components. Proponents are advised to contact the federal agency with jurisdiction of their proposed development for the most up-to-date information on federal policies and procedures as they relate to waterpower development.

#### **Private Land**

Proponents of a waterpower project are encouraged to perform their due diligence by consulting all relevant documents before pursuing with a development that does not include access to Crown land in some manner. Ownership of the bed and banks of the river can be established by consulting the deed of your property and requires additional real estate and legal expertise.

### 3.2 Site viability

Assessing the viability of a site will tell us if it is worth developing. There are three major factors to consider:

1. how much electricity the site is physically capable of generating;
2. what the social and environmental values of the river are; and
3. where and what type of connections to distribution/transmission lines are available.

To determine how much electricity a waterpower site can generate consider:

1. the **head**, or the height of the vertical drop the water will fall;
2. the quantity or **flow** of water; and
3. electricity **generation**.

The head is an important factor in the electricity generation equation. The higher and steeper the drop, the less water you need to create the same amount of electricity. Conversely, the lower the head, the more water you will need.

### 3.3 Water flows

The flow of water available to run through the turbines is equally important. More water = more electricity. Flow is a physical measurement of the amount or volume of water in the river over time. It is measured in cubic metres per second (m<sup>3</sup>/s). The amount of water available for the turbine needs to be determined through a multiuse approach that balances the actual physical amount of water in the river with all the demands (wildlife, businesses, social) on the same resource.

The following figure illustrates one year of the daily flows on an unregulated river (i.e., no water management) in Ontario. By analyzing this flow data over time a (**Flow Duration Curve [FDC]**) can be made to provide a good summary of the changes in river flow.

Figure 3: Daily Discharge for an unregulated river

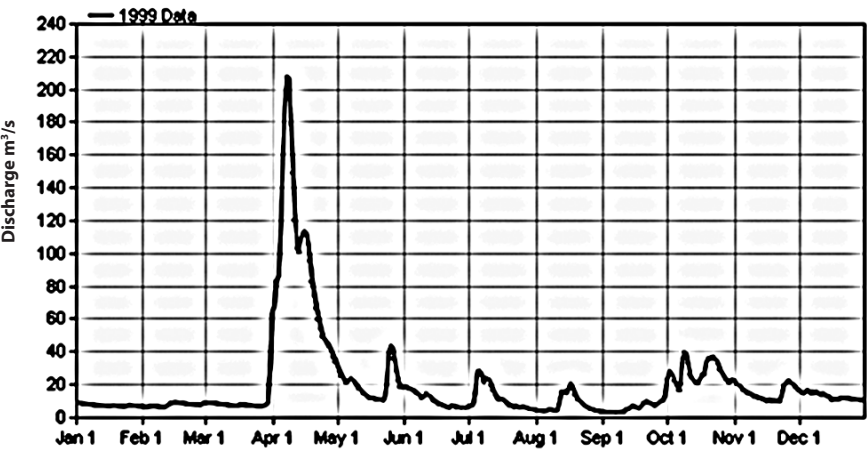
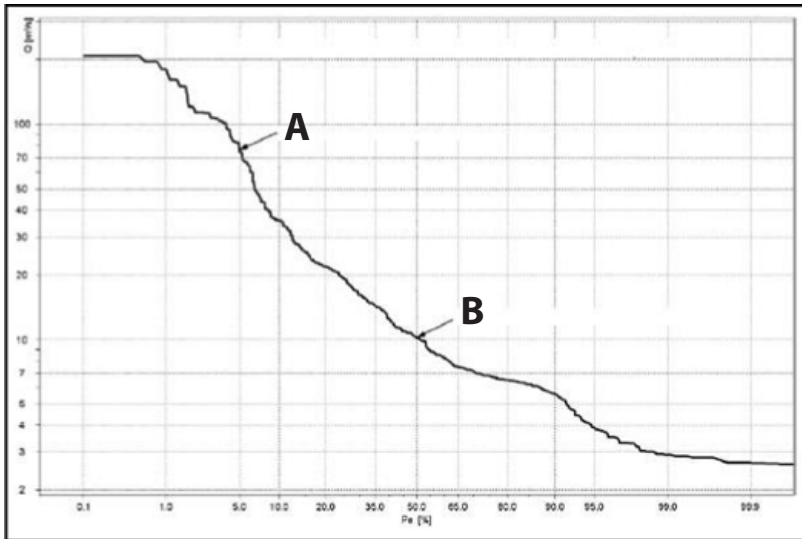


Figure 3 shows that during one year the river experienced low flows from January through April. In mid-April the flows dramatically increase, reflecting the spring melt water runoff. By mid-May, the flows are again low for the summer season. Several spikes from June through December indicate rainy periods.

Figure 4: Flow Duration Curve



This flow duration curve shows the percentage of time (x-axis) that the flow in the river in  $\text{m}^3/\text{s}$  (cubic metres per second – y-axis) has reached or exceeds a given flow rate.

For this example the flow in the river is greater than  $75 \text{ m}^3/\text{s}$  approximately 5% of the time (point A).

For most run-of-river projects, it is generally advisable to pick a plant flow in the order of 50 to 60% exceedance. Therefore, if we were to pick the 50% exceedance flow, we would get approximately  $10 \text{ m}^3/\text{s}$  (point B).

If the facility is going to produce electricity all year long it needs a steady flow all year long. In Ontario this usually means that an upstream headpond or reservoir is required.

Flow data for rivers across Ontario can be obtained from the Water Survey of Canada, [www.wsc.ec.gc.ca/products/main\\_e.cfm?cname=products\\_e.cfm](http://www.wsc.ec.gc.ca/products/main_e.cfm?cname=products_e.cfm).

### 3.4 Annual energy generation potential

To estimate annual energy generation potential, first determine the kW capacity of the site using a simple equation:

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

where:

P = Power or capacity of the plant in kW

H = Head in meters i.e., the vertical distance the water falls or the difference between the headpond elevation and the tailwater elevation.

Q = Plant flow in m<sup>3</sup>/s as determined above (for above example Q(50%)=10 m<sup>3</sup>/s)

g = Gravitational constant = 9.8 m/s

e = Efficiency of the generating equipment. As a first guess a value of 85% or 0.85 can be used until additional information is obtained from an engineering consultant or equipment supplier.

Example – for a site with a head of 5 metres then:

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

$$P = 5 \text{ m} \times 10 \text{ m}^3/\text{s} \times 9.8 \times 0.85$$

$$P = 416.5 \text{ kW}$$

Therefore, the plant potential capacity would be approximately 400 kW.

Once you know the approximate size of the plant, calculate the amount of energy generation (E) that can be expected per year:

$$E = P \times \text{time} \times \% \text{ of time the plant will run}$$

P = Power or capacity in kW. Use P= 400 kW from example above.

Time = number of hours in a year = 24 hours/day x 365 days/year = 8,760 hours/year

A consultant will have to give you an estimate of the percentage of time the plant will run based on your site. However, for a very rough estimate, 55% may be assumed. This will account for repair times and low flow periods when the plant cannot run at full capacity. Therefore, from our earlier example:

$$E = P \times \text{time} \times 55\%$$

$$E = 400 \text{ kW} \times 8,760 \text{ hours/year} \times 0.55$$

$$E = 1,927,200 \text{ kWhours}$$

**NOTE:** This example is based on a run-of-river type of project. Projects that involve any type of water storage/reservoir will need to determine and factor in the other uses or values of the stored water.





*McLeod Dam, Quinte Conservation – Dam was built to provide a storage area to prevent ice sheets from moving downstream into the City proper. It was updated in 2007 to also produce hydro-electricity.*

## 4.0 Waterpower Financial Modeling

### 4.1 The Feed-in Tariff Program

The Feed-In Tariff (FIT) Program was developed for the Province of Ontario to encourage and promote greater use of renewable energy sources including on-shore wind, waterpower, renewable biomass, biogas, landfill gas and solar photovoltaic (PV) for electricity generating projects in Ontario. The fundamental objective of the FIT 4.0 Program is to facilitate the increased development of renewable generating facilities of varying sizes, technologies and configurations via a standardized, open and fair process.

The FIT Program is open to projects with a rated electricity generating capacity greater than 10 kilowatts (kW) and generally up to 500 kW. Projects larger than 500 kW are eligible for the Large Renewables Procurement.

The FIT program is open to a variety of participants who generate renewable energy and sell it to the province at a guaranteed price for a fixed contract term. FIT program participants can include homeowners, communities, municipalities, Aboriginal communities, business owners, and private developers. Participants are paid a guaranteed price over a 20-year term (40 years for waterpower projects) for all the electricity that is generated and delivered to the Ontario grid.

The microFIT program offers a streamlined process for homeowners and other eligible participants to develop a small or “micro” waterpower project 10 kW or smaller on their property.

Large Renewable Procurement (LRP): The Large Renewable Procurement program has replaced the Large FIT program for projects greater than 500 kW. LRP provides municipalities with a stronger voice and additional opportunities to participate in the development of renewable energy projects. The program includes an initial Request for Qualifications (RFQ) to qualify applicants, followed by a Request for Proposals (RFP) to evaluate projects proposed by Qualified Applicants. The program design requires developers to take certain steps to engage with municipalities before contracts are awarded.

## 4.2 Generation Gross Revenue

To calculate the potential average annual gross revenue of a project, multiply the plant capacity times the design capacity factor, times the number of hours in a year (8,760), times the selling price of electricity. Under the current FIT Program, the maximum available price for waterpower is 24.6 cents per kWh. For the 400 kW example with a 55% capacity factor, the expected average yearly revenue would be:

$400 \text{ kW} \times 55\% \times 8760 \text{ hours} \times 24.6 \text{ cents/kW hour}$

or approximately \$474,000 per year

The energy actually produced by a waterpower facility over the years – and therefore the actual amount of revenue – will be affected by the amount of snowfall/rainfall in the watershed, by downtime needed for repairs and by environmental and social needs.

For example, environmental and social uses of the river can reduce flow and/or restrict timing of flow. These instances will reduce plant capacity and in turn, reduce total gross revenue.

A facility with storage (head pond or reservoir) has much more flexibility in terms of production as the water can be managed to produce energy as needed or on demand. It is critical to understand the intended function of the project when preparing the initial estimate of costs and revenues.

## 4.3 Waterpower project financial analysis

Financial analysis compares the revenue from the sale of electricity with all of the costs (pre-feasibility, planning, pre-development, construction, operation and financing costs) over the course of the years (or “life cycle”) of a project’s operating life.

The revenue should be used to repay money borrowed to build the project, and to pay the on-going operating costs. Money left over after these payments have been made is the project owner’s profit.

Waterpower projects will usually have an expected life cycle of 50 or more years, but it is normal to analyze the expected costs and revenues for the first 25 to 40 years to determine whether a project is viable or financially worthwhile. Generally project proponents want to see a return on their investment within 15 years. This means startup money is repaid within 15 years.

Two ways to measure the financial viability of projects i.e., how the banks will evaluate the project, are Simple Payback and Return on Investment.

**Simple Payback** is all the costs, divided by expected yearly operating profit. Yearly operating profit in this calculation is the revenue from electricity generation, minus the annual operating costs excluding loan principal and interest payments. The result is expressed in years. For the purposes of very preliminary analysis, a capital cost of \$7,000 to \$10,000 per kW should be assumed for small hydro projects.

***Example using a 400 kW project***

Investment of \$4 million

Annual revenue \$474,000

Annual operations \$50,000

Simple Payback = \$4 million / (\$474,000 - \$50,000)

This is about 9.4 years

It is not unusual for viable waterpower projects to have Simple Payback results of 8 to 12 years. The shorter the time indicated by the Simple Payback calculation, the more viable the project.

**Return on Investment** (ROI) is a calculation that takes into account the concept of the time-value-of-money, comparing projects with different distributed cash flows over time. It helps answer the question "What else could an investor invest in to get a better return."

The higher the rate-of-return indicated by the ROI calculation, the more viable the project. Most waterpower project investors will require the ROI to be above 15% in order to seriously consider investing; some investors have even higher criteria.





*South Falls Generating Station - Ontario Power Generation (5 MW)*



## 5.0 The Business of Waterpower Development

A feasible waterpower site is the foundation of a successful project. A strong business plan will make the project happen. Three things can determine the long term success of the project:

1. Identifying appropriate project team members;
2. Finding appropriate business partners and adopting the right business model; and
3. Choosing the best financial options.

### 5.1 Project team members

The project team is a group of people who work together to make the project a success. Every project is unique and, depending on the role of the developer and potential partners, the project team will differ. The project team must include a mixture of technical and business team members, such as:

- **Developer:** The developer (proponent) is typically the one that takes the most risk on the project and as an equity (ownership) partner generally puts in the most money. The developer(s) will often be responsible for securing financing and permits/approvals, and will sometimes act as the engineer and/or constructor. The developer, in many cases, will also be the operator, at least for an initial period.
- **Engineer:** The engineer is the first technical expert required. The engineer will help determine the technical feasibility of building and operating the project, and will estimate the costs of construction and operation, revenues, and the Return on Investment (ROI) to determine profitability. Often the engineer will help to manage the entire design and construction process.
- **Environmental Consultant:** The environmental consultant will assist with assessing the potential environmental impacts of a project and will suggest strategies to eliminate or minimize these impacts. They may also lead or review the environmental assessment process.
- **Lawyer:** The lawyer will help to review risks associated with the project, such as insurance, tax, land access, labour and financing. The lawyer will also help to create business and partnership models and, together with the engineer, will determine permit, approvals and licensing requirements and assist with obtaining them.

- **Banker:** A banker is often required to provide the debt portion of project financing i.e., the loan. This is the money required for the project that has not been contributed by the project developer.
- **Constructor:** In some cases the project partners, either the developer or the engineer, will take responsibility for construction. In other cases, the constructor will be contracted by the project team. Typically, construction is undertaken for a fixed price, and will involve qualified skilled labour and businesses.
- **Suppliers and Sub-contractors:** The constructor or developer will typically act as the general contractor responsible for obtaining all the skilled labour, equipment and materials required to build the project. A broad number of qualified suppliers and sub-contractors will be involved.
- **Operator:** The operator has the day to day responsibility for managing the facility in compliance with any applicable legislation, regulation and policy.

The OWA has established a roster of expertise in small hydro to assist project proponents.

## 5.2 Partnership Models

Figure 5: Characteristics of Business Partnership Models

Type	Description	Comment
Joint Venture Agreement (JVA)	Shared assets. Partners agree on percent ownership and responsibilities. Agreement defines governance structure and process, monetary flow, and conditions under which agreement can be altered or cancelled.	Involves investment in project and assumption of business risks.
Limited Partnership (LP)	Shared assets. Partners have authority to decide what will be done. Provides more legal separation between the partners than a JVA.	Dominant partner with greatest investment retains greater authority and liability.

### 5.3 Financing options

There are two ways of finding the money for a project:

1. **Equity** – where a company, individual or community invests their own money
2. **Debt** – where money is borrowed from outside third parties such as banks Most projects are a blend of both equity and debt.

Choosing the best financial arrangement depends on:

- **Project Return on Investment (ROI)** – as a general rule, the more profitable the project, the more financing options will be available
- **Ownership structure and equity investment** – the form of partnership and the degree of owner capital (equity) in the project is an important factor in determining options for financing the balance of the project costs.
- **Risk** – There are a number of risks which will affect project financing such as
  - strength of the partnership;
  - source of revenues and extent to which the revenue stream can be guaranteed over the life of the project (i.e., strength of the Power Purchase Agreement);
  - percentage of initial equity investment;
  - source of skilled labour;
  - strength of operator experience; taxes and insurance, etc.

## 5.4 Waterpower project stages, tasks and timelines

Waterpower projects and their costs can be broken down into stages:

Pre-feasibility, pre-development and planning, permitting and construction, and operation and maintenance.

*Figure 6: Waterpower Development Stages*

Stage	Tasks	Cost	To keep in mind
<b>Pre-feasibility:</b> general information gathering focused on basic technical and financial needs, and potential barriers.	<ul style="list-style-type: none"> <li>• identify the opportunity</li> <li>• determine the energy potential</li> <li>• identify potentially affected values</li> <li>• determine type of application (e.g. Crown land vs private)</li> </ul>	A relatively inexpensive exercise that will cost \$5,000 to \$25,000 to complete	<p>Common to analyse several likely sites before choosing the best</p> <p>Building early relationships can expedite subsequent process steps</p>
<b>Pre-development and planning:</b> the period of time when a project is being studied and planned.	<ul style="list-style-type: none"> <li>• identify and pursue project team requirements</li> <li>• initiate and develop business model and relationships</li> <li>• financing – loans and negotiating sale of power</li> <li>• regulatory approvals</li> <li>• transmission connection study</li> </ul>	<p>Will take 1 to 2 years or more.</p> <p>Will range in cost from \$100,000 for a small and relatively simple project, to \$1-2 million dollars for more complex projects</p> <p>Financing for predevelopment work is generally more expensive because there is no guarantee of success at this stage (i.e., risk is higher)</p>	<p>It is important for proponents to look for and deal with issues that could stop the project early.</p> <p>There is no way of knowing whether/ how the project will go ahead until all of the technical, environmental, cost and permitting issues have been addressed and understood.</p>

Figure 6 continued

Stage	Tasks	Cost	To keep in mind
<b>Permitting and Construction stage</b>	<ul style="list-style-type: none"> <li>• detailed engineering and cost estimating</li> <li>• obtaining permits and approvals</li> <li>• Implement project development elements:               <ul style="list-style-type: none"> <li>• access roads</li> <li>• dams and water intake structures</li> <li>• canals and penstock pipelines</li> <li>• powerhouse buildings, generating equipment and controls, and</li> <li>• transmission lines to the grid connection point.</li> </ul> </li> </ul>	<p>Subject to changing costs of building material i.e., steel, concrete.</p> <p>Higher cost in remote locations</p>	<p>Construction takes from 1 to 3 years depending on the size and complexity of the project. Winter weather, spring floods, wildlife needs all impact timing of construction.</p> <p>The lead time required to order equipment (turbines, generators and controls) can be 1 year or longer.</p>
<b>Operation</b>	<ul style="list-style-type: none"> <li>• construction loan principal and interest payments</li> <li>• insurance</li> <li>• repairs and maintenance</li> <li>• operations personnel</li> <li>• environmental monitoring</li> <li>• administration</li> </ul>	<p>Regular maintenance costs will generally be related to the original investment – estimated as a percentage of capital costs</p>	<p>Owners will have to consider and account for costs and uncertainty beyond regular maintenance and normal operations and hydrologic variances year over year.</p> <p>Significant infrastructure re-investment can be expected during the first 20-30 years of operation.</p>





*Elliott Falls Generating Stations -  
Elliott Falls Power Corp. Micro Hydro Facility (700 kW)*

## 6.0 Waterpower and the Environment

When considering the potential impacts of waterpower development, the term “environment” is used in a broad sense to include the natural environment as well as social and cultural values.

### 6.1 Environmental considerations

From a natural environment perspective, a key benefit of producing energy through waterpower is that this energy is renewable and emissions-free (i.e., compared to CO<sub>2</sub> emitting forms of energy production). While these are of significant benefit, it is important to understand that there can also be local environmental impacts associated with waterpower development and operations.

Aspects of the environment that may be affected by waterpower include:

- **Fish and Fish Habitat** – The vast majority of new waterpower projects are anticipated to involve potential effects related to fish and fish habitat.
- **Aquatic Ecology** – changes in water levels, temperature, etc. can affect nutrient enrichment, access to aquatic species habitats, and connections between the river channel and the floodplain e.g.,
  - Downstream Ecosystems (erosion, low flows)
  - Upstream Ecosystems/Reservoirs (flooding, sedimentation)
- **Water-Resource Users** – navigation, resource-based tourism, water intakes. These potentially interested parties are important to consider for early involvement in a proposed waterpower project.
- **Water-Related Natural Resource Use** – e.g., recreational fishing, fur harvesting, baitfish harvesting and wild rice harvesting.

## 6.2 Importance of flow regime

The majority of impacts associated with waterpower arise from changes that waterpower development and/or operations make to the river's flow regime.

**Flow regime** is a concept that covers many parts of a river's behaviour including: magnitude, frequency, duration, timing, and rate of change. Flow regime is a defining characteristic of river systems, and is important to its environmental health and integrity, as well as to the interests of other users of the resource.

**Flow magnitude** refers to the volume of water moving past a fixed point over a period of time. Waterpower facilities and dams modify flow magnitude in rivers by holding water back in reservoirs and controlling the discharge of water below the dam.

**Flow frequency** refers to how often a flow of a certain magnitude takes place over a specific period of time. Waterpower operations and other control structures can change the recurring pattern of flows on long and short-term scales.

**Flow duration** is the interval of time, or how long or short a flow occurs. This can be affected by waterpower facilities with storage reservoirs, which manage water discharge to maintain flows for longer or shorter periods than what would naturally occur in the river.

The **timing of flows** relates to the release of water through waterpower turbines, to generate electricity during certain seasonal periods or times throughout the day. The timing of flow events created by waterpower operations often differs from that of an undeveloped river.

Finally, the **rate of change of flow (or ramping rate)** refers to how quickly flow rates can change in a specific period.

Here we have outlined the connections between potential environmental impacts and the many types of alteration to flows, and Section 4 laid out how a waterpower site's viability is dependent on flow. This is the fundamental challenge and opportunity of the power of water – to achieve a balanced sharing, a sustainable use, of this resource through understanding, respect, compromise, and cooperation.

### 6.3 Class Environmental Assessment for Waterpower Projects

The Ministry of Environment and Climate Change (MOECC) describes environmental assessment (EA) as a planning process that allows proponents to assess the potential for effects to the environment using best information available in order to make an informed decision about how or whether a project should proceed. In October of 2008, the Ontario Waterpower Association's *Class EA for Waterpower Projects* (Class EA) was approved by the Ministry of the Environment and is now the source document for understanding the rules governing the development of waterpower facilities. All new waterpower facilities and significant expansions of existing facilities are subject to the provisions of the Class EA. The planning process ensures clear requirements for considering environmental impacts and working with communities to design projects. The outcome of the Class EA process is used to inform the more detailed project permitting and construction phases of a project. EA is neither the beginning nor the end of the project cycle. A copy of the *Class EA for Waterpower Projects* can be obtained by contacting the Ontario Waterpower Association.







*Wasdell Falls Generating Station - Wasdell Falls Limited Partnership (WFLP) -  
Very Low Head (VLH) Turbine (1.65 MW)*

## **7.0 Tools and Resources**

### **7.1 The Ontario Waterpower Association**

The Ontario Waterpower Association (OWA) has a variety of communication and resources materials available.

***[www.owa.ca](http://www.owa.ca)***

The OWA Feed-in Tariff Homepage has helpful FIT resources.

***[www.owa.ca/feed-in-tariff-for-waterpower](http://www.owa.ca/feed-in-tariff-for-waterpower)***

### **7.2 RETScreen for waterpower**

The RETScreen Clean Energy Project Analysis Software is a decision support tool developed by numerous experts from government, industry, and academia. The software is free and is used to evaluate the energy production and savings, costs, emission reductions, financial viability and risk for various types of renewable energy and energy-efficient technologies (RETs).

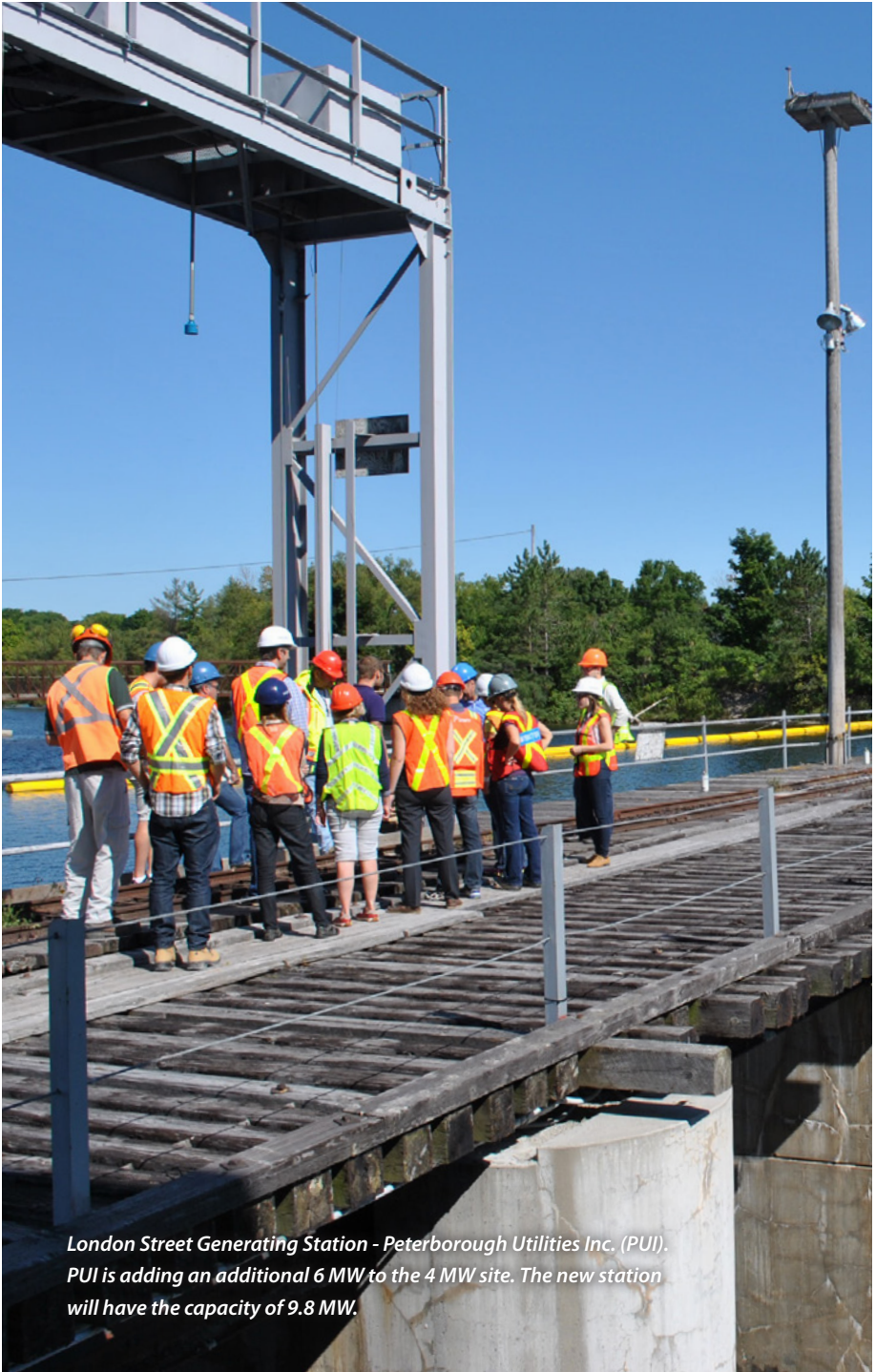
***[www.retscreen.net/eng](http://www.retscreen.net/eng)***

### **7.3 Ministry of Natural Resources and Forestry Waterpower Atlas**

An online mapping tool to help access the waterpower potential of rivers across Ontario.

***[www.ontario.ca/rural-and-north/renewable-energy-crown-land](http://www.ontario.ca/rural-and-north/renewable-energy-crown-land)***





*London Street Generating Station - Peterborough Utilities Inc. (PUI). PUI is adding an additional 6 MW to the 4 MW site. The new station will have the capacity of 9.8 MW.*

## 8.0 Contacts

There are several organizations and government agencies that offer support and assistance in waterpower developments. Some are listed below:

**Ministry of Natural Resources and Forestry**

***[www.ontario.ca/ministry-natural-resources-and-forestry](http://www.ontario.ca/ministry-natural-resources-and-forestry)***

**Ministry of Energy**

***[www.energy.gov.on.ca/en](http://www.energy.gov.on.ca/en)***

- **Feed-in Tariff**

***[www.energy.gov.on.ca/en/fit-and-microfit-program](http://www.energy.gov.on.ca/en/fit-and-microfit-program)***

- **Renewable Energy Facilitation Office**

***[www.energy.gov.on.ca/en/renewable-energy-facilitation-office](http://www.energy.gov.on.ca/en/renewable-energy-facilitation-office)***

**Ministry of Environment and Climate Change**

***[www.ontario.ca/ministry-environment-and-climate-change](http://www.ontario.ca/ministry-environment-and-climate-change)***

**Ontario Energy Board**

***[www.ontarioenergyboard.ca/OEB](http://www.ontarioenergyboard.ca/OEB)***

**Independent Electricity System Operator**

***[www.ieso.ca](http://www.ieso.ca)***

**info@owa.ca    (866) 743-1500**



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