# Handbook for Developing MICRO HYDRO In British Columbia

March 23, 2004

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BC hydro

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## Disclaimer

This Handbook has been prepared for the purpose of outlining the conditions affecting the development of hydropower sites in British Columbia. BC Hydro makes no representations or warranties as to the completeness and accuracy of the Handbook. Any reliance on the information contained herein is at the risk of the user. Anyone considering a hydro development is urged to make independent inquiry into the conditions affecting such a development including, but not limited to, site, environment, hydrology, and legal and regulatory conditions. BC Hydro will not be responsible for any person's costs, regardless of how they may have been incurred, relating to the potential development of a hydro project or an attempt by such person to obtain rights, contracts, or other requirements necessary for a development. Any reference in the Handbook to any site, technique, product, or company is for information purposes only and shall not be considered an endorsement by BC Hydro.

## Acknowledgement

This handbook was prepared by BC Hydro, Engineering for the Green and Alternative Energy division of BC Hydro.

Much of the material in this handbook is based on reports produced by Sigma Engineering Ltd. for BC Hydro. Interconnection information was provided by BC Hydro, Distribution. The Water License and Crown Land Application process information is condensed from material on the Land and Water British Columbia Inc. website.

When using this handbook, it should be acknowledge that this information is only a snapshot of the current issues and processes surrounding micro hydro development. Over time these processes will change, rendering parts of the handbook obsolete.

We hope that this handbook will provide you with useful information, when considering the development of your micro hydro project.

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BC Hydro, Engineering

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# Contents

# Introduction

### *A Guide to Micro Hydro Development in BC*

This handbook is intended to further the development of micro hydro developments in British Columbia. As such, it is most relevant for projects with installed capacities of less than approximately 8000 kW. It describes key issues pertaining to micro hydro development and aims to make developers aware of the opportunities and challenges of energy development, so as to increase the likelihood of a successful project. It is not a technical manual; however, readers seeking technical information can refer to the “Literature Review“ in Appendix A.

### *Why is BC Hydro Promoting Micro Hydro?*

Micro and small hydroelectricity developments have significant potential for contributing to BC’s long-term energy mix. The province’s climate and geography are ideal for hydroelectric development. BC Hydro has developed many large hydro projects over the last century; however there are many opportunities for small or micro hydro developments. In the past small or micro hydroelectric development has not been deemed economically feasible and were subject to complicated regulatory processes. BC Hydro is seeking to enable the development of one of BC’s most underutilized energy resources, micro hydro.

### *How is BC Hydro Promoting Micro Hydro?*

BC Hydro is encouraging the private sector to develop, own, and operate micro hydro plants.

Many people would like to develop a micro hydro site but do not know where to start. Various studies have identified more than 600 potential small and micro hydro sites in British Columbia. This information has been used to publish the *Inventory of Undeveloped Opportunities at Potential Micro Hydro Sites in British Columbia*, which is available on the BC Hydro web site. To facilitate the development of micro hydro, a need was seen to create a handbook to provide information on the conditions and regulatory processes affecting energy development in BC.

Hydro representatives have also been working with Land and Water British Columbia Inc. to explore opportunities to streamline regulatory approvals for small and micro hydro projects. The goals are to reduce project approval times, reduce or eliminate duplication and focus on the project’s environmental impacts. Hydro is also working to streamline its internal processes surrounding interconnection, distribution and metering.

**Find It Online**
For more information on potential micro hydro sites in British Columbia, check out the following web site:

Inventory of Undeveloped Opportunities at Potential Micro Hydro Sites in British Columbia
http://www.bchydro.com/rx_files/environment/environment1837.pdf

# Key Components of Micro Hydro Development

This handbook presents a number of components that require consideration when developing a micro hydro site. Despite the sequential layout of the handbook, it should be realized that successful micro hydro development does not follow a set of sequential steps. Rather, a developer needs to consider all aspects of the project before expending too much effort in one area. They also need to reconsider project viability each time they gain additional information on the project. Therefore, a potential developer should read this handbook in its entirety prior to getting started in order to understand all of the challenges that lie ahead.

Since the key aspects of every micro hydro development are similar, the components that follow can act as a rough guide to areas that need to be addressed. Following is an overview of the components and contents of the handbook:

1. **Plan Development**
   This section outlines issues that should be considered in developing a business plan prior to purchasing supplies, hiring staff, starting construction, or simply spending too much money. It will provide guidance on selecting the appropriate type of project and the role of BC Hydro and respective government agencies in the project development.

2. **Site Selection**
   Choosing a site is one of the most important steps in developing a micro hydro project. This section provides a starting point for selecting a site and determining the feasibility of developing that site. It details the process of finding the status of existing water licenses and Crown Land access. It also presents BC Hydro's green energy criteria.

3. **Costs and Financing**
   It is important to consider project costs when developing a project. The cost of a project is largely dependent on facility size, penstock length, length of transmission lines, site conditions, and accessibility. A reasonable cost estimate including development, construction, and operating costs is required to determine project feasibility. The scale of a hydro project, even a small one, means that most developers have to rely on external financing for a large portion of their project costs. There are a host of requirements for obtaining financing. This section provides an outline of costs to consider and steps to obtain project financing.

4. **Permitting Process**
   This section outlines the processes involved in acquiring water licenses and obtaining access to Crown land. It also references some of the other permits that may be required to build a project. The provincial Crown owns all water present in streams, rivers and lakes in BC. Individuals or companies who wish to divert and use this "surface" water are required by law to first obtain a license under the BC Water Act. For access to Crown land a lease application is required. This section outlines the steps required to apply for and obtain a water license and some of the other development permits for small projects.

5. **Grid Interconnection and Energy Sales**
   This section outlines grid interconnection, transmission of energy through the power grid, and energy sales. BC Hydro will be involved in these areas. Plants connected to the grid, including those that generate exclusively for on site use, require an Interconnection Agreement. If all the generated energy is not used on the site and requires movement through the transmission grid to where the energy will be used, a Transmission Service Agreement is required. If it is planned to sell all the generated energy, or energy generated in excess of your own needs, an Electricity purchase Agreement is required.

**6. Construction**

This section discusses the construction considerations including construction timing, material supply, environmental management plans and construction contracts. Before entering into the final design and building stage of the project, most of the components discussed in the previous sections need to be finalized. Before starting construction it is important to consider how the project will be completed and who will coordinate the work. This section will provide a list of resources for both do-it-yourself builders, and those who wish to contract out.

**7. Operation, Maintenance, and Surveillance**

This section provides an introduction to operation, maintenance, and surveillance (OMS). It details OMS considerations during the design phase of development, and then presents ideas on how to manage OMS during the lifetime of the facility.

# 1. Plan Development

## Define the Purpose and Vision of the Project

Thinking of building a micro hydro development? There are many steps to follow and countless hours of work involved. Understanding the potential problems and challenges, and formulating a plan to deal with them, improves the chance of success. Whether simply generating energy for your own use, or producing additional energy to sell, the first thing required is a plan for the micro hydro development.

Some questions to consider in beginning to define the purpose of the development are:

- Is there a stream nearby that is suitable for building a small micro hydro project, or is there a need to identify a suitable stream to develop?
- Consider your energy requirements. Estimate your power and energy use at present, and how much you will use, say ten years from now. Will a micro hydro development generate enough energy for your needs, or will you need to supplement it with energy from other sources?
- What is your plan for the excess energy that your micro hydro project generates?
- Who will you sell energy to and what kind of water license will you require as a result?
- How will you gain financing for your project? Will you raise private capital from friends and relatives, form a company and issue shares to the public or to a small number of investors, or will you apply for loans or government grants?

The following sections will explain these issues in further detail and provide additional resources to help in planning a micro hydro project.

**Find It Online**
For more information on business development, check out the following web sites:

Minding your own Business
http://wsww.hrdc-drhc.gc.ca/hrib/hrp-prh/pi-ip/career-carriere/english/products/minding/mind-eng/index.shtml

Businessgateway.ca
Services for Canadian Businesses
www.businessgateway.ca

Canada Business Centre
Business Startup Assistant
http://bsa.cbsc.org/scdt/startup/interface2.nsf/engdoc/0.html

Canada / British Columbia Business Services Society
http://www.smallbusinessbc.ca/

## Develop A Business Plan

Identifying business opportunities requires the combination of systematic analysis with unstructured creativity. You may already have an idea of how you want your business to take shape and how you want to construct your micro hydro project. Developing a business plan will solidify these ideas and help map out a direction to take in the development process. Think of a business plan as a road map. It is a crucial document containing information about the development project, a marketing plan, a financial management plan and a management plan. A business plan will assist in setting and realizing goals and keeping the project on course.

There are countless reasons for preparing a business plan, but here are four main reasons for doing so:

**Assists in Financing** - The business plan identifies the amount and type of financing or outside investment required and when it is needed. Having a plan also makes it easier for a lender or investor to assess the viability of your proposal.

**Accountability -** A plan establishes a system of checks and balances for your business so that mistakes can be avoided.

**Control -** A business plan sets up benchmarks to keep your business under control and improves your ability to manage your business.

**The Big Picture** – Having a business plan encourages realism and allows for thinking through the entire business process.

There are numerous resources available to help with business plan preparation. A brief list of useful web sites is available in the Literature Review in Appendix A.

**Find It Online**
For more information on writing a business plan, check out the following web site:

Canada Business Service Centre
Interactive Business Planner
www.cbsc.org/ibp/home_en.cfm

### Timelines

When developing a business plan, it is important to consider the time required for all steps of the development process. Micro hydro sites cannot be developed overnight. Site selection, project feasibility, water license application, environmental assessment, project permitting and approvals, financing, energy purchase and interconnection agreements, equipment procurement and delivery, and site construction all take time. With the initiation and start-up phases having the highest degree of uncertainty.

## Water Licensing and Crown Land Access

A micro hydro project requires a water licence under the Water Act and tenure under the Land Act for any component of the project situated on Crown land. Land and Water British Columbia Inc. process applications through “one window” with the water licence and Crown land applications reviewed concurrently. Water licensing and crown land applications are covered in greater detail in Section 4 (Permitting Process).

## Establishing Preliminary Cost Estimates

Developing a micro hydro development project can be an expensive undertaking. Estimating costs that will incur throughout the project, before beginning, provides information on the investment required for starting and completing the project. Without this information, it is not possible to find potential project funders. Planning the costs and allocating existing dollars will help in developing a financial plan and determine how much money will need to be raised in order to get the project off the ground.

Costs for developing a micro hydro project fall under three categories: initial costs associated with project development, construction costs including detailed design and equipment purchasing, and annual costs incurred in the day-to-day running of the project. Annual costs include operation and maintenance expenses as well as applicable taxes and rental payments. The components of each are detailed below.

### *Initial Costs*

There are a number of costs involved in getting a project to the construction stage. These include site selection, cost estimates, feasibility studies, water licensing, other approvals, environmental impact assessments, obtaining land rights, permits, energy purchase agreements, financing fees, and interconnection agreements.

### *Construction Costs*

Construction costs include generating equipment, civil works (such as intake, penstock, and powerhouse), access roads, transmission lines, engineering (design, field, and quality assurance), project management, interconnection fees, financing fees, and contingency allowances for unforeseen costs.

### *Annual Costs*

There are a number of costs associated with the operation of a micro hydro project including operation and maintenance and other annual costs. Operation and maintenance includes the labor and materials for general plant inspections, intake/trashrack clearing, equipment servicing, and other general maintenance. Other costs include land leases, property taxes, water rental, income taxes, insurance premiums, transmission line maintenance, spare parts, legal and accounting costs, general administration, and a contingency allowance for unforeseen costs or lower than expected revenues. The largest cost for most projects is debt service, covering interest, principal, and reserve allowance.

For more detailed information on costs and expenses see Section 3 (Costs and Financing).

**Find It Online**
As part of Natural Resources Canada's Renewable Energy for Remote Communities Program, the CANMET Energy Diversification Research Laboratory has developed a Renewable Energy Technologies (RETs) project assessment tool called RETScreen. RETScreen is a computerized tool developed to help interested energy developers prepare preliminary evaluations of annual energy performance, costs and financial viability of potential projects. Check out the RETScreen web site at:
http://cedrl.mets.nrcan.gc.ca/e/412/retscreen

## Project Financing

Project financing is one of the key elements in project development. It is one of the more difficult and uncertain aspects of the project and it can not be fully confirmed until significant expenditures have occurred on design, permitting and negotiation. Developers face a challenging situation in determining how soon to approach financiers and how much effort to apply to this area before settling other areas of the project. Thinking about different methods of financing the project before beginning, leaves one better equipped to face this challenging task. See Section 3 (Costs and Financing) for details on financing options.

## Grid Interconnection and Energy Sales

### *Interconnection*

Every energy project connected to the grid must have an interconnection agreement. The interconnection agreement refers to the technical and legal requirements to ensure that the physical connection of the energy project to BC Hydro's power lines is done in a manner that provides adequate protection from electrical faults originating from either party's system. The physical connection must also meet well-recognized industry standards in terms of the quality of the energy provided.

More information on interconnection requirements is covered in Section 5 (Grid Interconnection and Energy Sales).

### *Energy Sales*

Identify an intended end use for the energy the micro hydro plant will produce. If the plant is to serve all or part of your own needs, you must determine what your energy needs are. This can be determined with a simple calculation if you are looking at residential use or a more complex one if commercial or industrial energy needs are involved.

You may also be interested in selling all or part of the energy. Depending on the size and location of the plant, you may be able to sell energy to BC Hydro, Powerex (BC Hydro's energy marketing subsidiary), Aquila Networks Canada (formerly Utilicorp Networks Canada (BC) Ltd. & West Kootenay Power).

BC Hydro is currently reviewing net-metering options. BC Hydro has developed a "draft" net metering program, which was submitted for review to the BC Utilities Commission (BCUC) on November 3, 2003. The draft program has been designed for residential and small commercial customers who wish to connect a small (rated capacity of 50 kilowatts or less) distributed generation unit fuelled by a renewable energy source to the BC Hydro electricity grid. Upon receiving feedback from the BCUC, BC Hydro will make any required revisions, and then launch its new net metering program. Full details of the net metering program will be posted on the BC Hydro web site.

More information on selling energy is covered in Section 5 (Grid Interconnection and Energy Sales).

**Find It Online**
Acquiring Energy – Information for Green IPPs
http://www.bchydro.com/ipp/

BC Hydro's Application for Net Metering Tariff
http://www.bchydro.com/rx_files/info/info8804.pdf

# 2. Site Selection

## Choosing a Micro Hydro Site

Many people find that they have a need for electricity in places that are beyond the reach of power lines. Others look wishfully at the creek that flows through their property and dream of tapping the energy of the water either for their own use or to sell to potential buyers. Regardless of the reason for wanting to develop a micro hydro project, an appropriate location is required for the project. Choosing a site is one of the most important steps in development, as it will largely determine the amount of energy that can be developed and the complexity of site development (i.e. costs). This section presents a number of issues to consider in determining the feasibility of developing a site. It also outlines the process of finding out about existing water licenses and crown land access, and presents BC Hydro's detailed criteria for "green" projects.

A partner document to this handbook is the *Inventory of Undeveloped Opportunities at Potential Micro Hydro Sites in British Columbia* produced by Sigma Engineering Ltd. for BC Hydro. The Inventory was developed from map and regional hydrology studies. Areas that were reasonably close to transmission or distribution lines were reviewed, as were areas near remote diesel stations. Stream basin areas were determined and the steepest section of creek that was over 10% slope (in grid areas) and 5% slope (in diesel areas) were selected as the best locations for an intake, penstock, and powerhouse. The projects were assumed to be run-of-river. Information on flows, penstock length, head, distance from transmission lines and road access were used to estimate the principal development costs of the potential sites.

The Inventory may be useful for developers who have not yet chosen a site, but it should be noted that it is limited to a map study and does not duplicate the in-depth study that should be done for each potential project site. Each site must be checked in the field to fully explore its development potential.

> **Find It Online**
> To view a copy of *Inventory of Undeveloped Opportunities at Potential Micro Hydro Sites in British Columbia*, go to the BC Hydro web site or visit your local library.
> http://www.bchydro.com/rx_files/environment/environment1837.pdf

### *What to Look For In a Hydro Site?*

There are several things to look for when selecting a site for micro hydro development. A good site should have the characteristics listed below. Where sites are less than ideal, developers can sometimes use creative approaches to optimize projects.

***Water…and Lots of It***
Generally, the larger the stream the more water available for a micro hydro development. However not all water can be diverted from a stream, for energy production, as water must remain in the stream for environmental reasons. The amount of water that must remain varies for different streams.

***High Head***
The greatest fall over the shortest route is preferable when choosing a micro hydro site as a long penstock can be quite costly. More head is usually better, since power is the product of head and flow. Thus less flow is required at a higher head to generate similar amounts of power. Also with a higher head, the turbine is able to run at a higher speed,

resulting in a smaller turbine and generator for a given power output. However, pipe pressure ratings and pipe joint integrity require careful design at very high heads.

***Close Proximity to Distribution (Transmission) Lines or Load***
The closer a site is to distribution lines, or the load center in the case of an off-grid plant, the less costly it will be to transmit electricity. For grid connection it is generally only economical to connect a micro hydro plant to the 12 or 25 kV distribution system. Connecting to the higher voltage transmission system greatly increases the interconnection cost. However, one cannot estimate interconnection costs reliably until BC Hydro (or the BC Transmission Corporation) has reviewed the impact of the project on the electrical system.

***Site Accessibility***
The terrain surrounding the stream must be suitable for running a length of pipe from the proposed intake structure to the powerhouse location. Anticipated high and low water flows and levels must be taken into account when sizing and siting these facilities. The site also requires access for construction and maintenance purposes.

### *How Much Energy Can Be Produced?*

The amount of energy generated by a micro hydro development depends largely on the head drop and flow rates available from the river or stream chosen for site development. For a rough estimate of the power potential use the equation, **P = Q x H x 7.83**, where **P** is the theoretical amount of power available (in kilowatts), **Q** is the flow (in $m^3$/s) and **H** is the head (in meters). Note that this equation is approximate. The actual power produced may vary depending on turbine generator efficiency and pressure losses through the intake and penstock. Also, environmental and fisheries constraints may require leaving minimum stream flow in the reach of the stream bypassed with the penstock. This flow cannot be utilized, reducing the amount of energy that can be produced.

The power potential identified in the previous paragraph is based on an estimate of the maximum water flow through the micro hydro turbine. However, the actual energy available from a hydro development depends on the actual streamflow available. Thus available energy will vary from day-to-day due to variations in streamflow. In addition, there are year-to-year variations in annual energy yields due to fluctuations in annual streamflow. The annual energy produced is estimated by the equation, **E = P x 8760 x CF**, where **E** is the estimated annual energy produced (in KWh), **P** is the power as defined above (in kilowatts), 8760 is the number of hours in a year, and **CF** is the plant capacity factor. The capacity factor (often expressed as a percentage) accounts for the plant not operating at full capacity year-round due to low stream flows, environmental releases, and plant outages.

If you are planning to use the energy you produce to supply your own needs and it is insufficient to meet your energy requirements, you can supplement your energy needs by purchasing from BC Hydro or by using a backup power source.

## BC Hydro's Green Energy Criteria

BC Hydro's goal is to ensure that 50% (on average) of incremental load growth over the next 10 year period will be from BC Clean electricity. Previously, the goal was to ensure that 10% (on average) of all new energy resources required to meet incremental load growth over the next ten years were "green". BC Hydro views green as a subset of the clean target, thus it will be included in the overall 50% Clean target. Micro hydro projects can help us meet this target. Our goal is to acquire energy from new, high quality projects that are aligned with BC Hydro clean and green standards.

### *What is Green?*

There are a variety of provincial, national, and international bodies working to define green energy. In Canada, a national standard under the Environmental Choice Program is Ecologo certification. This program is supported by Environment Canada and is recognized as a national standard and is used by other utilities and green energy distributors. For existing independent power producers (IPPs), the BC Hydro green criteria must be met. The criteria are:

***Renewable***
The energy source must be replenishable by natural processes in a reasonable length of time – at longest, within an average human life span. For example, hydroelectric generation relies on water, which is a renewable energy source.

***Low-Environmental Impact***
The project must avoid unacceptably high environmental impacts such as damage to fish populations, endangered species, or air quality. This criterion is evaluated on a site and technology-specific basis.

***Socially Responsible***
The energy must not be generated in a way that conflicts with key community and First Nation’s values. Again, this criterion must be judged on a site-specific basis.

***Licensable***
The project must meet all relevant regulations and standards.

Currently, BC Hydro is transitioning to EcoLogo’s low-impact renewable criteria. This means that any IPP signing a new Electricity Purchase Agreement (EPA) with BC Hydro will be required to meet these criteria in order to be considered green. The Provincial Government is also developing guidelines that will provide direction on what resources/projects are considered clean.

**Find It Online**
View BC Hydro’s Green Criteria documents at:
http://www.bchydro.com/rx_files/info/info4793.pdf

## Determining the Feasibility of Developing a Site

Reviewing topographic maps and making site visits are initial steps in site selection. Site conditions can vary greatly from assumptions made from using topographical maps. Every site is different, and the cost of each structure will vary depending on the site conditions. Site details such as river access and ground conditions, and the availability of existing roads greatly affect project costs. A site visit also allows for determining potential project layouts, including optimizing the intake and powerhouse locations.

Detailed hydrology studies and stream flow measurements are required to judge available flows including the seasonal variation in flow. Instream fish flow requirements could be larger or smaller than the estimates depending on the site-specific biological requirements. These are important considerations to keep in mind when examining project feasibility.

## Determining Site Hydrology

Site exploration and streamflow measurement will take time, but the time spent conducting these studies will help to avoid surprises at a later date. There are a number of tools available to help determine the hydrology of a potential micro hydro site. These include maps, streamflow data, and water quality indexes. These are discussed below.

### *Topographic Maps*

Mapping can tell a lot about a hydro project site. Maps can be used to locate old access roads, the origin and destination of the stream, the size of the drainage area, and the land title block numbers (which are needed in order to obtain building permits). Maps can provide rough estimates of the length of the pipelines and transmission lines, and possible project head. The 1:50,000 scale national topographic system (NTS) maps are usually the first source of mapping utilized, followed by 1:20,000 scale TRIM maps, local forestry maps and custom maps based on recent air photos. The first two types of maps can be obtained from map specialty stores. The different forms of mapping provide increasing amounts of detail accuracy at increasing cost.

### *Streamflow Data*

Streamflow data is available from the British Columbia River Data web site and from the Water Survey of Canada. In a few cases, streamflow measurements may already be available for a particular stream. In other cases, streamflow can be correlated from a nearby stream, which may have similar flow patterns. Actual streamflow measurements should also be undertaken and as much data as possible collected prior to a final commitment to go ahead. For more information, check out the Literature Review in Appendix A.

**Find It Online**
Each year, Environment Canada produces a National HYDAT CD-ROM, which provides rapid access to a stand-alone version of the National Water Data Archive. This large database contains daily, monthly, and instantaneous information for streamflow, water level, suspended sediment concentration, sediment particle size, and sediment load data for over 2900 active stations and some 5100 discontinued sites across Canada.

Check out the Water Survey of Canada web site for more information:
www.msc-smc.ec.gc.ca/wsc

Environment Canada's National Water Data Archive:
http://www.msc-smc.ec.gc.ca/wsc/products/hydat/main_e.cfm?cname=archive_e.cfm

Check out the British Columbia River Data web site for up-to-date information on stream flows in BC:
http://scitech.pyr.ec.gc.ca/water/Map.asp

Check out the Ministry of Sustainable Resource Management report "Streamflow in the Lower Mainland and Vancouver Island"
http://srmwww.gov.bc.ca/appsdata/acat/html/deploy/acat_p_report_1002.html

### *Water Quality*

The operation of a micro hydro development can be adversely affected by suspended sediment like silt and fine sand, bed load (including the sand, gravel, and rocks that move along the stream bed), floating debris, dissolved chemicals, and ice. These things should be kept in mind when selecting the intake site and in specifying equipment that comes into contact with the water.

There are a number of other hydrological considerations to keep in mind when siting a micro hydro project. Be sure to obtain assistance or consult good technical references when determining site potential.

## Interconnection Cost Considerations

Power line and grid interconnection costs can be a significant component of micro hydro project costs. Studies, system upgrade, legal agreements, interconnection facilities, and transmission tariffs are all part of connecting the plant to the BC Hydro system. These requirements and costs are required to assess the economics of the project. See Section 5 (Grid Interconnection and Energy Sales) for more information.

## Water Licenses

The Crown owns all water in British Columbia. Once a potential development site has been selected, approval is required to use the water and access the land. Section 4 (Permitting Process) will go into greater depth with regards to the procedure for obtaining a water license in British Columbia.

Find It Online
Check out the Land and Water British Columbia Inc. web site for more information on water rights in BC:
http://lwbc.bc.ca/water/app_package/water_rights_in_BC.pdf

Search the Land and Water British Columbia Inc. water license database for active licenses and applications
http://srmwww.gov.bc.ca:8000/pls/wtrwhse/water_licences.input

## Access to Crown Land

If any portion of a proposed hydro project is situated on Crown land, Crown land tenure is required. Section 4 (Permitting Process) discusses this in more detail.

**Find It Online**
Search the Land and Registries Portal. The portal provides access to major land and resource registries within government, across all ministries. This single window provides clients with access to information regarding titles and encumbrances on private lands, crown lands and surface and subsurface rights respecting resources.
http://srmwww.gov.bc.ca/sstu/portal/

Find out more about Crown land access through the Crown Land Registry Services web site:
http://srmwww.gov.bc.ca/clrs/

BC Land Titles Branch:
http://srmwww.gov.bc.ca/landtitle

# 3. Costs and Financing

## Establishing Preliminary Cost Estimates

Developing a micro hydro project can be an expensive undertaking. Total project costs should be estimated early in the project to provide a good understanding of the total investment required. Planning of project expenditures allows for the development of a financial plan, identifying how much money is needed at each stage of the project. This information is required when approaching potential project funders.

Costs for developing a micro hydro project fall into three categories: initial costs associated with project development, construction costs including detailed design and equipment purchasing, and annual costs incurred in the day-to-day running of the project. Annual costs include operation, maintenance, and surveillance expenses as well as applicable taxes and rental payments. The components of each are detailed below.

### *Initial Costs*

#### *Feasibility Studies*

Once a potential micro hydro site is selected, a detailed feasibility analysis should be carried out. The purpose of this study is to assess the project in detail, such that a decision can be made whether to proceed with the project. Feasibility studies typically involve such things as a hydrologic assessment, an environmental assessment, preliminary designs, and detailed cost estimates. The costs for these studies are calculated based on an estimate of the time required by experts to complete the necessary work. Sometimes if there is a need for a lower cost, less detailed report a pre-feasibility study is done first to help define some of the project parameters.

#### *Development*

Development activities for micro hydro projects typically include costs for such items as applying for and obtaining permits and approvals, land surveys and obtaining land rights, legal and accounting services, transmission interconnection studies, electricity purchase agreements (EPA), project management, and financing fees (loan application). Permits and approvals are required for water and land use, environmental studies, and construction. There is more information on Water Licenses and Crown Land Access in Section 4 (Permitting Process). Grid interconnections and energy purchase agreements are covered in Section 5 (Grid Interconnection and Energy Sales).

### *Construction Costs*

#### *Engineering*

Engineering costs will vary depending on whether you will be designing the micro hydro project on your own or hiring engineers and contractors to carry out the work. If you decide to hire staff, costs will be incurred in completing the detailed design of your project, issuing tender documents for the purpose of selecting contractors, negotiating and establishing contracts, and supervising construction. As with the feasibility studies and development, engineering costs are calculated based on an estimate of the time required by experts to complete the necessary work. Disbursement could include travel and living out costs, and quality assurance testing.

#### Equipment
A micro hydro project requires various pieces of electromechanical equipment including turbine-generators, controls, electrical protection (including electrical equipment for the powerhouse and possibly a remote monitoring system), pumps, and gates. The cost of this equipment varies depending on the size and gross head of the project. Typically, the generating equipment for projects with higher head and lower flow are less expensive than that for lower head, higher flow projects. In addition to equipment supply costs, there is also need to consider costs for transporting and installing the equipment. These costs are dependent on the size of equipment, as larger equipment will need to be transported in sections and assembled on site.

#### Balance of Plant
The balance of a plant for a micro hydro project typically includes items such as access roads, transmission lines, substations, and costs for civil works such as dam or weir construction, dewatering, spillway and intake construction, and pipelines. The costs associated with each are specific to each project and vary according to the materials used and complexity of construction.

#### Owner's Costs
The owner's costs include all costs not specifically identified in the engineering, construction, and supply contracts. They could include the Owner's business costs related to the project such as office, legal, and accounting fees, financing fees and interest during construction, project management (unless designated to the engineer) and construction insurance.

#### Contingency
Contingency costs should always be included in a cost estimate in order to allow for unforeseen expenses. If project costs are well defined, a contingency of 10% of all project costs is often used. For less defined project components due to poor or unknown site conditions, much higher contingency values should be used.

### Annual Costs

#### Loan Costs
The loan costs cover interest, principal repayment, and reserves. It is the largest annual cost and is usually fixed once the loan amounts and prevailing interest rates are settled soon after construction ends.

#### Land Leases
If the hydro project is located on leased land, an annual lease payment is required. These costs are site specific and will depend on the area and value of land that is leased.

#### Property Taxes
Applicable property taxes (provincial or municipal) have to be estimated on a site-by-site basis and will depend on the area and value of land and fixed structures (except equipment) used and/or the revenue generated by the hydro development.

#### Water Rental
There is an annual charge for the use of water. Water rental costs will depend on the installed capacity and the annual energy generation of the hydro plant as well as the use category. Annual Water Rental fees for hydro projects are covered in greater detail in Section 4 (Permitting Process).

***Insurance Premiums***
Insurance is required for public liability, property damage, equipment failure, and business interruption. The annual costs for insurance can be significant for a micro hydro plant and should be estimated with the help of an insurance broker. The degree of coverage may also be specified in the electricity purchase agreement and the loan agreement.

***Transmission Line Maintenance***
The maintenance of transmission lines associated with a micro hydro project will involve periodic clearing of trees and replacement of parts that become damaged as a result of lighting, impact, or other events.

***Operation, Maintenance, and Surveillance***
Routine and emergency operation, maintenance, and surveillance of the project includes such tasks as daily monitoring (by remote communication), regular inspection of the equipment (including lubrication and adjustments), snow and ice clearing, and scheduled maintenance. Associated with this are the ongoing maintenance and repair costs for the intake, dam, pipeline, powerhouse, and electrical and mechanical equipment. These tasks may require the hiring of a part-time operator to supervise the facility and perform operation, maintenance, and surveillance tasks as required. Operation, maintenance, and surveillance considerations are discussed more fully in Section 7.

***General Administration***
Annual general administrative costs include the costs of bookkeeping, preparation of annual statements, bank charges, and communication. If legal services are required, they generally fall under this category. There will be a cost for maintaining working capital, which is needed to absorb the sometimes-uneven flow of project revenues.

***Green Criteria***
A project delivering energy under green criteria may be subject to certain costs in order to prove that green status is being maintained including review fees and environmental monitoring costs.

***Contingencies***
A contingency allowance should be included to account for unforeseen annual expenses. Generally, the contingency allowance is calculated based on an estimate percentage of all other annual costs.

## *Project Evaluation*

To determine if the project is economically viable a cash-flow evaluation of the project should be done. The cash-flow analysis looks at overall project revenues and expenses on a year by year basis over the life of the project. Revenues will consist of energy sales, and expenses will consist of loan carrying charges and annual costs identified in the previous section. Loan carrying charges consisting of repayment of the loan capital and interest could be the largest ongoing project expense. The loan may also require reserve accounts for hydrology and maintenance to be established up front or from early year cash flows.

The cash-flow analysis should demonstrate the viability of the project. It will also highlight variation in year-to-year profit or loss. However, it should be remembered that this analysis is based only on average revenue and expenses. Actual project revenue will vary from projected revenue due to variations in annual streamflow. Expenses can also vary due to unforeseen equipment breakdowns or due to natural events such as floods or windstorms. Insurance can only partially offset such events.

When evaluating cash-flow, income tax should be taken into account. However, it should be noted that Revenue Canada allows for quick depreciation of much of the micro hydro plant costs under the Capital Cost Allowance Class 43.1. The depreciation rate for this class is 30% on a declining balance.

For an example of a cash-flow analysis see the RETScreen model at Natural Resources Canada web site. Various lending agencies and energy purchasers may use their own cash-flow models.

**Find It Online**
As part of Natural Resources Canada's Renewable Energy for Remote Communities Program, the CANMET Energy Diversification Research Laboratory has developed a Renewable Energy Technologies (RETs) project assessment tool called RETScreen. RETScreen is a computerized tool developed to help interested energy developers prepare preliminary evaluations of annual energy performance, costs and financial viability of potential projects. Check out the RETScreen web site at:
http://www.retscreen.net/ang/menu.php

With an idea of how much financing is required for the project, a search of different avenues of project financing can begin.

## Methods of Project Financing

Project financing is one of the key elements in project development and often the last step before construction can begin. It can be one of the more difficult and uncertain aspects of the project and it may not be fully confirmed until significant expenditures have occurred on design, permitting and negotiation. Developers face a challenging situation in determining how soon to search for project financing and how much effort to apply in this area before other areas of the project are settled. Thinking about project financing should begin early in the project.

This section reviews the elements of project financing that are likely to be present in lending agreements written between a developer (borrower) and a financial institution (lender). Every situation will be different, but the same elements appear in most lending agreements. This section is written to provide a checklist of the significant requirements of the financing process.

The following sections have been written with the assumption that the project developer is reliant on capital markets and/or institutional lending to provide the required funding.

## Identifying Sources of Funding

### *Debt and Equity*

Project financing is usually comprised of debt and equity. When developers begin looking at developing a project, they make enquiries and find a suitable site for development. This may take place over a period of years and is considered to be some of the “sweat” equity in the project. Before too long, some out-of-pocket expenses will be encountered such as the following:

- water license fees;
- land survey costs;
- preliminary engineering;
- preliminary environmental studies;
- acquisition of property (either by purchase, lease or option);

- acquisition of equipment (some used pieces that appear to be a bargain); and
- payment of development rights or finders fees to third parties

Some of the proceeding expenses may have been incurred before approaching a prospective electricity purchaser (or in defining an appropriate project for internal energy use). Further costs will be incurred during the period of time when discussions are ongoing with the purchaser. Until there is an agreement in place, it is difficult to attract financing to the project due to the uncertainties involved. The developer may need to rely on their own financial resources. These initial time and capital expenses are all forms of equity, since they add value to the total project if done properly.

Once successful in obtaining an electricity purchase agreement (EPA), the financial challenge begins. Major commitments for the supply and construction of the project that will quickly overtake the initial expenditures. Although there may be expressions of interest from equity and debt funders, serious discussions usually cannot take place until the EPA is in place, or at least well on the way to completion. Previous projects have all required a minimum of 20% equity and more commonly 25% or 30%. (Note: all percentages refer to the full development cost of the project, not just construction.) Some lenders may recognize some or all of the previous expenditures toward the total equity, but there will still need to be further capital injected before any debt funding is advanced. The debt funders are usually unconcerned about the nature of such funding, as long as the debt that is eventually placed on the project has the first priority of repayment. Hence a government grant, loan, or subordinate (lower ranking) debt could also be deemed as equity by the senior lender, as detailed below.

***Sources of Equity Funding***

In addition to internal resources, equity or deemed equity may be obtained from the following sources:

- Private capital (friends, relatives, investors)
- Formation of a company and issuing shares to the public or a small number of “sophisticated” investors (subject to securities regulations)
- Loans through government development agencies (as long as such loans are in second place to any other debt placed on the project)
- Government grants
- Venture capital
- Affiliations with senior independent power producers (who may agree to carry a large proportion of the funding in exchange for a commensurate share in the project)

In any of the preceding forms of funding, legal agreements should be drawn up to protect the various interests. It may soon be necessary to incorporate a company to develop the project, or to set up a partnership. As more outside funds are provided, the founders once 100% share in the project will diminish. Most developers are successful in obtaining a greater percentage share in the project than what their direct financial contributions would warrant, in effect a reward for the entrepreneurship that lead to the project opportunity. The percentage share should be a function of the investment value of the project and the state of advancement or likelihood of completion when the outside investment occurs. This is usually a contentious issue between the original partners and those looking to come into the project.

Each developer must make a choice of equity funding that is right for the situation. They must balance their personal shares in the project with the probability of success in associating with various individuals and organizations, based on their track record in energy developments.

***Sources of Debt Funding***

The availability of debt funding for a project is a function of the quality of the project and its size. Without limiting the names to any particular lending group the following is a list of typical debt funding organizations:

- Schedule A banks
- Schedule B banks
- Trust companies
- Lease and capital companies
- Some government agencies
- Life insurance companies

In recent years larger construction companies have become involved in financing projects through the construction phase. In return for securing the construction work, they provide the relatively risky construction finance at market rates, which is paid out when the long term funding is secured after the project starts operation.

Developers will often engage a fiscal agent who will do the legwork for securing project financing (usually for a fee that is contingent upon successful funding). Some fiscal agents will arrange both debt and equity funding. This may be an appropriate way to go if there are no other resources. A direct approach to individual funding organizations can also be made. It is likely that financial organizations will look more favorably on a loan request if it is secured by equity other than from the project and the EPA alone. However, this is often not possible on a stand-alone project.

Each of the agencies will charge a different rate and treat the loan during the construction phase separately from the term loan after construction. Schedule A banks tend to be the most risk averse and are generally not interested in smaller projects. Schedule B banks, trust companies, and lease companies, on the other hand, tend to be more interested in smaller projects because they fit with the business profile of such banks. Government agencies have occasionally funded micro hydro projects, but usually have special criteria (based on technology or location) that need to be adhered to. Life insurance companies look at a broad range of projects, but have a preference for funding terms of 15-20 years and probably do not look at smaller projects.

**Find It Online**

For more information on finding project financing, go online to the Canada Business Centre's web site at http://bsa.cbsc.org/scdt/startup/interface2.nsf/engdoc/8.html

## Applying for Project Financing

An application for project finance can be made at any time, but before it becomes too formalized or expensive, it may warrant making some general inquiries to test the market for the financial community's enthusiasm for the project. Testing the financial market for interest may provide valuable information on how to structure the project to ensure that it is more financeable.

The Application for Project Finance tells prospective lenders about the micro hydro development project. An application is typically structured with the following components:

**i) Introduction**

Provides a background to the project and the developer.

**ii) Project Description**
Outlines the nature of the project, the construction and operation plan, and the status of approvals. Layout drawings should be provided and a hydrology study may be required.

**iii) Participants**
Outlines the people and companies directly involved in the development of the project, and any other persons or companies with interests in the project or the area.

**iv) Financial Analysis**
The financial analysis consists of the capital cost estimate and the investment analysis. The loan will be advanced with reference to the cost estimates and any changes to the budget will have to be reported. The investment analysis demonstrates that the project revenues will be sufficient to repay the capital cost and provide adequate reserves for debt service, maintenance, and profits for the developers. The lenders are generally not interested in the level of profit, but want to ensure there is enough debt service coverage to support unforeseen events. Reserve funds are also used to preserve debit service coverage.

**v) Financial Statements**
One of the tests lenders use to assess credit worthiness of a project is to review past financial history of the proponent. An applicant will have to submit details of personal or company finances in order to satisfy the Lender's requirements that technical and financial resources are available to complete the project. This will be a big step for anyone who has not completed a similar project.

If the Lender views the information favourably, they will return a copy of a Term Sheet (different lenders use different names) for consideration. If the borrower is fortunate, they may be more than one offer to choose from.

### *Term Sheet and Refundable Deposit*

A Lender that considers that the project has merit will issue a Term Sheet or Conditional Offer of Finance. This letter sets out the lender's general terms and conditions for the provision of financing.

The choice of lender depends upon the borrower's circumstances, the availability of lenders, and a balancing of all the various risks and costs. It is helpful in the selection process to have a financial model, which provides inputs for the finance rates, various fees and potential range of future costs (estimated). By doing so, the borrower can determine the true net cost of the financing and weigh this against factors such as convenience or flexibility of different lenders.

### *Commitment Fee*

Once the decision to proceed with a lender is made, the acceptance is signed and the first installment of the commitment fee must be paid. Typically a commitment fee is 1-3% of the value of the loan and the amount payable upon acceptance is some fraction (10-50%) of the commitment fee. This is considered to be the good faith deposit and it shows sincerity while the lender further investigates the project and the borrower. It by no means guarantees that the loan is finalized. The lender in its sole discretion may request further information or elect not to proceed because of uncertainty over the project or external changed conditions (change to lending policy, for example) and the deposit fee will be returned without any further compensation between the parties.

On the other hand, if the lender agrees to proceed to the next step while the borrower has a change of heart (perhaps they have found a better deal) the installment on the commitment fee is non-refundable and is considered earned by the lender. If all proceeds normally, the lender will approve the loan and the balance of the commitment fee will become payable. The timing of the second payment toward the commitment fee may vary depending on the situation. Depending on the lender's practice, it may need to be paid immediately, just prior to the first loan advance, at the end of construction, or proportioned between any of these noted milestones.

### *Offer of Finance*

Usually a period of one to two months passes while the lender considers further backup material concerning the proposed loan. The signed term sheet becomes tangible proof that financing is being arranged, but the offer remains conditional until the lender's credit committee has approved it. Once approved, the balance or a further portion of the commitment fee becomes payable and the conditional offer becomes a binding agreement between the parties.

When the acceptance and approval of the conditional offer and the payment of the installment(s) on the commitment fee are made, the first stage of funding is complete. The Lender is chosen and most terms have been agreed to, subject to detailed documentation. In some ways, the detailed work is just beginning, because so far no funds have been advanced and the loan documents are not yet complete. The following sections look at the other steps leading to the advancement of funds.

## Detailed Loan Documentation

Soon after the acceptance of the Term Sheet or Conditional Offer of Finance and its confirmation, the work to complete the loan documentation begins. The lawyer for the Lender will then initiate the document process and provide drafts of the following documents for comment by the borrower, the borrower's legal counsel, and the lender.

### *Legal Counsel and the Loan Documents*

The borrower is usually obligated to pay for the legal fees of the lender, but the lawyer for the lender does not take any instructions from the borrower. The borrower should satisfy itself that the lawyers have suitable model documents available since the job will go quicker and less expensively if well established precedents are utilized. The borrower will need to employ its own legal counsel with regard to the review of the various pieces of loan documentation.

Various agreements will also contain appendices and schedules (all of which are to be read together), which include a list of definitions relating to the project and loan as well as licenses and agreements which have been obtained prior to the date of the loan. Despite the number of documents, many of them are only one or two pages long and have a very specific purpose that is simply expressed.

The legal status of project lands is one of the key issues affecting the financing. The ability to pledge land title is one of the most reliable forms of security that the lender has, security that there lawyer will want to preserve. However the land being a Crown Land lease or easement instead of fee simple may complicate this. Many successful projects have been built on Crown Land, but it maybe necessary to allow some extra time to resolve this with loan documents.

## Operation of the Loan During Construction

### *Conditions Precedent to the first Draw*

Before any funds are disbursed from the loan, the borrower must prove that the required amount of equity has been paid into the project account and disbursed on approved expenditures. A draw will not be advanced unless there are actually invoices due that are not funded by equity. In the Loan Agreement there will be a list of conditions precedent, which will set out in detail all of the information, permits, and contracts that are required to be in place prior to any loan advance. Proof of insurance will be required with a certificate in favour of the lender covering loaned amounts.

### *Components of Draw Requests*

Draw requests will be based on a form of draw request provided as part of the loan documentation. At each request, the borrower may be asked to confirm that the project is on budget, that equity and past draws have been disbursed and that the project has no liens or claims filed. Other elements of the draw request may include:

**Promissory Notes**
Notwithstanding all of the other documentation, each time there is a progress draw, the borrower will be required to sign a promissory note in the amount of the draw stating that they will promise to pay such amount in accordance with the terms of the loan.

**Certifications**
Certificates, statements, or letters may be required from the borrower, the borrower's engineer, the review engineer, and others to confirm that:

- The cost to complete is within budget or approved extras have been granted. The lender will always be looking to ensure that the cost to complete is less than or equal to the undisbursed balance of the loan. If not, the borrower will be required to inject additional equity to make up the shortfall;
- The workmanship is to the required standards;
- The project is on schedule or has a revised completion date;
- There are no liens or claims on the project; and
- All of the permits remain in good standing.

Sometimes a financial spreadsheet will be required indicating the cost of construction to date by various account codes (budget items) measured against the initial budget. The cost to complete information will also be calculated.

### *The Review Engineer*

The review engineer is an agent of the lender, but generally paid for by the borrower. The review engineer is responsible for conducting an initial overview of the project to assess it for technical soundness of concept as well as a budget overview and hydrology review. They may also be required to perform site inspections before and during the construction. To the extent that there are independent reports already completed that the lender could rely on, some of the tasks of the review engineer could be waived. The review engineer may also be responsible for reviewing technical and financial documentation during construction that is provided in support of each draw request.

The Review Engineer's Report is normally a precondition of financing and the comments of the review engineer on matters of hydrology, design, electricity purchase contracts, schedule, construction contracts, environmental matters, permitting and project budget should be addressed in one manner or another (including being waived) before the first draw. The review engineer does not take design responsibility for the project, as such matters are left with the borrower's engineer. To some extent, the review engineer must rely on the background information provided by the borrower's engineer. The review engineer's report is simply intended to give some comfort to the lender that the project is feasible within the budget indicated.

Draw reviews are made each time the borrower requests a loan advance. The review engineer will review the information provided by the borrower in support of the draw request and make comments to the lender on the content of the submission. They will make the lender aware of any unusual events that they are aware of that have occurred during construction and will sign a confirmation that the loan draw is valid. In some instances, if the borrower's engineer is an independent consultant and has knowledge of the principal construction activities covered by the draw, their verification of the draw may be accepted in lieu of a review engineer.

Inspections may occur in conjunction with each draw review. These are primarily to get an indication of the overall progress of the project and to verify the statements made in the draw request.

## Operation of the Loan After Construction

### *Conversion*

After construction, the borrower may wish to convert the short term construction funding into longer term funding as soon as possible because the interest rate could potentially be lower. The lender on the other hand wants to make sure that everything in the project is operating normally and that all documentation is complete before they lock in the funds. The requirements to achieve the conversion will be stated in the Loan Agreement and could include:

- Confirmation by the review engineer that the project is operating in accordance with the plans;
- Report from a risk manager confirming the suitable project insurance is in place;
- Land leases to be finalized;
- Mortgage on lands to be granted; and
- Interim financial statements showing some months of project operating costs and revenue.

### *Covenants*

The routine operation of the project and the loan will require the borrower to maintain certain financial standards, in addition to doing everything that is necessary to keep the project functioning properly. The following are typical covenants that the lender may require, otherwise the loan could be considered to be in default:

- The debt service ratio is to be maintained at greater than 1.25 (1.25 is a typical value, but each lender may have their own criteria). This means that the cash flow from the project after operating expenses but before debt service should be 125% of the debt service (interest plus principal). This allows the project debt to be paid and while leaving some money for other costs. However, the debt service ratio is mainly to provide a cushion on anything causing reduced income and thereby a lower amount of money to service the debt.

- Restrictions may apply to the borrower on disbursement of funds from the project through dividends to shareholders or affiliates.
- Additional indebtedness may be subject to lender approval or may require that the lender be given a prior or equal right to make additional loans.
- Regular financial statements and confirmation that there have been no material changes in the project or the business may be required.

### *Reporting and Review*

The lender may require an annual report from the review engineer confirming that the project is operating normally and advising of any material changes. In addition to the above noted financial reporting requirements, the lender will also require the borrower to provide notice upon any contemplated change that could be adverse to the Loan Agreement. For recourse loans, where the loan is performing properly, the lender would not stand in the way of the borrower developing new projects or increasing business, because anything that makes the borrower stronger will in effect make the loan more secure. However the lender would like the opportunity of passing judgement on any new ventures in case these could weaken the borrower or the loan security.

## Summary of Financing Requirements

Project financing is a significant undertaking involving the creation and management of numerous documents. The decisions of the lender will be based on a review of all pertinent documents, so it is important to ensure that as a project is developed there is a good system of retrieving the important documents for lender review. This can be assisted by prior knowledge of which documents may be necessary and ensuring that they are duplicated for lender reference. In addition, as new documents are created, they too should be referenced and structured so that they will suit lender requirements as well as their primary purpose.

Borrowers will find that many of the loan documents address the dark scenario of business failure and other factors that would adversely affect the loan. Lenders have developed the various covenants and events of default to provide them with early warning of problems and give them time to react. The nature of the documents means that there is usually more than one way to default on the loan and borrowers must be cautious and prudent in their behaviour to ensure that the loan can be secured and that it is maintained in good standing.

With the use of the preceding guidelines, any well-conceived, well-documented and profitable projects should be able to obtain suitable project financing.

# 4. Permitting Process

## Obtaining the Necessary Permits and Licenses

Permitting and licensing requirements can include a wide variety of issues such as legal compliance, public safety, environmental concerns and First Nations consultation. A key component for developing a successful micro hydro project involves an awareness of the existing institutional and legal regulations, and may require interaction with various agencies and levels of government. Taking the time to understand the required approvals can save you both time and money.

A number of government ministries and entities have potential permitting or review authority. Thus, obtaining permits or approvals can require a considerable investment in time. In some cases, additional studies are required to support the application process. Despite the costs and effort required to obtain the required approvals, the process can be beneficial as it helps you focus attention to potential problems early in the planning phase.

Start early. Obtaining the necessary permits and licenses can take a year or longer, depending on the complexity of the project and its location. You will need to allow for this when you prepare your business plan.

## Approvals Checklist

The diversion of surface water from streams or rivers requires a provincial water licence. This also applies to streams or rivers on private land. If dams or diversions are to be constructed or operated, the design and construction plans must be reviewed and approved prior to construction. If structures such as the powerhouse site, penstock, road or transmission line are proposed for Crown land, application(s) for Crown land tenure(s) is required.

Applications for a water licence, a Crown land tenure or both are referred by LWBC to other government agencies and legally binding conditions and obligations can become a part of the licence and/or tenure document. Agencies may impose various construction, operation, and environmental obligations. Where application is being made for Crown water and land a single referral will be provided to the agencies.

> **Find It Online**
> Land and Water British Columbia Inc. is the specialized agency of the provincial government that is responsible for Crown land management. For more information the LWBC website is located at:
> http://lwbc.bc.ca/

The LWBC Waterpower Project Application Guidebook specifically outlines the steps and information requirements for waterpower project applications, including Micro Hydro. Please refer to the Waterpower section of the LWBC website at:
http://lwbc.bc.ca/applying_for_land/water_power.htm

The LWBC Waterpower Project Application Guidebook is located at:
http://lwbc.bc.ca/applying_for_land/pdf_docs/Waterpower_Guidebook.pdf

LWBC has developed a comprehensive Agency Resource Guide that assists applicants by describing the role of the agencies that are typically involved in the permitting process.
http://www.lwbc.bc.ca/water/app_package/agency_resource.pdf

The following is a list of some of the approvals that are required. This is not an exhaustive list and legislation is subject to change. See the LWBC Agency Resource Guide listed above or contact the local, provincial, or federal organizations listed for more detailed information on required approvals.

- First Nation's treaty negotiations are ongoing throughout British Columbia. The local band needs to be consulted in order to avoid or minimize infringements of aboriginal rights or title. For more information, see First Nations Consultation at the end of this section.
  **Contact**: Local Band Office

- If the proposed water source supports fish life your intake must be properly screened to prevent the passage of small fish. The Fisheries Act prohibits the deposit of any deleterious substances (substances that would degrade or alter water quality) into water frequented by fish, as well as the harmful alteration, disruption or destruction of fish habitat.
  **Contact**: Department of Fisheries and Oceans Canada

- If the proposed works affects navigable waters as defined in the Navigable Water Protection Act approvals are required.
  **Contact**: Canadian Coast Guard

- For works located within municipal boundaries, unorganized territory, or regional districts, contact the local offices for information on any zoning and bylaw compliance and for building permits where required. Some regional districts require additional fees and agreements.
  **Contact:** Municipal and Regional District Offices

- If the works are to be located within provincial forest areas, tree farm license, or supply areas, or on lands other than private holdings, a license or special use permit to authorize timber cutting and removal can be obtained by formal application. Local forest companies may also need to be consulted.
  **Contact:** Ministry of Forests

- If roadways or driveways that are required for access to the micro hydro development site join provincial highways, or other secondary roads, they require approvals prior to connection.
  **Contact:** Ministry of Transportation

- Before beginning any form of construction, permission is required from every property owner whose land the works will cross or affect. All agreements should be detailed in writing.
  **Contact:** Land Titles Registry Offices

- Insurance coverage should be arranged for all works during and after construction; and comprehensive general liability insurance should be retained if selling or supplying energy to individuals, communities, or industry. Liability may also be limited by wording in the energy sales agreement.
  **Contact:** Insurance Agents or Brokers

- Electrical installations require a permit. The homeowner can do installations for a single-family dwelling; in all other cases, electrical contractors holding approved certification must do the installations. All equipment and machinery should be approved prior to installation.
  **Contact:** Community, Aboriginal & Women's Services, Safety Engineering Services

- If the sale or supply of surplus energy to individuals, communities, or industries is planned, approval by the British Columbia Utilities Commission may be required.
  **Contact:** British Columbia Utilities Commission

- If the work affects mining claims (active or not) the claim holder may need to be consulted. If there are no claims, but the developer wants to prevent claims in the project area a Mineral Reserve (non-staking) should be obtained.
  **Contact:** Ministry of Mines

**For More Information…**
There are various acts and regulations, both federal and provincial that govern the approval and operation of hydro projects. Relevant federal and provincial acts and regulations are listed and discussed in Appendix B of this Handbook.

**Find It Online**
All BC statutes and regulations are available over the Internet or in hard copy from the Queen's Printer:
www.qp.gov.bc.ca/statreg

## Water Licenses & Crown Land Applications

A waterpower project requires a water licence under the Water Act and tenure under the Land Act for any component of the project situated on Crown land. Land and Water British Columbia Inc. has responsibility for both acts, and their policy for waterpower projects is to review water license and Crown land applications concurrently. The process will change over time, refer the latest version of the LWBC Waterpower Project Application Guidebook for current information.

The current LWBC guidebook outlines ten steps in the process for developing a waterpower project. Steps 1-7 relate to the requirements for the submission, review and adjudication of an application. Steps 8-10 relate to the requirements for construction, operation and monitoring of the project.

Step 1: Submission of Application
Step 2: Review of Application by LWBC
Step 3: Preparation of Development Plan
Step 4: Review of Development Plan
Step 5: Project Review
Step 6: Preparation of Summary Report
Step 7: Decision on Application
Step 8: Construction of Project
Step 9: Operation of Project
Step 10: Monitoring of Project

### *Step 1: Submission of Application*

Application packages are available at any LWBC regional office or from their web site. The information submitted should include the following:

- Completed application forms for a water licence and Crown land tenures (if required)
- Maps and plans of the project
- Title certificates and legal plans
- Preliminary project definition
- Certificate of incorporation
- Application fees

Completed applications may be filed with Land and Water British Columbia Inc. in person or by mail. Be sure that your application is complete in order to avoid processing delays.

**Find It Online**
**Water Rights Information**
http://lwbc.bc.ca/water/surface.html

Water License Application and Amendment Forms are available online through the Land and Water British Columbia Inc. web site
http://lwbc.bc.ca/water/forms/

Waterpower Project Application Completeness Checklist
http://www.lwbc.bc.ca/applying_for_land/pdf_docs/WP_Checklist.pdf

### *Step 2: Review of Application by LWBC*

LWBC reviews the application for completeness. If complete, LWBC will discuss the schedule for constructing and completing the project. If incomplete, the application will be returned with an explanation of deficiencies.

It is likely that LWBC may require an application for an Investigative Permit if field studies are required and the project area is Crown Land.

### *Step 3: Preparation of Development Plan*

You must prepare a Waterpower Project Development Plan, which consists of a Project Definition and an Impact Assessment. The Project Definition outlines the location and physical characteristics of the project. The Impact Assessment should identify all impacts of the construction and operation of the project. A template is available from LWBC.

### *Step 4: Review of Development Plan*

LWBC reviews the Development Plan for completeness to ensure that there is enough information to proceed to the next step. If incomplete, LWBC or other agencies will advise you where corrections are needed.

### *Step 5: Project Review*

LWBC will ask relevant local, provincial, and federal government agencies, as well as non-governmental organizations, the general public and First Nations for input on the project as appropriate. The purpose of this step is to determine:

- Project impacts and appropriate mitigation and compensation measures to address the impacts
- The potential effect of the project on rights people may have under the Water Act and the Land Act
- The potential for infringement on Aboriginal rights and title over land and water resources. See First Nations Consultation at the end of this section for more information.

The mechanisms for input will vary depending on the stakeholders and the specific projects. Some mechanisms that may be used include: general meetings, working committees, site inspection, addendum reports, agencies' input and direct resolution.

### *Step 6: Preparation of Summary Report*

You must prepare a report that summarizes the Development Plan and outlines the conclusion of the impact assessments from the Project Review (Step 5). The report should outline how all concerns and key impacts have been addressed or mitigated.

### *Step 7: Decision on Application*

LWBC will review the application and make a decision to grant or deny the application. If the application is approved, you will be offered tenure to the Crown land provided with a draft water licence. Once you accept it, LWBC will sign and issue the land tenure and water licence. Once the offer is accepted, you will be required to pay the full amount of annual rent and fees for the water licence and land tenure(s). The water licence decision by LWBC can be appealed by you or by other persons who believe their rights have been affected. The appeal goes before the Environmental Appeal Board and must be filed within 30 days of the decision.

***Step 8: Construction of Project***

You must submit criteria for the design of the project and plans for its construction (including an environmental management plan) to ensure that it meets LWBC requirements, as well as any additional requirements in your water license. This design must be reviewed and permission given by LWBC to proceed with construction, prior to each stage of construction and before any work can begin.

***Step 9: Operation of Project***

Conditions may be imposed on a project, as determined in Step 5, to mitigate effects. You must submit a report outlining the parameters and procedures for operation. LWBC will review and give directions for commencement of the project.

***Step 10: Monitoring of Project***

You are responsible for monitoring the project for the amount of electricity generated (to determine annual water rentals) and for compliance with conditions for mitigating impacts. This may involve implementing an environmental monitoring program for a specified amount of time.

## Water Rentals & Fees

The Water Act provides for the Crown to establish tariffs, fees, and rental charges payable in respect of applications, licenses, and permits, and for water diverted or used from a stream. The application fee for a power license that includes the industrial, commercial, and residential categories is based on either the intended plant installation (kW produced), or the anticipated additional output produced in a single normal year at all sites where the water is to be used.

For hydropower projects, licenses are issued for three different categories – Residential, Commercial, and General.

**Residential use** applies to projects with a capacity of 25 kW or less, where the power is used to meet the household requirements of the licensee.

**Commercial use** applies where the power is sold to immediate family members, employees or tenants of the licensee and the project capacity does not exceed 499 kW, or where the project supplies power to an industrial facility in which the licensee has an interest of more than 50%.

**General use** applies to projects where the capacity exceeds the licensee's household and commercial needs, and includes projects that sell energy into the provincial power grid.

**Find It Online**

For further details on the different power classifications, consult section 15 of the Water Regulation, available from the Queens Printer or on the Internet at:
http://srmwww.gov.bc.ca/wat/wrs/waterreg/15.htm

Annual water rental fees for hydro projects depend on the use of the power (commercial or general), the capacity of the plant and the actual annual output of the plant. For commercial use projects, the annual fee is $1.726 per kilowatt of installed capacity, plus $1.036 for each megawatt-hour of electricity produced. For general use projects, the annual fee is $3.45 per kilowatt of installed capacity, plus $1.036 for each megawatt-hour of electricity produced. Please note that these fees are indexed.

**Find It Online**
For further information on water rentals and fees see:
http://www.lwbc.bc.ca/water/factsheets/fs3fees.html

Annual rent will depend on the individual situation, but the following table gives a rough idea for average outputs of 60% of the installed capacity:

| Installed Capacity | Residential Use | Commercial Use | General Use |
|---|---|---|---|
| 25 kW | $50 | --- | --- |
| 100 kW | Not applicable | $700 | $900 |
| 1 MW | Not applicable | $7,000 | $9,000 |
| 2 MW | Not applicable | $14,000 | $18,000 |

## Crown Land Tenure Type

The any portion of the project lies on Crown land, Crown land tenure is required. The type of tenure would initially be a short-term permit or a licence of occupation until construction of the project is complete. At this time the tenure areas could be surveyed after which a lease or right of way (for linear components such as transmission lines) would be offered.

The purchase of the Crown Land is an option to be discussed with the regional LWBC office upon completion of the project construction, as noted below.

**Find It Online**
The Land Title Branch registers ownership of land in BC and is responsible for the accuracy and security of title for all privately held land parcels. Land Title Offices can help you with registration of title, land title searches, and providing copies of documents and survey plans. Find them online at:
http://srmwww.gov.bc.ca/landtitle

### *Rental*

The charge imposed for the land tenure is dependent on the location of the land and the type of use proposed. An appraisal may be required to determine land value.

### *Crown Land Lease or License of Occupation*

Crown land can be disposed on a lease development purchase system. After a lease is issued, the lessee develops the land in accordance with the purposes for which the lease was issued. When the land has been developed, the lessee may apply for and purchase a Crown grant. Land that has been leased usually involves a long-term tenure of 20 years or more, and involves land area on which substantial developments are to take place. A license of occupation involves a shorter term and minimum development criteria and is more consistent with the needs of a micro hydro developer.

### *Crown Land Sale*

To apply to purchase Crown land, you must apply to the Commissioner of the Land recording district where the land is located. Note though, that Crown grants do not pass title to the bed or shore of a body of water, even if the body of water is included within the lands that are subject to the grant. However, the Minister may grant exceptions by issuing special certificates.

### *Rights-of-Way*

Statutory rights-of-way are used if pipelines or transmission wires are required to cross Crown land. They would allow you continued operation, maintenance, and surveillance of machinery and equipment located at the hydro plant site.

## First Nations Consultation

Aboriginal interests need to be considered in most micro hydro developments as the diversion, storage, and use of water, and/or construction, maintenance, and operation of facilities may adversely affect aboriginal interests.

It is the Province's obligation to consult with First Nations in respect of aboriginal interests and to consider information gathered on aboriginal interests in the decision-making processes. The province generally requires the project proponent to address aboriginal interests before they get involved. Aboriginal interests are defined as potentially existing aboriginal rights and/or titles. The Province is bound to avoid or minimize infringements of aboriginal rights or titles.

The scope of the consultation and the degree to which workable accommodations should be attempted will be proportional to the soundness of the aboriginal claim. In most circumstances, the duty will be greater than simple consultation. It will require the intention to substantially address the concerns of the First Nation whose use and occupation of the lands are at issue. Some examples of different forms of consultation include:

- Meetings and correspondence with First Nations
- Exchanges of information related to proposed activities
- Development and negotiation of consultation protocols
- Site visits to explain the nature of proposed activities
- Research existing studies or undertake new ones
- Participation in local advisory bodies

In situation where consultation is required, the Province follows a four-step process as outlined below:

1. Initiate consultation
2. Consider the impact of the decision on aboriginal interests
3. Consider whether any likely infringement could be justified in the event that those interests were subsequently proven to be existing aboriginal rights and/or title
4. Look for opportunities to accommodate aboriginal interests and/or negotiate resolution bearing in mind the potential for setting precedents that may impact other Ministries or agencies.

**Find It Online**
Government of British Columbia's Provincial Policy for Consultation with First Nations
http://www.gov.bc.ca/tno/down/consultation_policy_fn.pdf

Treaty Negotiations Office
http://www.prov.gov.bc.ca/tno

Indian and Northern Affairs Canada
http://www.ainc-inac.gc.ca/

Band Contacts
http://www.gov.bc.ca/tno/negotiation/bc_first_nations.htm

# 5. Grid Interconnection and Energy Sales

## Introduction

This section covers the requirements for grid interconnection, transmission of energy through the grid, and energy sales. If developing the power for your own use in an application not connected to the BC Hydro grid you do not have to worry about these issues. However if your plant is to be connected to the grid, even if you are developing power for your own use and do not plan on delivering energy to the grid, you will require an Interconnection Agreement. The Interconnection Agreement is to ensure power quality, safety, and reliability for all grid-connected generators and consumers.

## Interconnection

BC Hydro has established an office for Distribution Generator Interconnections to assist independent power generators in the selection of appropriate interconnection options in connecting to the BC Hydro distribution grid. The office provides a point of contact to potential generator applicants and acts as liaison between the applicant and the various BC Hydro departments involved in the interconnection process. If the interconnection is at transmission voltages of 35 kV or above, the generator applicant is referred to British Columbia Transmission Corporation (BCTC) which deals with transmission interconnections.

An interconnection refers to the connection of a generating source with BC Hydro's distribution system or BCTC's transmission network. Every generator project connected to the grid, whether delivering power to the grid or not, requires an Interconnection Agreement. The Interconnection Agreement refers to the technical and legal requirements to ensure that the physical connection of the generator to BC Hydro's power system is made in a manner that:

a) provides adequate protection from electrical faults originating from either party's system (although BC Hydro may provide general advice, they do not take responsibility for the protection of the generator's plant);
b) the quality of the power provided meets industry standards;
c) the power producer and BC Hydro have agreed on notification protocols, safety procedures, and other conventions of prudent electrical utility practice;
d) The measurement of power for quality and quantity meets BC Hydro requirements.

BC Hydro has "distribution interconnection standards" to ensure that the connected plants will not have detrimental impacts on the BC Hydro system or its customers. The generator is responsible for reviewing the standards and making submissions to BC Hydro, which are consistent with the standards. Usually an iterative process results because there is a degree of custom design with each interconnection as standard designs cannot cover every situation. A summary of the technical interconnection requirements for projects up to 8 MW is provided in Appendix C. Typical single line drawings are also provided to assist with the interpretation of the requirements. The drawings provided for plants rated > 500 kW must be sealed by a British Columbia registered engineer.

### *BC Hydro's Interconnection Process*

BC Hydro will assist the Power Generator in determining the most appropriate interconnections, whether to the BCTC Transmission network (greater than 35kV) or to the BC Hydro Distribution system (35kV or less). The optimal interconnection is largely dependent on the generator's geographic site location and on the proposed power output of the generator.

The steps in BC Hydro's interconnection process include:

- initial inquiry by the generator,
- identification of interconnection options by BC Hydro,
- submission of a formal interconnection application by the generator,
- interconnection study by BC Hydro, and
- development of the interconnection requirements by BC Hydro.

It should be noted that the generator is responsible for the costs of the BC Hydro studies identified above.

**Find It Online**
See "Generator Interconnections" on the BC Hydro web site at http://www.bchydro.com/info/ipp/ipp992.html

Plants rated up to 500 kW are often connected at a three-phase secondary service voltage of 208V to 600V. For larger micro-hydro sites the interconnection will generally be made to the distribution system at voltages of 12.5 kV or 25 kV, as there are greater difficulties in connecting at higher service voltages. The Office of Distribution Generator Interconnections at BC Hydro has been established to assist the generators in determining the best connection option. The office will conduct preliminary studies in order to provide the generator with an evaluation of the options, including an initial estimate of interconnection costs.

When the generator is ready to proceed with project development, an updated application for interconnection is made to BC Hydro. If the interconnection is at a distribution voltage (35 kV or less) BC Hydro will deal with the application. If the interconnection is at transmission voltage (greater than 35 kV) British Columbia Transmission Corporation (BCTC) will deal with the application. Once a formal application is made and the generator pays the estimated study costs, BC Hydro and/or BCTC will conduct in-depth studies to determine the cost and technical requirements for connecting to the provincial power grid. Based on these studies, a document outlining Project Interconnection Requirements (PIR) will be produced.

Once the Project Interconnection Requirements are developed, the generator and BC Hydro or BCTC can complete a Generator Interconnection Agreement (a legal document) defining the rights & responsibilities of both parties. This agreement will set out times for further submittals, payments for services and construction, and various contractual procedures. BC Hydro will inspect the final installation to ensure it is consistent with the Agreement.

An initial single point of contact for interconnection inquiries is:

**☎ BC Hydro - Initial Inquiries and Contact Office**

Office of Generator Interconnections
BC Hydro
6911 Southpoint Drive (E10)
Burnaby, BC V3N 4X8
Phone: (604) 528-3313
Fax: (604) 528-3392
gen.connections@bchydro.com

**For Additional Technical Information**
Request a copy of "BC Hydro Connection Requirements for Non-Utility Generation, 35 kV and Below", or for connections at 69 kV and up "Transmission Interconnection Requirements for Power Generators".

Some areas of British Columbia are served by electrical utilities other than BC Hydro. If a generation plant were situated in the service area served by one of these other electric utilities, an interconnection agreement would have to be reached with the local utility rather than with BC Hydro. In a case where this applies, the BC Hydro office listed above can provide the appropriate contact.

## Transmission

If you do not use all the generated energy at the generation site, and decide to move the energy through the transmission grid to where it will be used, you will require a Transmission Service Agreement. If your energy is sold directly to BC Hydro, BC Hydro will look after the necessary transmission and distribution capacity. If you sell energy to a party other than BC Hydro either you or the energy purchaser will be responsible for energy transmission costs.

There are established tariffs and agreements for the transmission of energy through the BCTC network. Additional information on transmission, including tariff schedules, can be found on the BCTC website.

**Find It Online**
See the BCTC web site at http://www.bctransco.com

## Energy Sales

If you plan to sell some or all the energy you generate you will need to enter into an energy purchase agreement with BC Hydro or another energy purchaser. A contract that governs the sale of electricity between a generator and an energy purchaser is called an Electricity purchase Agreement (EPA). Another name for an EPA is a Power Purchase Agreement. An EPA is a contract that contains the agreed to terms and conditions guiding the sale of energy. In order for a new generator to obtain an EPA it is necessary to locate a buyer interested in purchasing energy from your generation plant.

### *Information Requirements*

The method of contracting for the sale of the plant output depends upon whether the plant is under development or if it is operating. Contracting for the sale of output from an operating plant need only focus on commercial delivery terms such as price, quantity, and duration of contract. However, a plant that has not yet been built must address both commercial delivery terms plus the allocation of development/construction risks such as cost overruns, change in quantity, and delays in achieving commercial operation. Environmental (Green) criteria may also need to be addressed.

Finding a buyer can be done in two ways. The first is to approach potential buyers such as BC Hydro and make an unsolicited proposal to sell energy. The other method is to respond to requests for proposals (RFP) issued from time to time by prospective purchasers. An RFP is the easier method because the RFP will outline what the buyer is looking for. An unsolicited proposal, on the other hand, must make assumptions about what the buyer is interested in. Although electricity is easily measured, its value can vary greatly due to the attributes such as quantity, location, contract duration, supply reliability, shaping of deliveries (daily and seasonal variations) and price volatility. The cost of production is of secondary importance.

### *Agreement Terms and Conditions*

Electricity Purchase Agreements can vary in format. However, they all begin with a statement of the purpose and nature of the contract and contain a number of key components, including:

- Identification of parties – the buyer and seller
- Definitions – technical and commercial terms relevant to the project and agreement

- Conditions Precedent – events that must occur before the contract is deemed valid
- Condition Subsequent – events that must occur to ensure the contract remains valid
- Commercial Operation Date – the date on which the project is operational and capable of making deliveries under the terms of the contract
- Seller's Plant – a description of the plant
- Suspension Conditions – conditions that allow suspension of certain terms of the contract
- Termination conditions – reasons for early termination resulting from a default in the agreement
- Purchase and Sale terms – the commercial terms of the contract including term and price as well as conditions that determine who bears risk for certain events.
- Statements and Payments – administrative requirements
- Insurance conditions – minimum insurance conditions
- Assignment – notice and consent of sale may be required
- Force Majeure – an event over which neither party has control and which may cause delay prior to the Commercial Operation Date
- Dispute Resolution – defining how to settle any dispute fairly and at minimum cost

For an example of an Electricity Purchase Agreement (EPA), visit the BC Hydro website to view the standard EPA to successful bidders selected in the 2002/03 Green Power Generation Call for Tenders.

**Find It Online**
See the BC Hydro web site at http://www.bchydro.com/info/ipp/ipp4799.html

### *BC Hydro's Calls for Tenders*

BC Hydro has conducted two recent calls for green energy.

Sixteen projects successfully bid into the 2002/03 Green Power Generation procurement process. Combined, the projects represent 1,764 gigawatt hours of new green generation, to be purchased from BC Hydro under 10- to 20-year contracts. Of the 16 projects, 14 are micro hydro projects. All projects must be operational by September 30, 2006.

In 2000/01, BC Hydro invited independent power producers (IPPs) to submit proposals for green energy projects. As a result, Hydro completed 20-year electricity purchase agreements for 23 projects. Three developers subsequently withdrew projects from the process. Of the remaining 20, 19 are micro hydro projects.

**Find It Online**
See "Acquiring Power" on the BC Hydro web site at http://www.bchydro.com/info/ipp/ipp956.html
BC Hydro contact for green energy purchase green.ipp@bchydro.com

### *Other Energy Sales Options*

Energy generated in BC does not have to be sold to BC Hydro. It can be sold to other utilities or power marketing companies in the province. Examples include Aquila Networks Canada, a major utility operating in the Kootenays and Okanagan, and Powerex, a power marketing company wholly owned by BC Hydro.

☎ **Aquila Networks Canada** (formerly Utilicorp Networks Canada (BC) Ltd. & West Kootenay Power)
Dave Cochrane
Manager, System Operations
(250) 368-0547

☎ **Powerex**
Business Development
Brian Moghadam
Manager, Custom Trading, Powerex
(604) 891-5058
brian.moghadam@powerex.com
www.powerex.com

Generators can also sell energy directly to other jurisdictions including the United States. However in the case of the U.S., the direct marketing of energy raises a number of difficulties. One obstacle is securing transmission access to the U.S. market. Further, in the case of the western U.S., the standard EPA requires delivery of energy even during transmission outages (by locating alternative sources of energy).

The licensing requirements for selling energy to the U.S. are as follows. The seller needs to obtain interconnection and transmission agreements with BC Hydro. To sell energy at the U.S. border, an Export Permit is required from the National Energy Board and an Energy Removal Certificate is required from the BC Ministry of Energy and Mines under the Utilities Commission Act. To sell directly to U.S. customers, an U.S. import permit and a Power Marketing Application with FERC are also required.

This handbook is generally directed at developments selling to BC Hydro or utilizing generation directly with surplus sales to BC Hydro. Developers should carefully evaluate the issues noted above as well as other issues before considering a project intended for sales to a third party, including export.

# 6. Construction

## Pre-Construction Inventory

The construction phase, including planning, of a project is typically the most expensive. Therefore, it makes sense to ensure that a number of details have been finalized prior to embarking on this project component. The following is a list of issues that should have been completed prior to construction phase:

- Finalize Costs (with fixed price agreements where possible)
- Water License
- Land Use Approval
- Electricity purchase Agreement
- Interconnection Agreement
- Other Approvals
- Financing

## Construction Considerations

Depending on the size of the project, you may choose to do much of the work yourself or have the project done under contract. In either case, be well prepared both technically and legally to undertake the work. There are a number of things to consider when beginning construction of a micro hydro development.

### *Construction Timing*

The time of year for project construction can influence the pace and quality of work. From November to March, most areas of British Columbia experience high rainfall or snowfall, fewer hours of daylight, and sub-freezing temperatures – all of which can slow down construction progress. The quality of work can also be affected, especially if proper precautions are not taken to keep fresh concrete warm during freezing or sub-freezing temperatures. In addition, access to remote areas can be challenging. Environmental issues can be magnified during periods of high rainfall.

Aside from weather, there may be other construction restrictions that need to be worked around. For example, fisheries concerns or high water levels may affect instream work, and bird-nesting concerns may delay tree removal. Thus, various issues could cause long delays in a project, possibly affecting scheduled in-service dates and project financing.

### *Materials Supply*

The availability of materials is an important consideration. The delivery time for major equipment such as the turbine and generator can take 6 months to a year. Thus, planning is important to ensure timely delivery of all materials.

### *Construction Permits and Inspections*

In addition to approvals, permits, and land zoning discussed in Section 4 (Permitting Process), various permits may be required for all or part of the construction work. Building permits are obtained from the local Municipal or Regional District Offices.

An electrical inspection is required and it will ensure that code requirements are met. Additionally, other Provincial or municipal government staff may visit the site to carry out inspections.

### *Environmental Management Plans*

Environmental impacts are associated with nearly every construction project. An Environmental Management Plan is developed before construction to lay out steps to be taken to minimize and mitigate the impacts. Plans deal with a number of issues including:

- keeping deleterious material out of watercourses through slope treatments and sedimentation ponds;
- fuel storage and the presence of oil spill contingency equipment;
- waste collection and disposal; and
- emergency response plans.

The plans are a requirement of LWBC and Green certification programs.

## Getting it Built

### *Who Should Do the Work?*

Depending on the size of the project and your level of technical expertise, you may choose to do much of the work yourself or have the work done under contract.

### *Construction Contracts*

When hiring someone for project construction, a decision is required as to the type of contract that best suits the situation. There are several options including:

***Day Labour or Cost Plus Contracts***
Under this type of contract agreement, a contractor or individual labourers are hired at fixed hourly rates and the owner agrees to pay for all hours worked. This is probably the most flexible contract arrangement because little in the way of detailed engineering or contract documents is required. However, there is a risk of higher costs if the work takes longer than expected and good supervision is required to ensure the work is completed expeditiously.

***Unit Price***
A unit price contract is a flexible document in which the bid prices are based on estimated quantities, while the contract payments are based on actual quantities. This contract has the effect of fixing the final costs prior to construction, but there is the risk that if quantities exceed the estimate, the cost will be greater than anticipated. Depending on the quantities and the manner in which contractors weight their prices, the increase could be substantial. Also, there is a need to verify the quantity measurements.

***Lump Sum***
A lump sum contract specifies a body of work to be done without regard to quantities. Contractors must rely on their own interpretation of quantities to derive their prices. While this type of contract is very simple to arrange, problems or errors in the drawings,

changed field conditions, or in the definition of the work may give contractors justification for charging a substantially higher price.

***Stipulated Sum***
This form of contract combines aspects of a lump sum and a unit price contract. The contract units are for entire pieces of work such as the intake, penstock, or powerhouse, but there is provision for variations by including values for adding or deleting quantities, such as earthworks, pipe, metal work, concrete and reinforcing. In addition, hourly rates are provided for labour and equipment. This form of contract can limit the amount of extra work involved and provide a simple means of reducing quantities, if required.

### *Form of Construction Contracts*

The form of construction contracts can vary. However this section will discuss the standard components of the Canadian Construction Document Committee (CCDC) contract, which is well recognized in the industry and outlines standard components of a construction contract.

**i) Introduction**
The Introduction sets out matters of mutual understanding, such as the governing laws, lawful money, location, type of project, and time constraints.

**ii) Form of Tender**
A document within the document, the Form of Tender is submitted by contractors with their offer to build the project as described in the documents. It contains blank spaces for filling in a Price Summary, Schedule of Unit Prices, Schedule of Alternative Prices, Schedule of Addition/Deletion Prices, and Schedule of Labour & Equipment Rates. In addition, contractors should provide a summary of their relevant work experience and a time schedule.

**iii) Contract Forms**
When a successful contractor is chosen, most of the information from the Form of Tender is entered into similar forms in this section. There should be space for both parties to sign and seal the Contract. The General Contract Conditions should also be outlined, covering job standards such as insurance requirements, safety regulations, methods of payment, and remedies for each party if the other party fails to live up to their side of the contract.

**iv) Supplemental General Conditions**
In this section, there is the ability to waive any of the preceding conditions or clarify any other points unique to the project or to the owner's requirements.

**v) Detailed Specifications**
This section contains the actual job description for each separate item required (e.g. intake, penstock powerhouse) and outlines the method of construction to follow.

| | |
|---|---|
| *Scope:* | Describes the work that is included in the item |
| *Materials:* | Describes the grade and quality of materials to be used for the various components |
| *Submittals:* | Describes elements that need the owner or engineer's approval prior to the inclusion in the work such as valves, machinery, concrete mix, design and special procedures. Turnaround |

| | |
|---|---|
| | times for approving submittals must be specified. |
| *Construction:* | Describes the workmanship to be utilized in the item |
| *Measurement and Payment:* | Describes how the items are measured (by units or lump sum) and how the units are paid for. |

**vi) Drawings**

Drawings should be provided to explain all facets of the project. As changes are made, revisions should be issued. The drawings are subsequently marked up in the field to record construction changes and revise as-built drawings.

**Find It Online**

The Canadian Construction Documents Committee (CCDC) is a national joint committee responsible for the development and production of Canadian construction contract forms and guides. For more information on construction contract documents, visit their web site:
www.ccdc.org

### *Do-It-Yourself Designing & Building*

If you decide to design and build your project on your own, you will not be required to draw up and administer construction contracts, but you will likely still have a contract with one or more equipment suppliers. The most important aspect of owner-built construction is simply the effective utilization of labour and materials. Start with a plan and provide options to allow the work emphasis to shift if required. Make sure materials are readily available and that equipment is sized for the job. Above all schedule the work to take advantage of the weather conditions, and to allow for timing of instream work.

In constructing be aware of erosion and corrosion problems. Water run-off must be monitored so that construction activities do not lead to erosion that undermines the existing facilities. Corrosion can occur when steel and other metals are exposed to the atmosphere, especially when different metals are in contact with each other. Proper protection coatings must be applied and the dielectric effects caused by the contact of dissimilar metals should be avoided. In addition, damage to protective finishings that occurs due to transportation or installation must be touched up.

The person responsible for project construction is also responsible for site safety. Although the Worker's Compensation Board provides worker protection and regulates safety practices, this does not allow for ignorance of safety issues and will not absolve the responsible person or the contractor of the legal consequences resulting from poor safety practices. Do-it-yourself developers should inform themselves through extensive review of reference materials.

### *Scheduling*

When developing a project, a construction schedule is required to assess the many variables that come into play, such as site conditions and project design. Once a schedule is established, it should be followed to keep control of the project. Where variations occur, update the schedule to look for areas of conflict and revise the starting times of other activities accordingly. In general, allow some "float" time to accommodate unexpected delays and prevent conflicts with one area of work infringing on another. When scheduling construction activities, ensure that times specified in permits, contracts, and financing agreements continue to be met.

### *Project Management*

When a project is underway, there must be an individual responsible for administering contracts and coordinating the work of the contractors. This person, the Project Manager is responsible for purchasing, shipping, storing, and moving materials used for the project into place. They are also responsible for quality inspection and progress monitoring. This is especially important where sections of the work are covered after completion, such as concrete reinforcing, buried pipe, and building frames. The Project Manager is also responsible for ensuring payments to the contractors, completing any extra work orders and claims, and modifying the Contract Drawings into As-Built Drawings to reflect any changes made through the entire process. Depending on the size of the project and the experience of the project manager, many of the noted activities may be delegated to others under the direction of the project manager.

**Find It Online**
The Project Management Institute (PMI) is the leading, non-profit international organization dedicated to promoting professionalism in the practice of project management. Visit the West Coast B.C. Chapter of the PMI web site for more information:
www.pmi.bc.ca

# 7. Operation, Maintenance, and Surveillance

## Introduction

Ongoing operation, maintenance, and surveillance (OMS) are required to keep a plant running smoothly. However, OMS should not be considered only after building a micro hydro facility. It should be considered in choosing a site, designing the facility and when looking for financing. Sites that are remote or have poor access will have greater servicing costs. Facility design can greatly influence ongoing OMS costs including surveillance requirements and replacement and repair costs. Consideration should also be given to the availability of spare parts and the possible purchase of spare parts in advance. In financing the project the annual OMS costs need to be factored into the overall project cash flow. Thus, OMS should be thought of continually throughout the development of the micro hydro project.

This section provides an overview of issues relating to the OMS of a micro hydro development. First, it addresses considerations during the design phase design phase and then presents some ideas on the management of OMS during the lifetime of the facility.

## Design Considerations

It is essential that the long-term OMS costs be considered during the design of a micro hydro facility. For instance, it may be initially cheaper to buy and use uncoated steel pipe rather than a pipe coated for corrosion protection. Once the maintenance costs (the cost of replacing or field coating steel pipes to deal with corrosion), operating costs (increased friction and reduced energy with uncoated pipe), and expected life span are considered it may be cheaper to purchase coated steel pipe. This type of lifetime and reliability analysis should be considered carefully in all aspects of the design – it could save a lot of time and money.

The ease with which maintenance can be performed should also be considered during the design phase of a micro hydro facility. For example, equipment that requires regular maintenance should be located in a place that is easily accessible, and not located in a confined space. Also, if any equipment may need to be removed for maintenance during its lifetime, the means of achieving such a task should be considered. For instance, if any part of the generator needs to be removed for replacement, repairs, or upgrades - is there an economical way of doing it? Is there a hoist or crane capable of moving all the pieces of the generator? Can the roof of the building be removed easily for external crane access? By meticulously thinking through all the possible OMS scenarios that may occur, a lot of time and money can be saved over the life of the project.

## Managing OMS

Even for the smallest micro hydro installations, a plan that ensures the consistent operation, maintenance, and surveillance of the facility is useful, if not necessary. To accomplish consistency in OMS, plans and procedures should be developed. These plans are typically located in the following documents:

***OMS Manual***
The OMS Manual contains the operating instructions for the plant. It is written in a language that the operators can easily understand. OMS Manuals ensure consistent error-free operation of the plant.

***Equipment Manuals***
Manufacturers usually provide Equipment Manuals for most equipment (i.e. turbines, hoists, pumps, switches, etc.). The availability and organization of equipment manuals greatly help OMS efficiency. A great deal of time and money can be spent on trying to find out how to do the necessary OMS, when the actual OMS may take little time or money to complete.

***Facility Drawings and Design Information***
Make sure to keep the proper design information and drawings for all aspects of the plant that are uniquely designed. This information can make future repairs and modifications much easier.

***Maintenance Schedule***
A Maintenance Schedule outlines when and what maintenance should be done. A schedule should be made according to a specific plant's equipment OMS needs. It could consist of a checklist that must be signed by a supervisor or a worker once the maintenance has been completed. It could be a schedule developed using specially designed scheduling software.

***Log Books and OMS Records***
Log Books record what OMS has been completed, and what has happened in the day-to-day operations of the plant. This can help trouble shoot problems regarding the facility's OMS down the road. If any major work is completed that greatly changes the facility's design or operation, a record should be kept for future reference. Over time, new operators will be hired and they can benefit from the recorded experience of their predecessors in operating the plants.

## Other Annual Costs

In addition to OMS there are other annual costs such as loan repayment, land lease, property tax, water rental, insurance premiums, transmission line maintenance, general administrative costs, and contingency allowances that need to be considered. These items are outlined in Section 3 (Costs and Financing).

# Appendices

**Appendix A:** Literature Review

**Appendix B:** Overview of Acts & Regulations

**Appendix C:** Interconnection Requirements

# Appendix A: Literature Review

## BC Government Acts & Associated Publications

The Revised Statutes and Consolidated Regulations of British Columbia
This site contains unofficial copies of BC Acts and Regulations
Including:

Fish Protection Act
Water Act
Water Protection Act

http://www.qp.gov.bc.ca/statreg

*Water Protection in British Columbia*
http://lwbc.bc.ca/water/general/protect.html

*Water Regulation in British Columbia*
http://lwbc.bc.ca/water/waterreg

*Water Rights in British Columbia*
Includes information on water licenses, rights and obligations of users
http://lwbc.bc.ca/water/app_package/water_rights_in_BC.pdf

*Water Rights & Obligations*
http://lwbc.bc.ca/water/app_package/wl_rights.pdf

*Water Rights Information, Research and Copy Charges*
Includes charges for copies of the official version of the *Water Act* and *The Water Protection Act*
http://lwbc.bc.ca/water/factsheets/fs4copy.html

*How to Apply for a Water License*
http://lwbc.bc.ca/water/general/apply.html

## Handbooks & Manuals

Canada. Department of Energy, Mines and Resources. (1980**).** ***Micro Hydro. Volume 1: A Survey of Potential Micro Hydro Developments for use by Remote Communities in British Columbia.*** [Report ER-809E].

Presents the results of a study to estimate micro hydro potential in remote locations of British Columbia, not served at the time of publication by BC Hydro. The province was divided into 10 regions according to major physical and climatic variations. Sub-areas represent each of the regions on the basis of population, energy demand, topography and potential water availability established from iso-flow lines.

Canada. Department of Energy, Mines and Resources. (1980). ***Micro Hydro. Volume 2: Guidance Manual of procedures for Assessment of Micro Hydro Potential.*** Energy Mines and Resources Canada, Ottawa. [Report ER-809E].

This manual presents procedures for the assessment of actual sites for micro hydro development. It provides direction and a step-by-step procedure for a pre-feasibility level investigation from initial map studies through to preliminary site layout cost estimates, economic and financial evaluation. A case study is included.

Canada. Department of Energy, Mines and Resources. ***Small Hydropower Handbook for British Columbia.*** (1986*).* Energy, Mines and Resources Canada & Conservation and Renewable Energy Office, BC., Ottawa.

A detailed manual to assist people interested in developing a small hydro opportunity on sites which do not justify the expense of extensive professional engineering services. It does not assume any previous acquaintance with the subject. Sections focus on feasibility assessment; site exploration and layout; civil works and equipment required; permits, licenses and legal aspects; economics and financing; selection and installation of equipment; operation, maintenance, and surveillance information. Low Head and Cold Weather Considerations are discussed in specialized appendices. The emphasis is on providing an understanding to allow users to do as much as possible themselves, with minimal capital costs.

Canada, Department of Energy, Mines and Resources. (1986, 1989, 1990). ***Small Hydro Sites and Potential Sites in British Columbia.***

A comprehensive listing of these sites, with information relevant to their potential for hydro development.

Commission of the European Communities. Directorate General for Energy. European Small Hydro Association.(1990). ***Layman's Guidebook on How to Develop a Small Hydro Site.*** European Small Hydro Association, Brussels. Part I: 73p. Part II: 111p.

Part I addresses non-technical readers with a general introduction, followed by chapters on economic analysis and environmental mitigation. Part II is written for non-experts, but presupposes a technical understanding of engineering terms, formulae and procedures. Three sections cover the potential of water resources, civil engineering works and electro-mechanical equipment.

Curtis, D., Langley, W. & Ramsey, R. (1999). ***Going With the Flow: Small Scale Water Power Made Easy.*** Maya Books, Twickenham, UK. 160p.

Although written for schemes less than 100kW, this recent guide is also intended to give useful information to the reader generally interested in small hydro schemes. Coverage includes components, site assessment, system design, economics, installation, electrical aspects, and maintenance. Case studies are presented.

Fraenkel, Peter et al. (1991). **Micro-hydro Power: A Guide for Development Workers.** Intermediate Technology Publications, London.160p.

Still in print, this is a comprehensive guide for the non-specialist.

Harvey Adam et al. (1998*).* ***Micro-hydro Design Manual: Guide to Small-scale Water Schemes*.** Intermediate Technology , London. 374p.

New edition of an established guide, available from CISTI, written to give quick and reliable methods of planning a scheme, assessing viability, and sizing and selecting components. Sections include major components, civil works, hydrology, financial evaluation and commissioning and testing. The manual provides worked examples throughout so that financial and engineering calculations can be followed in detail.

Independent Power Producers of Ontario (IPPSO). (2000). **Canadian Power Directory 2000.** IPPSO, Toronto, Ont. 331p.

Reference guide to Canadian project developers, equipment and service suppliers, financiers, associations, government agencies, consultants as other resources. Available from IPPSO.

Inversin, Allen R. (1986). ***Micro-hydropower sourcebook : a practical guide to design and implementation in developing countries.*** NRECA International Foundation, Washington, D.C.

A complete reference to the planning, construction and implementation of micro schemes.

Mathews, Robert (2000). **Micro Hydro Course Materials.**

60 pages of text and figures are provided with a Micro-hydro course (2-5 days long) that is provided at several locations in B.C., throughout the year. The course materials include two videos, overhead projections, slides and explanations provided by an individual with over 15 years experience, including about 20 installations up to 55kW. Contact: Appropriate Energy Systems, Box 1270, Chase, B.C. V0E 1M0, Ph.: 250-679-8589.

Sigma Engineering. (1983). **Small-Hydro Power Resource in the Provincial System.** Ministry of Energy, Mines & Petroleum Resources, British Columbia. 2 Vols. Vol I: Technology and Resource Assessment. Vol II: Economic and Financial Assessment.

Provides guidelines for developing small hydro sites from a technical and regulatory viewpoint, and a step-by-step guide for establishing preliminary designs and costs. 665 potential small hydro sites in BC, including those suitable for micro schemes, are identified.

## Subject Specific References

**Agreements to Purchase Electricity**

**Connection to Utility Distribution Systems**

Canadian Electrical Association. (June 1994). ***Connecting Small Generators to Utility Distribution Systems.*** CEA, Montreal, Q. [CEA 128-D-767].

BC Hydro. Distribution Engineering and Planning. ***BC Hydro Connection Requirements for Non-Utility Generation, 35KV and Below*.** BC Hydro, Vancouver, BC. 36p.

On the BC Hydro web site at http://www.bchydro.com/info/ipp/ipp992.html

**Dams**

United States Department of the Interior. Bureau of Reclamation. 3rd ed. (1987). ***Design of Small Dams**.* Bureau of Reclamation, Denver. 860p.

Definitive text on the planning, design, construction, operation and evaluation of small dams up to 200' high. Major sections on spillways and outlet works, ecological and environmental considerations, flood hydrology, construction and hydraulic computations.

**Design (General)**

American Society of Civil Engineers. Energy Division. (1989). ***Civil Engineering Guidelines for Planning and Designing Hydroelectric Developments. Volume 4: Small Scale Hydro**.* American Society of Civil Engineers, New York, NY.

Intended for use by civil engineers in conjunction with the *Conventional Guidelines* also published by ASCE, these guidelines give an insight into problems and solutions related to all aspects of small hydro projects. Particular emphasis on the need for evaluation, planning, and design considerations.

Koch, C. P. (1990). ***Small hydroelectric design manual*****.** C.P. Koch, New Westminster, BC. 29p.

Written to help with design calculations which are essential before practical aspects of a project can be considered.

Shawinigan Consultants. (1983). ***Methodology for the Design and Costing of Small Hydro Plants**.* Canadian Electrical Association, Montreal, Q. 247p.

A useful manual, which presents a simplified methodology intended for project assessments at the site identification and reconnaissance levels. The six sections include layout options, technical considerations, cost estimates and project evaluation.

**Economics and Financing**

BC Hydro. Resource Planning. (1991)*.* ***Financial Evaluation Guide for Private Power Projects***. BC Hydro, Vancouver, BC. 35p.

Explains the different components of electricity, types of costs, and factors affecting costs, and provides a guide to calculating a project's potential value.

Ontario. Ministry of Energy. (1986). ***Small Hydro '86. Proceedings. March 5-6, 1986**.*

Conference papers dealing with municipal and private micro projects, with a focus on economics and financing. Largely dealing with Ontario and Quebec, but much is of general applicability.

Sigma Engineering. (1983). **Small-Hydro Power Resource in the Provincial System. Vol II: Economic and Financial Assessment.** Ministry of Energy, Mines & Petroleum Resources, British Columbia.

Provides a step-by-step guide for establishing preliminary designs and costs.

Tudor Engineering Company. (1983). ***Simplified Methodology for Economic Screening of Potential Small-Capacity Hydroelectric Sites.*** Electric Power Research Institute, Palo Alto, CA.

A step-by-step guide for users with limited technical background to estimate the power and energy output, and project costs for a potential site, and to perform preliminary economic analysis. Appendices discuss engineering design and layout, equipment, and hydrology and data collection methodology and evaluation.

**Electrical Safety**

Electrical Industry Training Institute. (1997). ***High Voltage Substation Electrical Awareness**.* EITI, Surrey, BC. 50p.

Safety manual written for electrical workers in BC, with sections on electricity, safety equipment, substation equipment, working distances, safety grounding and station inspection.

Electrical Industry Training Institute. (1998). ***High Voltage Substation Electrical Awareness for Non-Electrical Workers***. EITI, Surrey, BC. 17p

Supplement to the above publication.

**Environmental**

Environmental & Social Systems Analysts (1991). ***Small Hydro Environmental Handbook.*** Canadian Electrical Association, Montreal, Q. [CEA 950 G 741].126p.

This handbook describes three aspects of the environmental and regulatory planning of small hydro developments: government regulatory approval processes, recommended steps in the environmental planning of a project, and a detailed environmental screening process. Answers to the questions addressed will provide readers with the basis for initial contacts with provincial and municipal government representatives.

Ottawa Engineering Ltd. (1992). ***Environmental Aspects of Small Hydro Projects.***

**Equipment** (see also Generators, Pumps as Turbines, Turbines)

Hulscher, Wim & Fraenkel, Peter. (1994). ***The Power Guide: An International Catalog of Small-Scale Energy***. Stylus Pub, Hendon,VA. 240p.

Mathews, Robert. 7th ed. (1998). ***Energy Alternatives Design Guide & Catalogue*.** Energy Alternatives, Chase, BC. 40p.

Explanations, advice and guidance for do-it-yourself developers of the lower range of micro hydro schemes, complement a catalogue of relevant equipment.

**Feasibility Studies**

Canada. Department of Natural Resources. ***RETScreen*** [Software]**.** NRCAN, Ottawa, Ont.

Downloadable Renewable Energy Project Analysis Software, developed by the Government of Canada through the CANMET Energy Diversification Research Laboratory (CEDRL) of Natural Resources Canada. The RETScreen Small Hydro Model is based on twenty years of data and can be used to evaluate micro hydro projects using worksheets to carry out an energy model, a cost analysis and a financial summary. A hydrology worksheet is also provided.

Fritz, Jack J. (1984). ***Small & Mini Hydro Systems: Resource Assessment & Project Feasibility***. McGraw-Hill, New York. 300p.

Technical manual and guidebook consisting of a collection of technical papers by different experts on hydrology, turbine design, generators and electrical equipment, dams, site design, economics and environmental considerations. Includes a comprehensive chapter on feasibility with examples and case studies.

Lanmer Consultants Ltd. (1982*).* ***Considerations for Small Hydro Developments in Off-Grid Locations*.** Energy, Mines and Resources Canada, Ottawa, Ont.

Ontario. Ministry of Energy. (1986*).* ***Streams of Power: Developing Small Scale Hydro Systems****.* Renewable Energy in Canada, Toronto, Ont. 107p.

Small handbook covering the basic issues and considerations in planning a micro hydro system and a step-by-step guide to making a preliminary feasibility analysis and options available for developing a site.

U.S. Department Of Energy. Hydrologic Engineering Center & The Institute for Water Resources. (1979*).****Feasibility studies for small scale hydropower additions: a guide manual.*** US Army Corps of Engineers, Ft. Belvoir, VA.

An extensive, but readable, manual providing technical data and procedural guidance for the systematic appraisal of the viability of potential small hydropower additions to existing facilities. With emphasis on the need for detailed planning studies, six sections focus on concepts and technology, economic and financial issues, hydrologic studies, existing facility integrity in relation to dam safety, and electromechanical and civil considerations. Two case studies are used to test the manual and to illustrate the application of its data.

**Generators**

Smith, Nigel. (1994). **Motors As Generators for Micro-Hydro Power.** Stylus Pub VA. 82p.

This practical handbook, which is still in print and available from CISTI and Stylus Publishing, is a guide to the use of induction motors for electricity generation in remote locations. It is based on the practical experience of manufacturers and installers of induction generator units working in a number of countries.

**Hydraulics**

Chow, Ven Te. (1981). ***Open Channel Hydraulics*.** McGraw-Hill, New York, NY.

An engineering text which aims to bridge the gap between theory and practice with a simplified explanation of hydraulic theory, and a minimal use of advanced mathematics.

Sections include basic energy and momentum principles, design of channels, an analysis of various types of flow, spillways, surges and practical problems related to transitions.

Parmakian, John. (1963). ***Waterhammer Analysis*.** Dover. New York, NY. 161p.

An engineering text which analyses and offers solutions to practical waterhammer problems associated with gates, pumps, pipes and other operations. Reliability of analysis methods has been demonstrated in field tests. An elementary knowledge of hydraulics and calculus is essential.

Choudry, ***Waterhammer Text.***

Has computer program listings. Same author produces a waterhammer computer program package, which is relatively expensive but covers most applications.

Karney, Bryan. **TransAM Model** by HydraTek Associates.

This is a relatively inexpensive but powerful water hammer analysis program (for MS - Windows) devised by a University of Toronto professor. It is mainly suited to Pelton turbines, but could be used on other machines with guidance.

**Hydrology**

Acres International Ltd. (1984). ***Hydrologic Design Methodologies for Small-Scale Hydro at Ungauged Sites- Phase I.*** Energy, Mines and Resources Canada, Ottawa, Ont.

Acres International Ltd. (1985). ***Hydrologic Design Methodologies for Small-Scale Hydro at Ungauged Sites- Phase II .*** Energy, Mines and Resources Canada, Ottawa, Ont.

Acres International Ltd. (1988). ***Streamflow Analysis Methodology for Ungauged Small-Scale Hydro Sites.*** Energy, Mines and Resources Canada, Ottawa, Ont.

Acres International Ltd. (1994). ***Hydrologic Design Methodologies for Small-Scale Hydro at Ungauged Sites- Upgrading of Ontario and Atlantic Province Models* .** Environment Canada, Water and Habitat Branch, Ottawa, Ont.

Ministry of Sustainable Resource Management. ***Streamflow in the Lower Mainland and Vancouver Island***. Located at: http://srmwww.gov.bc.ca/appsdata/acat/html/deploy/acat_p_report_1002.html

**Intakes**

American Society of Civil Engineers. Energy Division. Committee on Hydropower Intakes. (1995). ***Guidelines for the Design of Intakes for Hydroelectric Plants*.** American Society of Civil Engineers, New York, NY. 469p.

State-of-the-art guidelines for the sound environmental design of intakes. Information provided on intake types and features, forebay, hydraulic design considerations, trashrack and gate design, fisheries considerations, sedimentation, and environmental factors.

Lauterjung, H. & Schmidt, G. (1989). ***Planning of Intake Structures*.** Vieweg, Braunshweig 122p.

A planning guide written for nonspecialists providing most important fundamentals for the planning and design of intakes. Contains description of the essential basic hydrological data required, hydraulic modes of operation and calculation methods for proof of stability. Presupposes some advanced mathematical knowledge.

**Miscellaneous Topics**

American Society of Civil Engineers. Energy Division.Task Committee on Lessons Learned from the design, Construction and Operation of Hydroelectric Facilities. (1994). ***Lessons learned from the Design, Construction and Operation of Hydroelectric Facilities.*** American Society of Civil Engineers, New York, NY.

A compilation of over 70 project examples which include a number of micro hydro developments. Easy to read case studies identify specific problems, causes and effects, investigations, actions taken, and lessons learned.

United States. Army Corps of Engineers (1981). ***Waterpower '81. An International Conference on Hydropower. June 22-24, 1981. Volume 1.*** USBR, Washington, DC. 898p.

American Society of Civil Engineers. (1983). ***Waterpower '83. International Conference on Hydropower. September 18-21, 1983, Knoxville, Tennessee. Volume 1.*** ASCE, New York, NY..556p.

American Society of Civil Engineers. (1985). ***Waterpower '85. International Conference on Hydropower. Las Vegas, Nevada, September 25-27, 1985. Volume 1.*** ASCE, New York, NY. 682p

These three *Waterpower* conferences of the early 1980's had a major focus on small and micro hydro, reflecting the wide interest in these areas at the time. Numerous case studies are presented, and issues discussed, many of which are still relevant.

***Renewable Energy - Small Hydro: Select Papers.*** (1997). Ashgate Publishing, Aldershot, Hants. 390p

**Penstocks**

American Society of Civil Engineers. Energy Division. Committee on Manual of Practice for Steel Penstocks. (1993). ***Steel Penstocks*.** American Society of Civil Engineers, New York, NY. 432p.

Everything you need to know about steel penstocks: design, manufacture, installation, testing, startup, and maintenance, including branches, wyes, associated appurtenances, and tunnel liners. Extensive section on design examples, with calculations.

American Iron and Steel Institute. (1992).***Steel Plate Engineering Data-Volume 4. Buried Steel Penstocks.*** (1992). American Iron and Steel Institute, Washington, DC. 87p.

A technical manual which assembles data and procedures successfully used in the design of buried penstocks. Includes sections on hydraulics, thrust restraint, pipe joints, linings and coatings, corrosion and methods of controlling it. Extensively illustrated.

American Iron and Steel Institute.(1982).***Steel Plate Engineering Data-Volume 4. Steel Penstocks and Tunnel Liners. A manual on materials, design and construction with design computations**.* (1982). American Iron and Steel Institute, Washington, DC. 111p.

Most of this manual is devoted to design and construction, but important preliminary sections consider design conditions and allowable stresses pertaining to non-embedded, buried, and concrete-embedded steel penstocks, and to tunnel liners. Appendices present sample design computations. Clearly illustrated with graphics and tables, and uses text suitable to the lay person.

**Protection and Control**

Ottawa Engineering & Acres International Ltd. (1996). **Low Cost Protections and Control for Mini-Hydro Intertie.** Canadian Electrical Association, Montreal, Q. n.p. [CEA 9152 G 973]

A report on a study into the concerns and requirements of Canadian utilities with respect to control, protection and operation of mini-hydro interties. Identifies and evaluates low cost p&c equipment. Includes case studies.

**Plastic Pipes**

KWH Pipe (Canada) Ltd. ***Sclairpipe (high density polyethylene pipe) Design, Construction Manuals.***.

American Water Works Association (AWWA). ***Standards C900 for Polyvinyl Chloride (PVC) Pressure Pipe.*** AWWA.

Uni-Bell PVC Pipe Association. ***Uni-Bell Handbook of PVC Pipe, Design and Construction.***

**Powerlines**

BC Hydro. ***Overhead Distribution Standards (1992): Overhead Electrical***, ***ES43 Series.***

Kurtz, E.B. and Shoemaker, T.M. (9th Edition). ***The Lineman's and Cableman's Handbook***, McGraw Hill, 1056 p.

Covers basic principles and best procedures for the construction, operation, maintenance, and surveillance of overhead and underground electric distribution and transmission lines.

**Pumps as Turbines (PAT's)**

Chapallaz, J-M., Eichenberger, P. & Fischer, G.(1992). ***Manual on Pumps used as Turbines***. Vieweg, Braunschweig, FRG. 221p.

Published in cooperation with MHPG, The Mini Hydro Power Group, this manual provides a detailed account of the use of pumps as turbines in micro-hydro schemes. Includes selection charts based on the test results of over 80 PATs to enable engineers or technicians select a unit for a specific purpose.

Koch, C. P. (1990). ***Supplement to the small hydroelectric design manual*.** C.P. Koch, New Westminster, BC. 12p.

A small manual in 3 sections: a method of estimating a centrifugal pump's performance as a turbine based on manufacturer's efficiency data, how to ascertain the suitability of a used pump with unknown data, and how to install a pump.

Williams, Arthur et al. (1995). ***Pumps as Turbines : A Users Guide***. Nottingham Trent Univ., Nottingham, UK. 58p.

Reprinted in 1997, this is a practical handbook to the use of standard pump units as a low-cost alternative to conventional turbines.

**Steel pipe** (see also Penstocks)

American Iron and Steel Institute. rev.ed.(1992).***Steel Plate Engineering Data-Volume 3. Welded Steel Pipe: Merits, Design Standards, Technical Data and References****.* American Iron and Steel Institute, Washington, DC. 113p.

A compilation of useful and readable information for the design of water systems using welded steel pipe. Includes design criteria and procedures, joints, fittings, above ground installations, corrosion and protection coatings. Complemented with technical charts and tables.

American Water Works Association. (1987). ***Steel Pipe - A Guide for Design and Installation. Manual M11***. AWWA. 174 pp.

Although intended for water supply lines, this manual also has application to steel penstocks and has sections on pipe characteristics, manufacture, hydraulics, design, joints, fittings, corrosion, handling and special details.

**Turbines**

Thake, J. (1999). ***Micro-Hydro Pelton Design Turbine Manual: Design, Manufacture and Installation for Small-scale Hydro-power***. Intermediate Technology Development Group London. 320p.

Recent comprehensive text on the use of Pelton turbines in micro hydro situations. Available through Stylus Publications, VA.

**References available from CISTI (Canadian Institute for Scientific and Technical Information)**
For purchase or borrowing arrangements see http://cat.cisti.nrc.ca/

Inversin, Allen R. (1986). ***Micro-hydropower sourcebook : a practical guide to design and implementation in developing countries.*** NRECA International Foundation, Washington, D.C.

A complete reference to the planning, construction and implementation of micro schemes.

American Energy Organization (OLADE)**.** (1983***). Mini-hydropower stations : a manual for decision makers****.* United Nations (UNIDO), New York, NY.

Canada. Centre for Mineral and Energy Technology. (1990). ***Development of a stand-alone induction generator for low cost micro-hydro systems.*** Centre for Mineral and Energy Technology, Ottawa, Ont.

Canada. Centre for Mineral and Energy Technology. Alternative Energy Division. (1979***). Micro-hydro power : reviewing an old concept.*** NTIS, Springfield, Va.

Monition, L., Le Nir, M & Roux, R. (translated by Joan McMullan). (1984). **Micro hydroelectric power stations** . J. Wiley, New York, NY.

Kahn, A & Hinton, E. (1994***). Modelling Design Sensitivity and Optimization of Micro-Hydro Schemes: Part 1 - Characteristic Features.*** Department of Civil Engineering, University of Wales, Swansea, Wales. [Internal report CR/832/94].

Kahn, A & Hinton, E. (1994). ***Modelling Design Sensitivity and Optimization of Micro-Hydro Schemes: Part 2 - System Analysis and Optimization by Dynamic Programming***. Department of Civil Engineering, University of Wales, Swansea, Wales. [Internal report CR/832/94].

## Published Papers

**Innovative Technologies, International Perspectives and Case Studies**

Antloga do Nascimento *et al*. (1999). “The evolution of small hydro plants in Brazil: New concepts for a new age” in *Hydropower into the Next Century, Gmunden, Austria, October 1999. Conference Proceedings.* International Journal on Hydropower & Dams, Sutton, Surrey, UK.
p. 71-80.

“Avoiding failure of mini hydro bearings”. (1998). *International Journal on Hydropower & Dams*. 5 (4). p. 79-80.

Barnes, Marla. (1991). “Strathcona Hydro: Carrying on a dream.” *Hydro Review.* 10 (7), December. p. 52-62.

Baxendale, J. (1997). “Planning the Dulyn Eigiau small hydro scheme in Wales”. *International Journal on Hydropower & Dams.* 4 (4). p. 65-68.

Beggs, S.L. . (1992). “Independent Canadian hydro: Responding to opportunities”. *Hydro Review.* 11 (3), June. p. 28-32.

Bell, P.A. & Smith, N. (1995). "Increasing the efficiency of stand-alone self-excited induction generators for micro-hydroelectric schemes." *International Journal of Ambient Energy*. 16, (3), July, p 155-161.

Bouziane,S., Deschenes,C. (1998). "Testing the characteristics of a propeller micro hydro turbine". *International Journal on Hydropower & Dams.* 5 (4), p. 53-9.

Brekke, H. (1999). "Utilizing small hydro for increased hydro production" in *Hydropower into the Next Century, Gmunden, Austria, October 1999. Conference Proceedings.* International Journal on Hydropower & Dams, Sutton, Surrey, UK. p. 81-89.

Brown, A. (1998). "Causes of breakdowns at micro hydro systems". *International Journal on Hydropower & Dams.* 5 (4). p. 81-82.

Busse, E., Haag, T &Coupe, L. (1992). "Generating electricity along municipal water supply systems". *Hydro Review*. 11 (2), April. p. 28-38.

Clemen, D. & Hayes, S. (1989). "Start-up and commissioning procedures for hydro electric units". *Hydro Review*. 8 (3), February. p. 64-70.

"Cost effective small hydro control". (1996). *International Water Power and Dam Construction*. 48 (10). p. 30-33.

Cowdrey, J.M. (1996). "Making small hydro work well on a water supply system". *Hydro Review*. 15 (1), February. p. 52-60.

Croker, K. & Rees, G. (1998). "Software package puts small hydro on the map". *International Water Power and Dam Construction*. 50 (3), p. 42-43.

Demetriades, G., Williams, A. & Smith, N. (1996). "Simplified propeller turbine runner design for stand alone micro-hydro power generation units". *International Journal of Ambient Energy.* 17 (3). July. p 151-156.

Dygert, D. (1999). Restoring turbine efficiency with abrasion resistant epoxies." *Hydro Review .* 18 (4), July. p. 28-33.

FitzPatrick, J.B. (1993). "Investigating syphon hydro intake installations*". Hydro Review Worldwide.* 1 (2), Fall. p. 28-33.

"Foundations for a harmonious future". (1998). *International Water Power and Dam Construction*. 50 (3). p. 34-37.

Gökler, G. & Heigerth, G. (1999). "Powerplant of the Viktor Kaplan Academy: an innovative mini hydro" in *Hydropower into the Next Century, Gmunden, Austria, October 1999. Conference Proceedings.* International Journal on Hydropower & Dams, Sutton, Surrey, UK. p. 109-115.

Haynes, F. D. (1993). "Seeking solutions for icing at dams and hydro plants". *Hydro Review*. XII (7), December. p. 58-64.

Henderson, D. (1998). "An advanced electronic load governor for control of micro hydroelectric Generation". *IEEE Transactions on Energy Conversion.* 13 (3), p. 300-4.

Henderson, D.S.& Maclean. (1998). "Control, protection and monitoring of a micro hydro generating set". *International Journal on Hydropower & Dams.* 5(1). p. 74-7.

Henderson, D.S. "The Ashfield Mill electronic load governor- Operational results" in *Hydropower into the Next Century, Gmunden, Austria, October 1999. Conference Proceedings.* International Journal on Hydropower & Dams, Sutton, Surrey, UK. p. 125-133.

Heniger, L. (1995). "Putting pumps to work for generation at small hydro sites". *Hydro Review Worldwide*. 3 (2), Summer. p. 36-38.

Jardine, Tom. (1997). "Peaks and troughs". *International Water Power and Dam Construction*. 49 (11), November. p 40-41.

Kahn, A. & Walters, G.A. (1990). "An Optimal Design Package for Micro-Hydro Systems", *Fourth International Conference on Small Hydro.* p. 256-267.

Kamberg, M.L. (1993). "Honey, Let's start a power company!" *Hydro Review.* 12 (7), December. p.36-40.

Kamberg, M.L. (1997). "Keeping water power in the family". *Hydro Review.* 16 (1), February. p.42-46.

Keith, G.O. *et al*. (1995). "Small hydro turbine/generator projects at TVA". *Waterpower 1995: International Conference, San Francisco, CA, 25-28 July 1995*. American Society of Civil Engineers, New York, NY. p. 543-552.

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Koseatac, A.S. (1993). “Procuring small hydro equipment: Ways to ensure satisfactory performance”. *Hydro Review*. 12 (7), December. p. 52-56.

Meier, Ueli. (1999). “Flat belt drives: a modern technology for small hydro plants”. *International Journal on Hydropower & Dams.* 6 (3). p. 78-79.

Punys, P. *et al.* (1999). “Prospects for installing small hydro at existing dams in Lithuania” in *Hydropower into the Next Century, Gmunden, Austria, October 1999. Conference Proceedings.* International Journal on Hydropower & Dams, Sutton, Surrey, UK. p. 99-107.

Reddy, H., Seshadri, V., Kothari, D.P. (1996). “Effect of draft tube size on the performance of a cross-flow turbine”. *Energy Sources*. 18 (2), March. p. 143-149.

“Reliable and cost effective micro hydro power”. (1998) *Electrical Line*. 4 (2), March/April.p41-43.
Describes a micro hydro development at Kamloops, B.C.

Small, S. (1998). “Rubber dams improve operations, safety”. *Hydro Review.* 17 (7), December.
p. 58-59.

“Small hydro turbine buyers’ guide”. (1997). *International Journal on Hydropower & Dams.* 4, (4), p. 60-63.

“Small hydro in Europe's renewable energy mix”. (1998). *International Water Power and Dam Construction*. 50 (6). p. 32-33.

Smith, Nigel P.A. (1996). “Induction generators for stand-alone micro-hydro systems”. *Proceedings of the 1996 International Conference on Power Electronics, Drives & Energy Systems for Industrial Growth, PEDES'96. New Delhi, India. Part 2.* IEEE, Piscataway, NJ.
p. 669-673.

Taylor, P. (1999). “Fuzzy logic takes control”. *International Water Power and Dam Construction.*
51 (11). p. 24-25.

Tong, Jiandong. (1998). “China’s approach to environmentally sound small hydro development”.
*International Journal on Hydropower & Dams.* 5 (1). p. 67-69.

Wuntke, W. (1996). “Addition of a mini hydro station at the Markersbach pumped-storage plant”.
*International Journal on Hydropower & Dams*. 3 (4). p. 54-5

## Useful Web sites

*See also “Web sites for Manufacturers and Suppliers”*

Canadian

http://geonames.nrcan.gc.ca/index_e.php
Site at which it is possible to determine latitude, longitude, and topographic map number for a particular site.

http://www.IPPBC.com/
Independent Power Producers Association of British Columbia
Contains information on memberships, news, conferences, and policies.

http://www.IPPSA.com/
Independent Power Producers Society of Alberta

http://www.newenergy.org
Website of IPPSO, the Independent Power Producers’ Society of Ontario.

http://maps.nrcan.gc.ca/topographic.html
Use to order topographic maps for general locations from Natural Resources Canada.

http://www.renewables.ca
Canadian Association for Renewable Energies: A federal non-profit association, incorporated to promote feasible applications of renewable energies. Offers frequently updated news and information. An archive holds records of previous bulletins. Good for an international perspective.

http://www.retscreen.gc.ca/

This is the site of the downloadable Renewable Energy Project Analysis Software, RETScreen, developed by the Government of Canada through the CANMET Energy Diversification Research Laboratory (CEDRL) of Natural Resources Canada. The RETScreen Small Hydro Model is based on twenty years of data and can be used to evaluate micro hydro projects using worksheets to carry out an energy model, a cost analysis and a financial summary. A hydrology worksheet is also provided.

http://www.msc.ec.gc.ca/wsc/products/main_e.cfm?cname=products_e.cfm

Water Survey Canada streamflow data (HYDAT) available on a CD-ROM.

**Other**

http://www.crest.org
http://solstice.crest.org

Solstice is the Internet information service of the Renewable Energy Policy Project and the Center for Renewable Energy and Sustainable Technology (REPP-CREST), and is a site dedicated to sustainable energy and development information.

http://www.eren.doe.gov/

U.S. Department of Energy renewable energy site with links.

http://www.eren.doe.gov/consumerinfo/refbriefs/ab2.html

Is a Micro-Hydroelectric System Feasible for You? An on-line paper, published by DOE. A starting point to the issues which should be considered and methods which may be used to carry out a preliminary feasibility assessment of a micro hydroelectric system. A reference list at the end of this brief provides sources of more information.

http://www.hydro.org/

U.S. National Hydropower Association

http://www.iea.org/

International Energy Agency

http://www.nrel.gov/

The US National Renewable Energy Laboratory

http://www.small-hydro.com

This site is a front-end to a database, which stores information about countries, contacts, organizations, and programs and activities related to small hydro. Links to related sites. Valuable to anyone wishing to find a complete source of Contact information, as well as information on the state of Small Hydropower in many countries.

## Publishers & Bookshops Specializing In Alternative Energies

Canada

http://cat.cisti.nrc.ca/
Canada Institute for Scientific and Technical Information, a National Research Council initiative.

**Other**

Gaiam Real Goods
360 Interlocken Blvd, Ste 300
Broomfield, CO 80021-3440
Web site: http://www.realgoods.com/

Ashgate Publishing Co.
Aldershot, Hants, UK
E-mail: info@ashgatepub.co.uk
Web site: http://www.ashgate.com

Stylus Publishing
P.O. Box 605
Hendon, VA. 20172-0605
E-mail: Styluspub@aol.com
Web site: http://styluspub.com/
Distributors in North America for publications of Intermediate Technology Publications, London. UK.

## Suppliers & Manufacturers

**Note:** This section only provides information on specialized equipment including turbines, generators, controls, pipe, electrical and intake equipment. There is no attempt made to list sources of common construction materials such as steel, concrete, lumber, prefab buildings etc. The listing may not include all suppliers and is not intended to endorse any particular supplier.

**British Columbia Suppliers**
**Packaged Plants**

**Energy Alternatives**
825 Laval Crescent
Kamloops BC V2C 5P2
Phone: 250-374-3943
Toll free: 1-800-265-8898
Fax: 250-679-8589
E-mail: energyalternatives@bc.sympatico.ca

**Thomson & Howe Energy Systems**
Site 17 Box 2 SS#1
Kimberley BC V1A 2Y3
Phone: 250-427-4326
Fax: 250-427-4326
E-mail: thes@cyberlink.bc.ca

**Wismer & Rawlings Electric Ltd.**
1616 Kebet Way,
Port Coquitlam, BC V3C 5W9
Phone: 604-944-1117
Fax: 604-944-1127
E-mail: rgould@wre.ca

**Turbines**

**Boundary Electric (1985) Ltd**
7990 Columbia Drive
PO Box 758
Grand Forks BC V0H 1HO
Phone: 250-442-5561
Fax: 250-442-8322

**Dependable Turbines**
Unit 7, 3005 Murray Street
Port Moody, BC V3H 1X3
Phone: (604) 461-3121
Fax: (604) 461-3086
E-mail: dtlhydro@towncore.com

**Controls**

**Thomson Technology Inc.**
19214-94$^{th}$ Avenue
Surrey BC V3T 4W2
Phone: 604-888-0110
Fax: 604-888-381
E-mail: ttinfo@tti.bc.ca
Web site: http://www.thomsontechnology.com

**HDPE pipe and PVC pipe**

**Prolite Plastics**
1620 Kingsway Ave.,
Coquitlam V3C 3YG
Phone: 604-944-0282
Fax: 604-944-8854
Email: sales@proliteplastics.com
Web site: http://www.proliteplastics.com/

**Steel pipe**

**Pipe and Piling Supplies (B.C.) Ltd.**
1835 Kingsway Avenue
Port Coquitlam BC V3C 1S9
Phone: 604-942-6311
Fax: 604-941-9364
Web site: http://www.pipe-piling.com

**Substations**

**Marcus Transformer of Canada Ltd.**
19522 96 Avenue,
Surrey, BC
Phone: 604-882-8488

**Boundary Electric (1985) Ltd**
7990 Columbia Drive
PO Box 758
Grand Forks BC V0H 1HO
Phone: 250-442-5561

**GEC Alsthom**
1-2155 Rosser
Burnaby, BC
Phone: 604-291-8881

**Wismer & Rawlings Electric Ltd.**
1616 Kebet Way,
Port Coquitlam, BC V3C 5W9
Phone: 604-944-1117
Fax: 604-944-1127
E-mail: rgould@wre.ca

**Out of Province Suppliers**

**General**

**Canadian Hydro Components Ltd.**
16 Main Street Box 640
Almonte, ONT K0A 1A0
Phone: 613-256-1983
Fax: 613-256-4235
E-mail: hydro@istar.ca
Web site: http://www.canadianhydro.com

**Canyon Industries**
5500 Blue Heron Lane
PO Box 574
Deming  WA 998244
Phone: 360-592-5552
Fax: 360-592-2235
E-mail: citurbine@aol.com

**Sulzer Hydro**
60 Worcester Road
Rexdale ONT M9W 5X2
Phone: 416-674-2034
Fax: 416-213-1031
E-mail: thomas.taylor@sulzer.com
Web site: http://www.sulzer.com

**Packaged Plants, Controls**

**Powerbase Automation Systems Inc.**
150 Rosamond Street
Carelton Place, ONT. K72C 1V2
Phone: 613-253- 5358
Fax: 613-257-1840
E-mail: ygrandmaitre@powerbase.com
Web site: http://www.powerbase.com/

**Phoenix Power Control Inc**.
17921 Bothell-Everett Highway #103
Bothell WA 98012
Phone: 425-398-8771
Fax: 425-398-8772
E-mail: hvernon@msn@phoenixcontrol.com

**Sulzer Hydro**
60 Worcester Road
Rexdale ONT M9W 5X2
Phone: 416-674-2034
Fax: 416-213-1031
E-mail: thomas.taylor@sulzer.com

**Ice Control**

**Fleet Technology Ltd.**
311 Legget Drive
Kanata ONT K2K 1Z8
Phone: 613-592-2830
Fax: 613-592-4950
E-mail: razek@fleet.co
Web site: http://www.fleetech.com

**Rubber Dams**

**Bridgestone Engineered Products Co., Inc.**
18377 Beach Blvd, Ste 216
Huntington Beach, CA 92648-1349
Phone: 1-714-377-7346
Fax: 1-714-377-2485

**Obermeyer Hydro Inc.**
PO Box 668
Fort Collins CO 80522
Phone: 970-568-9844
Fax: 970-568-9845
E-mail: hko@obermeyerhydro.com
Web site: http://www.obermeyerhydro.com

**Turbines**

**Voith Hydro Power Generation**
PO Box 712
York PA 17405
Phone: 717-792-7000
Fax: 717-792-7263
Web site: http://www.voithyork.com/

## Publications

The following are regularly published resources for small hydro and alternate energy information, although Energy Projects of all sizes may also be described.

**Hydro Review**
HCI Publications
410 Archibald Street
Kansas City, MO 64111-3046
Phone: 816-931-1311

E-mail: hci@aol.com
**International Water Power and Dam Construction**
PO Box 200
Ruislip, Middlesex HA4 OSY
United Kingdom
Phone: 44-181-841-3970
E-mail: waterpower@wilmington.co.uk

**IPPSO Facto**
Independent Power Producers' Society of Ontario
163-C Eastbourne Ave.,
Toronto, ONT. M5P 2G5
Phone: 416-322-6549
E-mail: IPPSO@ippso.org

# Appendix B: Overview of Acts & Regulations

**Water Act (Provincial)**

The provincial Crown owns all water present in streams, rivers and lakes in British Columbia. Individuals or companies who wish to divert and use this "surface" water are required by law to first obtain a license under the Water Act. All owners of land or projects who have a proposed use for surface water are given equal access to the water on a first come, first served basis. The water license specifies the terms and conditions under which the right to use water is granted, for example, the maximum quantity of water that may be diverted or stored. Once a water license is granted, the provincial Crown will charge an annual fee for the water used. A water license is legally considered part of (or "appurtenant to") the land or project of the licensee. If the land or project is sold, the water license automatically passes to the new owner.
http://www.qp.gov.bc.ca/statreg/stat/W/96483_01.htm

**Land Act (Provincial)**

In many cases the developer of a hydro project will require the use of land owned by the provincial Crown. In these cases the developer of the project must apply for the land. The Crown may sell, lease, grant a right of way over or grant a license to occupy Crown land. In a disposition of Crown land, the minister may impose various conditions including that the applicant must occupy and/or do work on the land within a specified period of time. Crown land located below the natural boundary of a body of water generally cannot be disposed of (sold, leased, etc.) by the Crown, but rights of occupation can be granted.

The Land Act outlines the application process for Crown land. The application is made to the commissioner of the land recording district where the land is located. The minister may require the applicant to provide further information, which could include feasibility studies, environmental assessments, timber cruises or land valuation appraisals. The minister may require the applicant to pay the cost of assessing the impact of the disposition or monitoring compliance with the terms of the disposition.
http://www.qp.gov.bc.ca/statreg/stat/L/96245_01.htm

**Fish Protection Act (Provincial)**

The objective of this Act is to protect the health of fish bearing streams, including water flows in these streams. The Fish Protection Act states that, when reviewing an application for a water license, the Comptroller of Water Rights or the Regional Water Manager may consider impacts on fish and fish habitat. The Comptroller may set conditions to protect fish or fish habitat, including a requirement for the licensee to monitor stream flow.

Section 6 of the Fish Protection Act was brought into force on March 10, 2000 and allows the province to designate certain streams as "sensitive streams" in order to protect fish populations considered to be at risk. Sensitive streams are those that require special protection because of inadequate water flows, or because fish habitat is damaged or endangered. Fifteen streams have been identified as candidates for immediate designation as sensitive streams. Additional designations will take place over the next several years. A water license on a sensitive stream may be issued only if there is no significant adverse impact on fish or if the impact is fully compensated for by an enhancement elsewhere. Sensitive streams are listed in the Section 6 Regulation under the Fish Protection Act. Unless otherwise stated, the sensitive stream includes tributaries as well as the main stream.

Section 8 of the Fish Protection Act allows for the issuance of licenses for the purpose of protecting stream flow for fish and fish habitat. Such licenses may be issued only to organizations considered to have a community-based interest in the stream, and the licensee must undertake works or activities in relation to fish and fish habitat in the stream.
http://www.qp.gov.bc.ca/statreg/stat/F/97021_01.htm

**Fisheries Act (Federal)**

The federal Fisheries Act is largely concerned with the regulation of the fishing industry, but has some clauses dealing with fish passage and fish habitat protection including water quality, riparian areas, and vegetation. The Fisheries Act defines “fish habitat” to be “spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes”. Based on this definition, a small steep tributary to a fish-bearing stream could be considered fish habitat, even though there may never actually be fish present in the stream.

If the proposed water source supports fish life, your intake must be properly screened to prevent the passage of small fish. The Fisheries Act also prohibits the deposit of any deleterious substances (substances that would degrade or alter the water quality) into water frequented by fish, as well as the harmful alteration, disruption or destruction of fish habitat (HADD).

Under the Federal Fisheries Act, the Minister (usually through the Department of Fisheries and Oceans) will request plans, studies or other information from a person proposing work that may disrupt or alter fish habitat or water frequented by fish or water flowing into an area frequented by fish. The Minister may then restrict the proposed work or require modifications or additions to the work. A permit may be issued to authorize HADD, subject to provisions of mitigation or compensation. Most of the environmental studies required will need to be conducted by a qualified professional such as a registered professional biologist (R.P.Bio.).

Under the Federal Fisheries Act, persons who damage fish habitat or pollute water frequented by fish have a duty to compensate or mitigate the adverse effects and to report the incident to a fisheries inspector. Also under the Act, anyone who damages fish habitat or pollutes water frequented by fish may be charged with an offence punishable by fine and/or imprisonment.
http://laws.justice.gc.ca/en/F-14/index.html

**Other Requirements**

In addition to the Water Act, Land Act, Fish Protection Act and the Fisheries Act, there are numerous other regulations and acts that govern the approval, construction and operation of the project. These together with the acts described above are shown in Table B at the end of this section. The table indicates which aspect of the project each regulation applies to. Some of them do not require a specific permit, but there is a requirement to inform the applicable agency as part of the Water Licence referral process and any concerns may be written into the terms of the Water Licence. LWBC will be able to advise of the appropriate agencies to contact for a specific project. Note that some of the regulations concerning construction activities may apply to the contractor during the normal course of construction and he may be responsible for obtaining permits and adherence to regulations during construction.

## TABLE A
## Acts and Regulations for Small Power Projects

| Act or Regulation | Relevant Project Phase | | | |
|---|---|---|---|---|
| | Initial Approval | Environmental Application | Construction | Operation |
| Fisheries Act (Canada) | • | • | • | • |
| Canadian Environmental Protection Act (Canada) | • | • | | |
| Transportation of Dangerous Goods Act (Canada) | | | • | |
| BC Fish Protection Act | • | • | • | • |
| BC Fisheries Act | • | • | • | • |
| BC Land Act | • | | • | • |
| BC Wildlife Act | • | • | | |
| BC Environmental Management Act | | • | | |
| BC Waste Management Act | | | • | |
| Transportation of Dangerous Goods Act (BC) | | | • | |
| BC Heritage Act | • | • | | |
| BC Soil Conservation Act | | | • | |
| BC Forest Act | | | • | • |
| BC Water Act | • | • | • | • |
| Forest Fire Prevention Regulations, B.C. Reg. 557/78. | | | • | • |
| Special Waste Regulations, B.C. Reg 432/82 | | | • | • |
| Guidelines for the Use of Explosives in Canadian Fisheries Waters (DFO, Final Draft 1988) | | | • | • |
| Land Development Guidelines for the Protection of Aquatic Habitat (DFO and MoELP, 1992) | | | • | • |
| Navigable Waters Protection Act (DFO – Coast Guard) | • | | | |
| Environmental Objectives and Procedures for Water Crossings (MoELP, 1984) | | • | • | • |
| Water Quality Criteria Approved and Working Criteria for Water Quality -1994 (MoELP, 1994) | | | • | • |
| Archaeological Impact Assessment Guidelines (Minister of Tourism and Minister Responsible for Culture, 1992) | | • | • | |

*This may not be a complete listing of acts or regulations that apply. Also, certain regulations apply only to larger projects, hence these are not listed above.*

# Appendix C: Interconnection Requirements

## Hydro-Electric Generating Plants Rated 100 kW - 8000 kW

This summarizes the BC Hydro (BCH) technical interconnection recommendations for hydro-electric generating plants rated 100 kW to 8000 kW, connected via the distribution system at 35 kV and below. Common BC Hydro primary distribution voltages are 12.5 kV and 25 kV. This material with Figures is intended as a *guide*, subject to site-specific analysis. Figures 1 and 2 show typical installations rated up to 500 kW for synchronous and induction generators, respectively. Figure 3 shows installations rated > 500 kW to 8000 kW, based on synchronous generators. A given plant may have additional or fewer protection relays compared to the Figures.

Generators are referred to as distributed generation (DG) in this appendix. DG is any grid-connected generation without reference to ownership, energy source, plant rating, or whether it sells electricity or does not.

The fundamental BCH requirements for grid-connected distributed generation are:

- protection of the BCH system from generator infeed to faults in the BCH system,
- power quality protection (voltage, frequency) of BCH load customers due to power quality excursions at the generator,
- lineworker and public safety.

### 1. Plants Rated 100 - 500 kW

These plants use 3-phase induction or synchronous generators. Generators connecting to a single-phase BCH primary line will be considered case-by-case for the starting voltage flicker and the running impact on feeder phase-current unbalance, phase-voltage unbalance and steady-state voltage regulation. Plants rated > 100 kW rarely connect to a BCH single-phase primary line. Site-specific studies are required for plants rated more than 10% of the primary feeder peak load to assess voltage regulation, power flow, power quality and short circuit levels on the feeder.

**Protection Philosophy:** is based on the assumption that the distributed generator (DG) unit may influence primary feeder devices. Islanding of a section of the feeder is possible, i.e. a separation occurs in the low or high voltage conductors such that some BCH customers remain connected to the DG side of the separation, and are at risk of voltage and frequency swings experienced by the DG.

**Primary Objectives:** the DG unit should be tripped off line within 10 cycles during outages and must not cause steady-state or transient voltage problems for customers anywhere on the feeder. The DG should disconnect promptly upon islanding and must not close into a dead feeder.

**TABLE F-1**
**Typical Interconnection Requirements, Plants Rated 100 - 500 kW**

Plants rated up to 500 kW are typically served by BCH at a secondary service voltage of 3-phase 4-wire 120/208 V or 347/600 V. BCH supplies, installs and maintains distribution transformers and a secondary voltage service to a DG entrance low voltage circuit breaker or fuses. Figures 1 & 2 show this arrangement. An exception is where a DG must build a primary voltage line on private property to reach the BCH distribution system. In this case, BCH provides a primary service to a DG -owned primary voltage line.

| Description of Requirement | What is Required to Meet the Objective |
|---|---|
| Allowable power converters | *Induction generators (IG) - require power factor (pf) correction to 90% or better at full load.<br>Synchronous generators (SG) - for all kW ratings; generator rated pf is 0.90 lag to 0.95 lead or better and capable of continuous operation at any voltage level within +/- 5% of rated voltage.* |
| Anti-islanding protection & synchronization | *IG – Voltage and frequency relays to detect islanding (27/59 and 81U/O). Speed matching required to within 1% of synchronous speed (15) prior to connection. Phase sequence and voltage unbalance protection (47).<br>SG - Voltage and frequency relays to detect islanding (27/59 and 81U/O). Phase sequence and voltage unbalance protection (47). Synchronizing function (25) so speed matching is within 0.3-0.5 Hz, voltage difference within 2% and phase angle difference within 10 degrees.* |
| Fault protection of the DG & BCH feeder | *BCH provides a secondary voltage service to customer fuses or a circuit breaker. Generator circuit breaker on the LV side. Overcurrent protection functions include 50/51 and 51N. Overcurrent relays may be voltage restrained in some cases.* |
| Grade of relays | *Utility grade relays. Microprocessor-based multi-function relays acceptable for generator protection in most cases.* |
| Relay protection function tests | *A set of protection test switches is preferred in each set of relay protection to provide isolation from CTs, VTs and trip buses and to facilitate ac injection tests. Test switches are not required where this facility is built into the relays. Tests may be performed using secondary injection, applied waveforms, a simulated utility, or if none of the preceding tests are possible, a settings adjustment test (where the unit provides discrete readouts of settings) to verify that the device trips at measured values.* |
| Transformer | *BCH provides a grounded-wye/grounded-wye transformer for 3-phase secondary service voltages. Customer-owned transformers are connected the same, or HV grounded-wye/ LV delta.* |
| Risk of BCH out-of-synchronism close | *Examined on case-by case basis.* |
| Lightning protection Equipment | *Arresters required on HV side of transformer per local BCH practice. Arresters recommended as shown in the Figures where lightning flash density greater than 5 flashes/sq. km /yr* |
| Detailed system impact studies | *Targeted studies such as voltage regulation, power flow, short circuit analysis, and flicker analysis performed for plants rated greater than 10% of the peak feeder load.* |
| Revenue metering | *Metering is typically performed on the load side of the customer's LV entrance mainswitch. . Remote interrogation by land or cell phones in some cases; otherwise manually read.* |
| Safety Practice Regulations | *Utility accessible, lockable, visible-break, load-break disconnect switch. BCH will prepare a Local Operating Order to define switching boundaries and the method to isolate for a Safety Protection Guarantee.* |

**2. Plants Rated > 500 - 8000 kW**

These plants use 3-phase synchronous generators. These plants have the potential to carry most of the feeder load and may also export power to the BCH substation LV bus in some cases. Requirements for this class of generation include all of the requirements of Section 1 above and the following additional items:

- differential protection of the transformer and generator may be required for larger plants,
- HV side circuit breaker,
- full feeder studies likely for plants rated > 1 MW, to assess voltage regulation, power flow, power quality and short circuit levels on the feeder, including reverse power flow through voltage regulators, protection coordination on the feeder and a substation/transmission protection review.

**Protection Philosophy:** is based on assumption that the DG unit may have a significant influence on the feeder, the substation, and adjacent feeders. Islanding of the entire distribution feeder or a substation LV bus may be possible.

**Primary Objectives:** the DG unit should be tripped off line within 10 cycles during outages and must not cause steady-state or transient voltage problems at customers anywhere on the feeder or on adjacent feeders. The DG unit should not cause overcurrent protection coordination problems, disconnect promptly upon islanding and must not close into a dead feeder.

**TABLE F-2**
**Typical Interconnection Requirements, Plants Rated > 500 - 8000 kW**

Plants rated > 500 kW are typically served at primary voltage, i.e. 12.5 kV or 25 kV. BCH installs a primary service to an IPP entrance disconnect switch. The IPP installs, owns and maintains this entrance primary switch and all equipment on the load side of the switch. The maximum aggregate generation connected to a 12.5 kV feeder typically cannot exceed 6.5 MVA, or up to 13.0 MVA of aggregate generation connected to a 25 kV feeder, subject to feeder voltage regulation and other considerations.

| Description of Requirement | What is Required to Meet the Objective |
|---|---|
| Allowable power converters | *Synchronous generators with rated pf 0.90 lag to 0.95 lead or better and capable of continuous operation at any voltage level within +/- 5% of rated voltage.* |
| Anti-islanding protection & synchronization | *Voltage and frequency relays to detect islanding (27/59 and 81U/O). Phase sequence and voltage unbalance protection (47). Synchronizing function (25) so speed matching is within 0.3-0.5 Hz, voltage difference within 2% and phase angle difference within 10 degrees.* |
| Fault protection of the DG & BCH feeder | *A HV side circuit breaker for BCH feeder & DG entrance transformer protection; LV side circuit breaker for generator protection. Differential protection (87) may be required for both the transformer and generator at larger plants. Feeder overcurrent protection functions include 50/51, 50/51N. Overcurrent relays may be voltage restrained in some cases.* |
| Grade of relays | *Utility grade relays. Microprocessor-based multi-function relays acceptable for entrance and/or generator protection in some cases.* |

| | |
|---|---|
| Relay protection function tests | *A set of protection test switches is required in each set of relay protection to provide isolation from CTs, VTs and trip buses and to facilitate ac injection tests. Test switches are not required where this facility is built into the relays.* |
| Transformer | *A dedicated transformer, connected HV grounded-wye/ LV delta. Some plants > 1 MW may require a neutral reactor on the transformer HV side to recover BCH ground fault protection sensitivity.* |
| Governor & AVR | *A turbine automatic speed governor is required for units rated 1 MW and up.*<br>*An automatic voltage regulator is required for units rated 1 MW and up, to maintain terminal voltage and reactive power flow within appropriate limits.* |
| Operating Data Transfer to BCH | *Plants rated 500 kVA and up provide MW, Mvar, MW.h, kV and interconnection status to the BCH Area Control Centre via dialup interrogation on a Telus analog, business line via a remote terminal unit at the DG. .* |
| Risk of BCH out-of-synchronism close | *BCH installs voltage supervision on BCH feeder CB and/or on feeder automatic line reclosers.* |
| Lightning protection Equipment | *Arresters required on HV side of transformer per local BCH practice. Arresters recommended as shown in the Figures where lightning flash density greater than 5 flashes/sq. km/yr* |
| Detailed system impact Studies | *Full studies of the feeder, substation and adjacent feeder impacts (voltage regulation, power flow, protection coordination, temporary overvoltages, etc.) for larger plants.* |
| Revenue metering | *Metering is typically performed on the HV side of the step-up transformer. . Remote interrogation by land or cell phone in most cases.* |
| Safety Practice Regulations | *Utility accessible, lockable, visible-break, load-break switch on high voltage side.*<br>*BCH will prepare a Local Operating Order to define switching boundaries and the method to isolate for a Safety Protection Guarantee.* |

Authored by Richard Fulton, Distribution Planning 31 July 2001; revised 10 January 2002; revised 30 January 2004

**For More Information**
Contact BC Hydro to obtain a copy of "Connection Requirements for Utility or Non-Utility Generation, 35 kV and Below"

**Note:** Before completing the detailed interconnection studies indicated in Section 5, BC Hydro will require technical information on the proposed generator. This will be obtainable from the generator manufacturer. Preliminary information or typical values can sometimes be used for initial studies.