A Community Guide for Waterpower Champions

Building Assets, Powering Communities

Ontario Waterpower Association

Affordable, Reliable, Sustainable

www.owa.ca

INTRODUCTION

The Ontario Waterpower Association (OWA) would like to invite you to be a waterpower champion and to get involved in supporting community waterpower. Community based waterpower is an opportunity to participate in the development of long lifespan assets, while powering communities with sustainable energy.

Waterpower has successfully been embedded in the fabric of numerous communities across the province for decades and in some cases for more than a century. Being a waterpower champion can help local development and strengthen local economies through building community participation, resilience and empowerment. By supporting waterpower in your community you can become active in creating a sustainable low-carbon future.

Opinion polls consistently show that waterpower has broad public support. Most recently more than 90% of Ontarians polled confirmed their support for waterpower. Polls show support for waterpower across all regions and all political affiliations.

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

As early as 2024, the province will need more electricity because of the retirement of nuclear assets. It takes many years for a waterpower facility to be permitted and constructed, which is why it's never too early to start planning at the local level.

This guide has been designed to assist those with an interest in championing community waterpower. We welcome all comments and suggestions to enhance future versions. Please provide comments to ***info@owa.ca***.

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Waterpower Champion

WHY BE A WATERPOWER CHAMPION

Waterpower is the original community power - embedded in dozens of villages, towns, Indigenous communities and cities across Ontario. Waterpower has been the backbone of strong communities for over 150 years. While steeped in history, new waterpower development is a core component of affordable, reliable and sustainable energy. It provides local development opportunities while being a renewable energy source and key to a low carbon future.

Your community may be an existing waterpower champion, may want to learn about potential opportunities or may just want to be informed. Wherever your community is, anyone can be a waterpower champion.

HOW TO BE A WATERPOWER CHAMPION

Beyond supporting community waterpower projects, there are several ways to be a waterpower champion.

1. **Sign the Ontario Waterpower Champions Charter**
2. **Celebrate Waterpower Day - June 20th - Sign a Proclamation for Waterpower Day**
3. **Connect with OWA**
    - Sign Up for the **OWA E-Newsletter.** You can sign up by clicking HERE or e-mail *info@owa.ca* to be added
    - **Follow, Connect and Share OWA on Social Media.** OWA is on Twitter and Instagram (@ONWaterpower) and Facebook, LinkedIn and YouTube as the Ontario Waterpower Association
    - Use OWA as your resource for future waterpower information and questions

ONTARIO WATERPOWER CHAMPIONS CHARTER

Our Council is committed to building the best possible quality of life for our residents. That means providing services, programs and amenities that make our community a great place to live, work, play and learn. It also means taking steps to think strategically about our future. Strategic thinking requires leadership, long term commitment and an unwavering responsibility to engage those we are elected to serve.

The **Ontario Waterpower Champions Charter** is a framework for Council to demonstrate its commitment to integrating and balancing its socio-cultural, economic and environmental goals.

The Commitment of Waterpower Champions:

- **We support the use and expansion of local waterpower;**
- **We support historical infrastructure and refurbishment opportunities;**
- **We conserve and enhance our man-made and natural environment;**
- **We value the voices – all of the voices – of our community; and**
- **We work with others collaboratively to create opportunities.**

Signed: ____

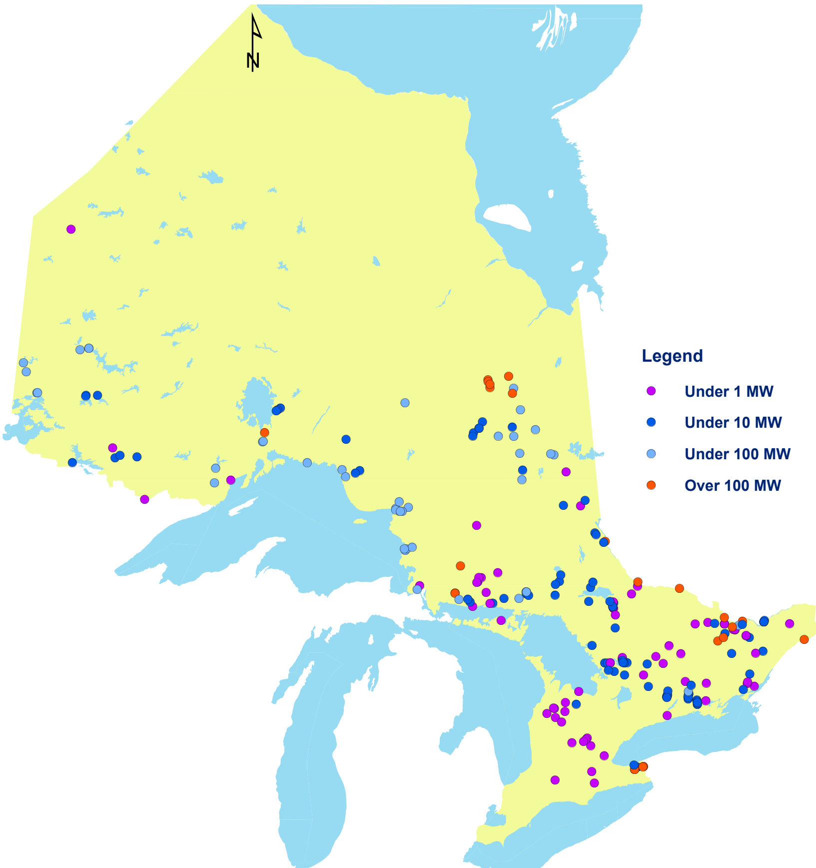
1.0 COMMUNITY WATERPOWER

1.1 Waterpower Facilities in Ontario

In countless communities across the province, the very identity of the community is inextricably linked with the generation of electricity from falling water. There are approximately 225 waterpower facilities in Ontario. Up until the 1950s the entire province was powered by falling water.

Waterpower facilities are distributed across the province and provide many local benefits. Water level and flow management often contributes to public safety by helping to minimize flooding and erosion, while benefiting cottagers, anglers and canoeists.

Figure 1: Waterpower Facilities in Ontario



1.2 Community Waterpower

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. Ontario waterpower ranges in capacity from less than 1 MW (Figure 2: backyard operations) to 2,000 MW (Figure 3: Sir Adam Beck, Niagara Falls).

Figure 2: Fletchers Horse Farm (7.2 kW) located in Waterford, Ontario - GreenBug Energy Inc.

Figure 3: Sir Adam Beck (2,000 MW) located in Niagara Falls, Ontario - Ontario Power Generation

1.3 Importance of Community Waterpower

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

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

Every community is unique, with different needs, interests, history, expectations and plans for the future. Your community may be…

- New to waterpower
- Have some experience with waterpower
- Have extensive experience with waterpower

Regardless of your community's experience and expertise, there are many ways to be a waterpower champion. For example; learning more about the technology, using opportunities to tour facilities during planned public events or simply using social media.

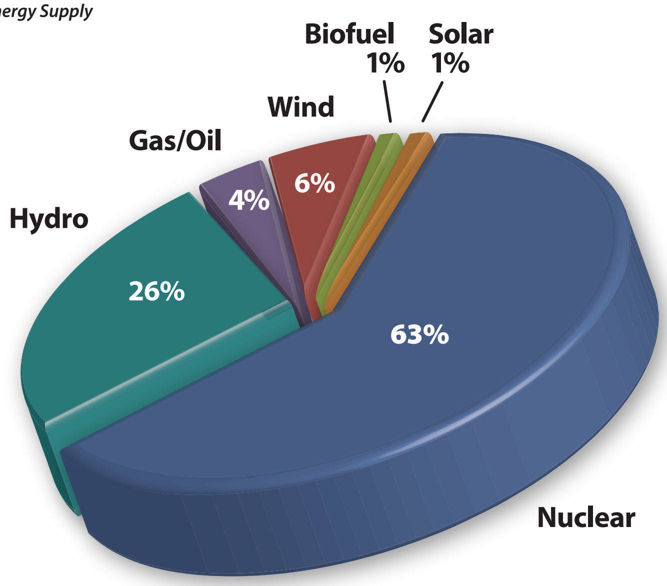
Figure 4: Chaudière Falls (29 MW) located in the City of Ottawa - Hydro Ottawa

1.4 History of Ontario Waterpower

Ontario's original economic prosperity was fueled by the province's first source of renewable energy – waterpower. 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. But there is still significant untapped waterpower potential.

Figure 5 breaks down the current energy supply in Ontario, with approximately 1/4 of the province's energy coming from falling water. Waterpower also accounts for 3/4 of the current renewable energy supply.

Figure 5: Energy Supply



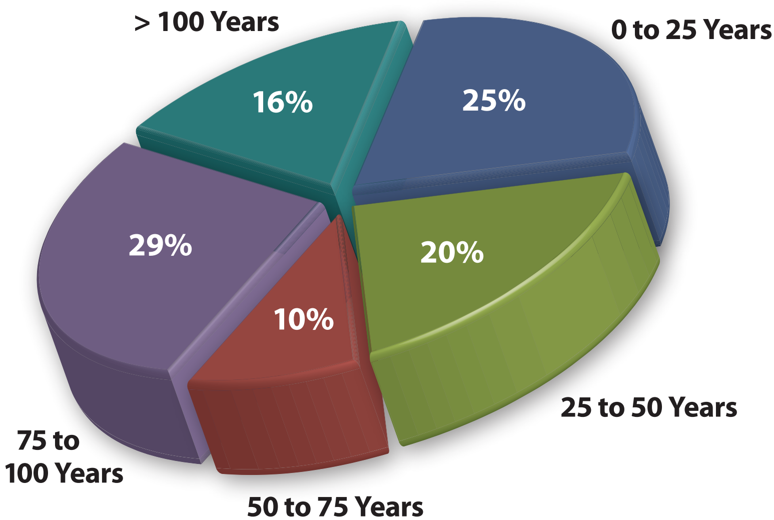
*Independent Electricity System Operator (IESO)

1.5 Assets

The long-term durability of waterpower facilities ensures that future generations will benefit from affordable electricity. Waterpower lasts a very long time, with close to 1/2 of Ontario facilities having been in operation for over 75 years.

Waterpower facilities range in terms of years in operation (Figure 6) and have been consistently developed for over a century during each and every decade. Facilities under 25 years old represent 1/4 of the province's assets.

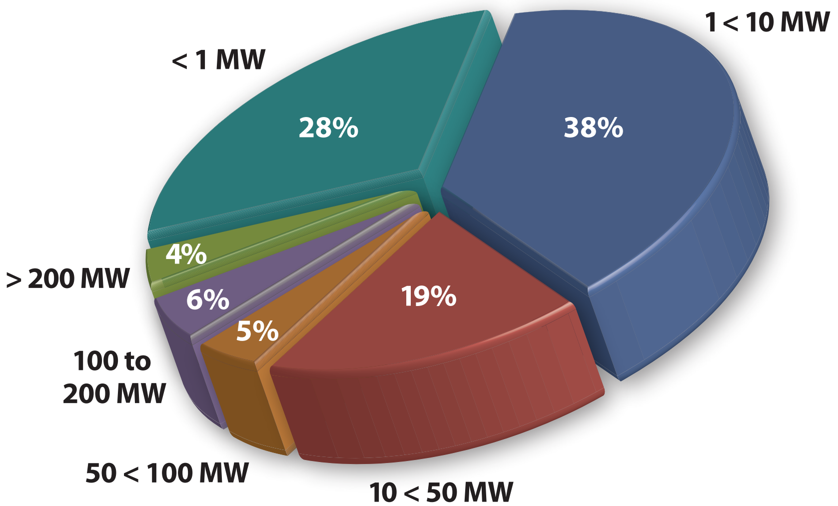
Figure 6: Waterpower Facilities: Years in Production



1.6 Part of the Community

Waterpower development played a significant role in early economic growth and in the evolution of settlement patterns that exist across Ontario. Today the physical evidence of a small waterpower legacy may be found in many communities. Small decentralized projects present a perfect opportunity for communities and the waterpower industry alike. Figure 7 shows that the majority of facilities in Ontario are under 10 MW in size.

Figure 7: Facility by Capacity

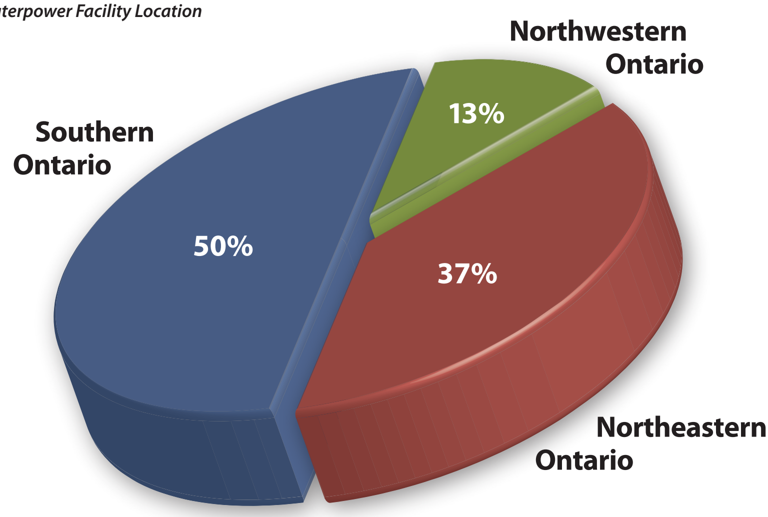


2.0 WATERPOWER BENEFITS AND OPPORTUNITY

2.1 Economic Engine

Waterpower still accounts for more than 80% of electricity generation in the north. Manufacturing, mining, and forestry companies located where they found a stable supply of energy; near clean, renewable waterpower. It also supports Indigenous communities through development partnerships and job creation. While waterpower is prominent in the north, the south also hosts about 1/2 of the facilities in the province (Figure 8).

Figure 8: Waterpower Facility Location



2.2 Bringing investment and jobs to Ontario

More than 80% of the investment made in the average waterpower project stays in Ontario, supporting local jobs and the economy. These jobs do not just include facility owners, but also construction and equipment companies, engineers, environmental consultants, financing and insurance companies, legal firms, project management experts and, importantly, in many cases, local and Indigenous communities.

Figure 9: Bracebridge Generation – Cascade Falls Waterpower Project

2.3 Existing Infrastructure Opportunities

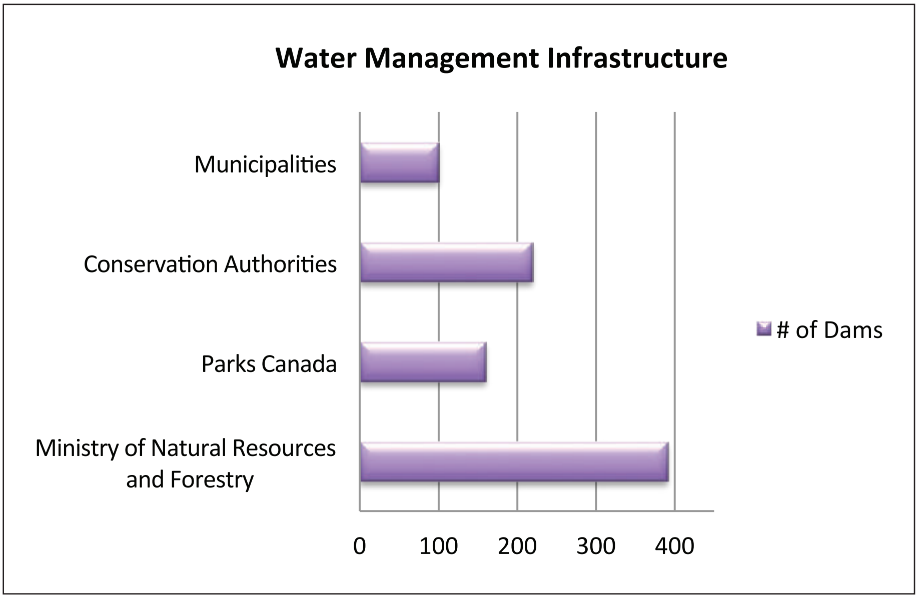
There are approximately two thousand (2,000) dams in Ontario that are currently not supplying hydroelectricity, but are serving alternative purposes (flood control, navigation, water management, etc.). Taking advantage of some of these existing resources and retrofitting for the future is a great opportunity for long term prosperity at a community level.

Like all infrastructure projects, older dams need to be upgraded to maintain structural integrity, ensure public safety and continue to serve its original function. This, when appropriate, can be an opportunity to add waterpower technology. Figure 10 shows the retrofitting of a small dam site.

Figure 10: Small Waterpower Application at McLeod Dam, Quinte Conservation

Ontario dams can be owned by both private dam owners and public entities. Public owners of dams include local municipalities, conservation authorities, provincial and federal government agencies. Figure 11 shows the breakdown of the number of dams owned by public entities in the province.

Figure 11: Water Management Infrastructure



2.4 Reliable - The Province's Battery

Waterpower is strategically important to the province's energy mix – providing the unique ability to store energy and produce it when needed. Electricity demands and supply change hourly, daily, weekly and seasonally, and waterpower responds.

Most flexible waterpower facilities are used every day to help ramp generation up quickly to match what is being used. During emergencies or at peak demand Ontarians rely on waterpower to respond quickly and ensure the supply of electricity. The three daily dispatch graphs below (Figure 12) show the profile of waterpower energy production.

Daily Support

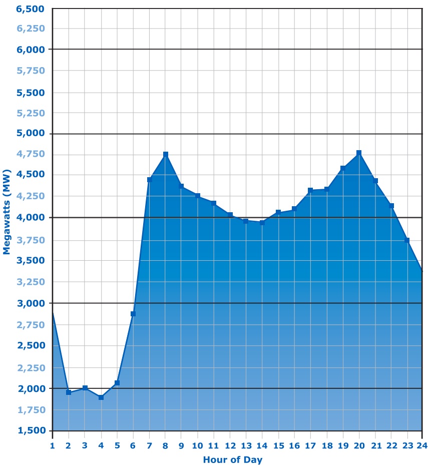
Example A: The system operators dispatch waterpower in the morning when energy is first being used by Ontarians. Waterpower is steadily used through the day, and then ramped up again at night when energy is again being used.

Seasonal Support

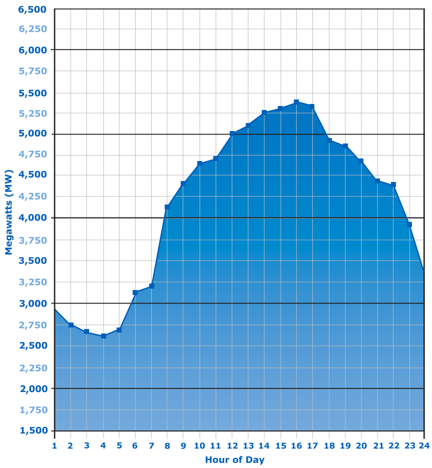
Example B: in the summer waterpower generation is used in the late afternoon, when air conditioning loads are highest. **Example C:** in the winter waterpower generation is used at night when we need lights and heat. This is when storing water is extremely helpful to the energy system to help with drastic changes to energy supply needed during winter evenings.

Figure 12: Hourly Waterpower Energy

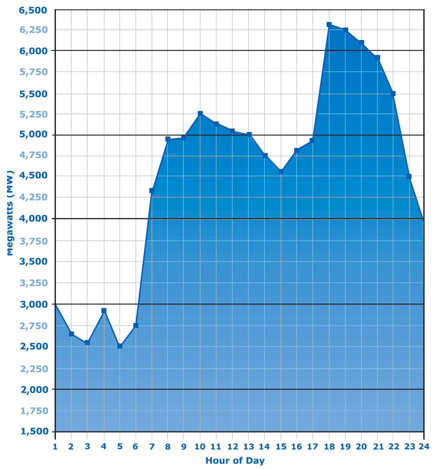
Example A – Typical April



Example B – Typical August



Example C – Typical January

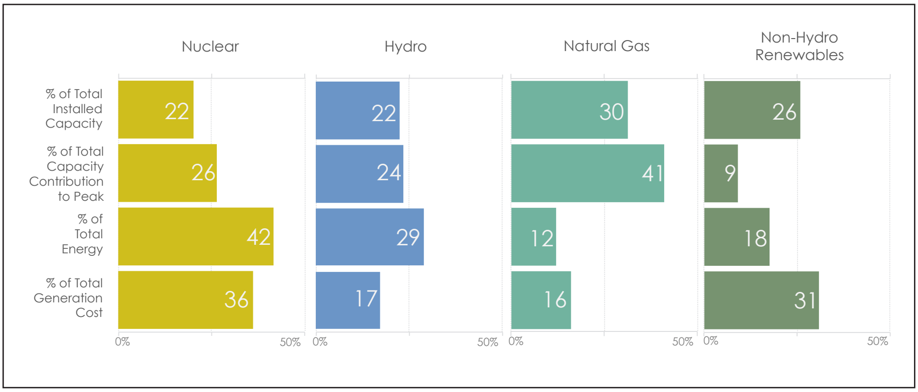


2.5 Affordable: Moderating Electricity Prices

Waterpower stabilizes energy costs with assets that last for decades. Sustained, steady investment in existing and new facilities is key to an affordable electricity system. The average waterpower facility lasts 3 times longer than a nuclear plant, 4 times longer than a wind farm and 5 times longer than solar panels.

The graph below (Figure 13) highlights how waterpower is different from other energy sources. The total generation cost in comparison to installed capacity is significantly lower than other technologies. Since waterpower lasts significantly longer than other energy sources, it moderates costs over time. It can be less costly to retrofit or add waterpower technology to existing infrastructure while it is undergoing regular maintenance. For example the addition of new turbines to an old facility increases energy efficiency and capacity of the plant.

Figure 13: Relative Contribution of Electricity Sources per LTEP 2013 projections. Source: IESO

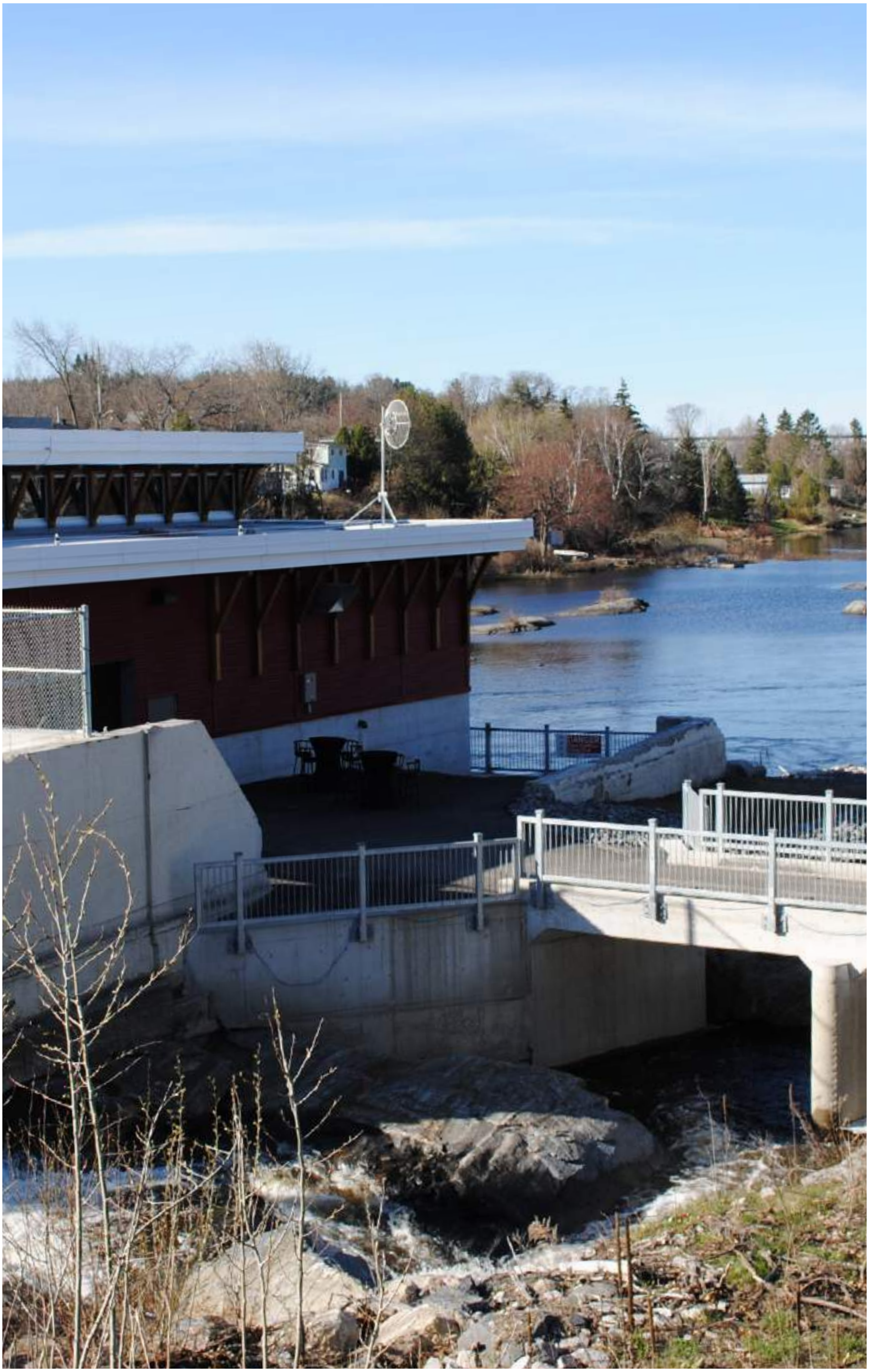


2.6 Sustainable - Economic, Social and Environmental

The waterpower industry is committed to balancing the economic, social and environmental challenges that communities face. Waterpower development and redevelopment can advance economic prosperity while assisting in moderating affordable electricity prices. Communities can leverage the environmental attributes of waterpower, while contributing to jobs and innovative development. The OWA has published a series of 44 Best Management Practices (BMP) focused on mitigating the impacts of waterpower facility construction and 3 focused on species at risk.

Figure 14: Smooth Rock Falls (7.4 MW), Gemini-SRF Power Corp.

Figure 15: Cascade Falls Generating Station (3.3 MW) located in Parry Sound, Ontario. Bracebridge Generation



3.0 ONTARIO'S ELECTRICITY SYSTEM

3.1 How does Ontario's electricity system work?

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?

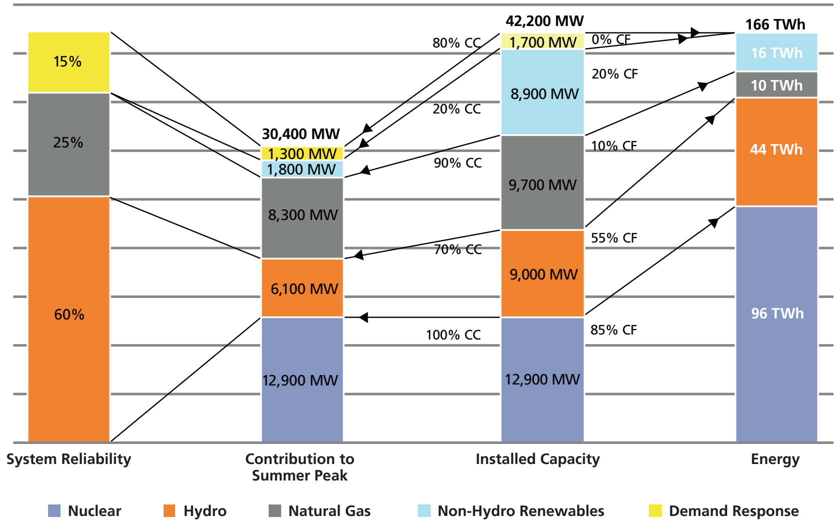
Renewable electricity is made from an energy source that can remake or replace itself. The energy of flowing water is such a source. So is the movement of the wind, the rays of the sun and the heat of the earth.

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 few 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 Independent Electricity System Operator (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 Figure 16, 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 16: Comparison of Electricity Sources



Renewable Energy Integration

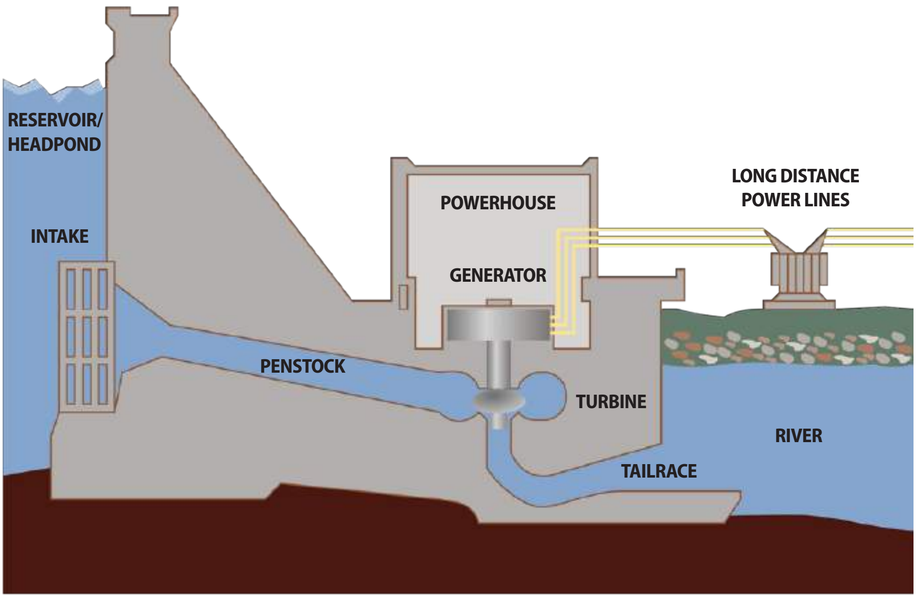
Although wind and solar power generation are renewable means of producing energy, they are intermittent energy sources. Intermittent energy means that it is not continuously available due to some factors outside of direct human control (wind not blowing, sun not shining). Effective use of these sources in an electric power grid can be enabled, by storing energy – for example through reservoirs or pumped storage facilities. Waterpower is a flexible source of electricity, since water flows are commonly stored and can be increased or decreased very quickly to adapt to changing electricity demands. Reservoirs and pump generating structures can provide a broad range of services to the system – from balancing out the variability of wind and solar sources to relieving transmission congestions. Renewable hydroelectric generation and water storage represent a natural pairing that contributes greatly to the integration of all generating sources of a power system.

4.0 AN INTRODUCTION TO WATERPOWER

4.1 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 17: 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.

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

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.

Kinetic waterpower

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.

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).

Figure 18: Example of Run-of-River with modified peaking facility. Matthais Generating Station (2.96 MW), located in Muskoka Ontario - Orillia Power Corp.

5.0 RESOURCE ACCESS AND SITE VIABILITY

5.1 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.

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.

5.2 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.

5.3 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 (m3/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 19: Daily Discharge for an unregulated river

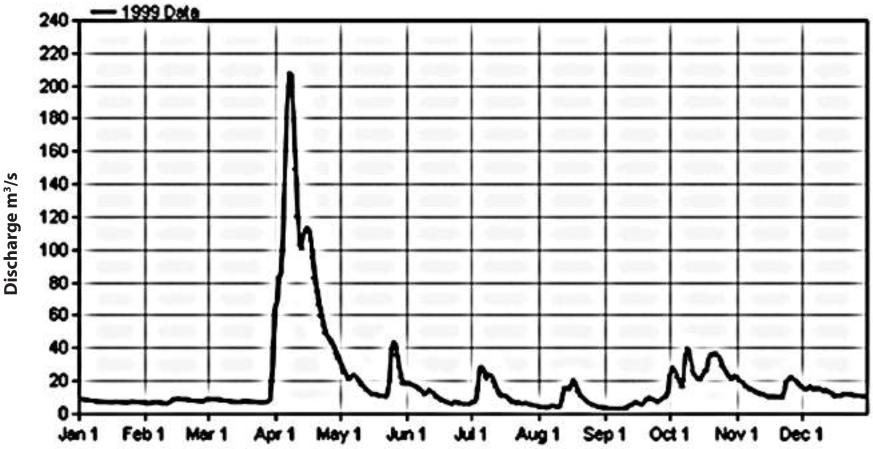
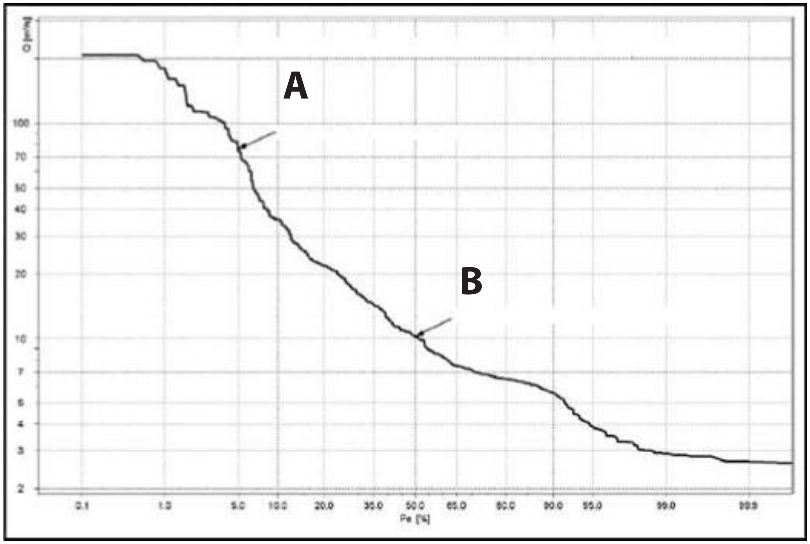


Figure 20 shows that during one year the river experienced low flows from January through April. In mid-April the flows dramatically increase, reflecting the spring melt water runoff. By mid-May, the flows are again low for the summer season. Several spikes from June through December indicate rainy periods.

Figure 20: Flow Duration Curve



This flow duration curve shows the percentage of time (x-axis) that the flow in the river in m3/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 m3/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 m3/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, *https://wateroffice.ec.gc.ca/*

5.4 Annual Energy Generation Potential

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

P = H x Q x g x 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 m3/s as determined above (for above example Q(50%)=10 m3/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 x Q x g e
P = 5 m x 10 m3/s x 9.8 x 0.85
P = 416.5 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 x time x % 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 x time x 55%
E = 400 kW x 8,760 hours/year x 0.55
E = 1,927,200 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.

Figure 21: South Falls Generating Station, located in Muskoka, Ontario - Ontario Power Generation (5 MW)

6.0 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. Be engaged at the outset;
2. Work with your waterpower partner to achieve the best outcome;
3. Help to facilitate the process;
4. Identifying appropriate project team members;
5. Finding appropriate business partners and adopting the right business model; and
6. Choosing the best financial options.

6.1 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.

6.2 Partnership Models

Figure 22: 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.

6.3 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.

6.4 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 23: Waterpower Development Stages

Stage	Tasks	Cost	To keep in mind
Pre-feasibility: general information gathering focused on basic technical and financial needs, and potential barriers.	• identify the opportunity • determine the energy potential • identify potentially affected values • determine type of application (e.g. Crown land vs private)	A relatively inexpensive exercise that will cost $5,000 to $25,000 to complete	Common to analyse several likely sites before choosing the best Building early relationships can expedite subsequent process steps
Pre-development and planning: the period of time when a project is being studied and planned.	• identify and pursue project team requirements • initiate and develop business model and relationships • financing – loans and negotiating sale of power • regulatory approvals • transmission connection study	Will take 1 to 2 years or more. Will range in cost from $100,000 for a small and relatively simple project, to $1-2 million dollars for more complex projects Financing for predevelopment work is generally more expensive because there is no guarantee of success at this stage (i.e., risk is higher)	It is important for proponents to look for and deal with issues that could stop the project early. 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.

Figure 23 continued

Stage	Tasks	Cost	To keep in mind

Permitting and Construction stage	• detailed engineering and cost estimating
	• obtaining permits and approvals
	• Implement project development elements:
	  • access roads
	  • dams and water intake structures
	  • canals and penstock pipelines
	  • powerhouse buildings, generating equipment and controls, and
	  • transmission lines to the grid connection point.
		Subject to changing costs of building material i.e., steel, concrete.
		Higher cost in remote locations
			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.
			The lead time required to order equipment (turbines, generators and controls) can be 1 year or longer.

Operation	• construction loan principal and interest payments • insurance • repairs and maintenance • operations personnel • environmental monitoring • administration	Regular maintenance costs will generally be related to the original investment – estimated as a percentage of capital costs	Owners will have to consider and account for costs and uncertainty beyond regular maintenance and normal operations and hydrologic variances year over year. Significant infrastructure re-investment can be expected during the first 20-30 years of operation.

Figure 24: Enerdu Generating Station (1 MW) located in Almonte, Ontario - Enerdu Power Systems Ltd.

7.0 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.

7.1 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_2 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.

All waterpower developments and significant redevelopments are required to undertake a rigorous environmental assessment (See 7.3) and permitting process through which local and site specific values are brought forward to inform impact management and mitigation approaches. The industry has adopted a leadership role in this regard, developing and publishing a series of Best Management Practices (BMPs) that go above and beyond regulatory requirements. Copies of BMPs for mitigating the impacts of waterpower facilities and species at risk can be obtained by contacting the Ontario Waterpower Association.

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.

7.2 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 5 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.

7.3 Recreation

Waterpower facilities are operated to balance multiple social, environmental and economic objectives. In fact, some of the most productive recreational fisheries are found on managed systems. All new waterpower developments and redevelopments are required to undertake a rigorous environmental assessment and permitting process through which local and site specific values, including those associated with recreation, are considered.

7.4 Health and Safety

Existing and new facilities are operated and regulated considerate of multiple values, including other water uses. Ontario has an outstanding track record of dam safety. The province has also introduced new "public safety around dams" Best Management Practices and the waterpower industry is pro-actively promoting their adoption across the sector and to other dam owners. Please visit the Public Safety section of the OWA website for more information.

7.5 Flooding

In order to protect against flooding, conservation authorities, governments and private industries have constructed and maintain protective infrastructure such as dams. Flood risk information and safety plans help municipal planners to reduce development in areas that are at high risk of flooding and reduces potential for residential harm. Waterpower can only protect high risk flood areas and zones as much as its infrastructure enables it to. Extreme weather events and community location to water bodies are out of the facilities or operators control and only so much can be done. Climate change will only increase the potential for flooding or drought occurrence.

7.6 Class Environmental Assessment for Waterpower Projects

The Ministry of the Environment, Conservation and Parks (MECP) 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.

Figure 25: Bracebridge Falls Generating Station (2.6 MW) - Bracebridge Generation Ltd.

Figure 26: Elora Generating Station (1 MW) - Shawman Power Corp.

Figure 27: Wasdell Falls Generating Station (1.65 MW) - Wasdell Falls Limited Partnership (WFLP) - Very Low Head (VLH) Turbine

8.0 TOOLS AND RESOURCES

8.1 The Ontario Waterpower Association

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

www.owa.ca

8.2 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 isused 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/ang

8.3 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

Figure 28: London Street Generating Station Plant #1 (4 MW) and new Plant #2 (6 MW)

9.0 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/page/ministry-natural-resources-and-forestry

Ministry of Energy, Northern Development and Mines

www.ontario.ca/page/ministry-energy-northern-development-and-mines

Ministry of the Environment, Conservation and Parks

www.ontario.ca/page/ministry-environment-conservation-parks

Ontario Energy Board

www.ontarioenergyboard.ca/OEB

Independent Electricity System Operator

www.ieso.ca

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info@owa.ca (866) 743-1500

Ontario Waterpower Association

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