SMALL HYDRO: A TOOL FOR SUSTAINABLE COMMUNITY DEVELOPMENT IN RURAL CANADA

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SMALL HYDRO: A TOOL FOR SUSTAINABLE COMMUNITY DEVELOPMENT IN RURAL CANADA

by

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ABSTRACT

An examination of the use of small hydro as a tool for sustainable community development, this dissertation combines research from the fields of community development, sustainability, and renewable energy development. Historically, community owned small hydro has been used for the benefit of local communities, initially through the provision of services and later through the generation of revenue. Current literature suggests that there is also a strong link between community energy and sustainability. Through an examination of four community-owned small hydro case studies, this research employed semi-structured interviews and sustainable development indicators to examine how each of the communities developed and used small hydro for the betterment of the community. This examination provided the basis for an evaluation of the overall impact of small hydro on community sustainability. Additionally, this dissertation discusses the connection, or lack thereof, between sustainability, energy use, energy generation, and the surrounding institutions (i.e. the energy disconnect).

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CHAPTER 1

INTRODUCTION

The use of renewable energy resources is not a new phenomenon. Harnessing energy from the sun, wind, and water can be traced back throughout history. Water in particular has been used as a source of energy for centuries, initially as a source of mechanical energy, and eventually becoming a source of electrical energy (Ministry of Natural Resources, 2004). Over time the use of energy from water, or hydro, has emerged as the dominant source of renewable energy. Currently hydropower technology supplies approximately 20% of the world's electrical energy, while using only a third of the global hydro potential (The Expert Group on Renewable Energy, 2005). Hydro's substantive history has resulted in many technological changes over time, becoming increasingly mature, efficient, economic, and accessible, with a wide range of facility scales and designs (Ontario Sustainable Energy Association, 2008; The Expert Group on Renewable Energy, 2005). These changes have been reflected in the shifts in hydroelectric development trends within the North American energy system.

The 18^{th} and 19^{th} centuries saw the establishment of local small hydro-mechanical mills as an essential part of both industrial development (e.g. textile and timber mills) and electrification in Canada, particularly within the province of Ontario (Widmann, Thonhauser, and Moritz, 2005). By the end of the 19^{th} century the use of small scale hydro for electrical energy generation had taken hold, supplying electricity for many small communities (CanREN, 2006). However, despite the early importance of small hydro, increased and widespread demand for a more secure and consistent supply of energy led to the amalgamation and centralization of small, fragmented energy systems into larger energy grids controlled by large utilities (Graham, 1983). This was paralleled initially by the development of large scale fossil fuel generation stations and subsequently by nuclear power generation facilities (Graham, 1983). These changes within the energy sector decreased the importance of the original small hydro facilities, and resulted in the decommissioning of many.

In terms of hydro development, the popularization of centralized energy meant a shift from localized small hydro generation to mega-hydro projects, characterised by large dams and reservoirs (Cahn, 2005). Many examples of such projects exist, one of the better known examples being the James Bay hydroelectric project on the La Grande River in Quebec. Not just within Canada, but globally, large scale dam projects have resulted in a variety of unforeseen environmental and social impacts (Goodwin and Falte, 2003).

Much of the environmental damage associated with large hydro came from the flooding of large tracts of land when rivers were dammed and reservoirs created. Reservoir creation had social impacts as well when people were displaced, traditional lifestyles changed, and cultural heritage sites were lost. While engineers and developers have worked to mitigate the impacts of hydro dams, large scale hydro continues to incite negative public perceptions as a result of past environmental and social impacts, views which also influence attitudes towards the development of hydropower at any scale.

After over a half a century of developing large scale centralized energy systems, another shift is beginning to occur. This shift is being driven by concern over energy security, climate change, and resource sustainability, as well as increasing concern over the efficiency and security of large scale generation facilities and accompanying transmission, especially as infrastructure ages and demand for energy continues to rise.

Development of renewable energy sources has become a fundamental aspect of any strategy to reduce greenhouse gas emissions, helping to address climate change concerns, as well as ensuring a sustainable energy supply. As a result, hydro development is being re-examined, including revisiting the potential for development or enhancement of smaller scale facilities designed to suit the physical, social, and environmental considerations of a particular community or region (The Expert Group on Renewable Energy, 2005). At present, hydro remains the most mature and economically viable renewable energy technology (International Small-Hydro Atlas, 2007; Bartle, 2002). This re-examination of small hydro also presents new opportunities for sustainable community development.

Small hydro is especially well-suited for use in off-grid or rural communities. For off-grid communities, the use of conventional, non-renewable forms of energy (e.g. diesel) can be costly, from both an economic and an environmental perspective. Exhaustibility of fuel sources, fuel transportation, and lack of energy grid access due to long transmission distances all carry long term fiscal and ecological consequences. These issues are additional drivers behind the need to develop predictable, renewable sources of local energy, something which small hydro has the potential to provide.

There are many grid-connected rural communities within Canada that have been hard hit by changes in the natural resource sectors (e.g. fishing, forestry, and mining). Natural resource depletion and/or structural economic changes have left these communities in economically compromised positions, including issues such as the loss of people and valuable skill sets through outmigration. This in turn has led to increased political pressure to identify new development opportunities for these areas. The growing sustainable development trend means that those development opportunities perceived as sustainable, both in terms of the methods or tools used and in long term development impacts, are increasingly likely to be favoured.

1.1 Objectives

This dissertation examines the use of small hydro as a tool for sustainable community development within rural Canada. The initial research question asked *how* do communities use small hydro as a tool for sustainable community development? Given that there are few communities that have successfully developed small hydro projects, it was logical to also ask *why* there has not been a more widespread adoption of small hydro as a sustainable development tool?

There are both applied and theoretical aspects to this research. By examining successful examples of community small hydro, this research provides evidence as to where, why, and how small hydro has been used by communities. These lessons learned, particularly those related to sustainability, the development process, and the benefits to the community, have a practical application for other communities that have the potential to develop local small hydro resources. Providing community-oriented information on the development of community small hydro helps to fill a gap in existing community energy and small hydro information and guides, many of which are either too general to be applied to small hydro development, or have been designed for experienced small hydro developers as opposed to communities.

There has been similar research on the links between energy, sustainability, and sustainable community development within the context of the developing world where the development of community small hydro is common. However, there is little research on these same links within the context of the developed world, particularly within Canada. This research hopes to contribute to the body of knowledge surrounding not only links between energy and sustainability, but between energy and sustainable community development. Specifically, through use of a case study approach, this research will determine if the development of community small hydro has had an impact on the overall sustainability of the community, as well as whether having a community owned source of energy has had any impact on the connection the community makes between the use of energy and the energy source. Although this research focuses on one aspect of sustainability, the interrelatedness of energy to additional aspects of community sustainability (e.g. finance, transportation, community planning) illustrate that this is one part of a complex system. These linkages indicate that consideration of a single part (i.e. community small hydro) must also include consideration of the whole (i.e. overall community sustainability). As a result, the implications of this research extend beyond community small hydro into the overall sustainable development of a community.

CHAPTER 2

LITERATURE REVIEW

2.1 Sustainability and sustainable development

"Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). This definition of sustainability was popularized with the publication of the 1987 World Commission on Environment and Development, commonly known at the Brundtland Report, which helped lay the foundation of the concept of sustainability as it is commonly accepted. In addition to helping define sustainability, the Brundtland Report initiated global discussions of sustainability and development, of maintaining consideration for the limits of nature and the environment, and of maintaining both economic welfare and social security (Astleithner, Hamedinger, Holman, and Rydin, 2004).

Traditional definitions of sustainability have two basic components: consideration for factors beyond the economic (i.e. social and environmental aspects); and a focus on the future, consideration for the generations yet to come (Spreng, 2005). From this starting point, the concept of sustainability has since evolved. The Millennium Summit and the 2002 World Summit on Sustainable Development introduced the idea that, in addition to efficient use of natural resources to ensure conservation for future generations, sustainability should also consider social equity for current generations (Hughes and Johnston, 2005). This idea of social equity encompasses a host of fundamental issues including human rights, oppression, and empowerment (Rogers and Ryan, 2001). As a result, in addition to consideration of social, environmental, and economic aspects, sustainability can also encompass quality of life (United Nations Conference on Environment and Development, 1992). From this point of view, meeting human needs within the confines of earth's ecological capacity is regarded as fundamental. The definition of human needs include access to jobs, food, water, sanitation, and *energy* (Anielski and Winfield, 2002).

If all of the aforementioned factors are considered, maintaining or enhancing quality of life sustainably requires different approaches, depending on the starting point. For developing countries this means starting with sustainable development and capacity building (Roseland, 2000). For developed countries this means the re-interpretation of the accepted understanding of human needs, wealth, and capital, as well as the adoption of a lifestyle that is more fitting to the planet's finite ecological capacity and space (World Commission on Environment and Development, 1987). And thus, as well as meeting needs, sustainability also encompasses the idea of limitations, imposed by our ability to meet both the present and future needs of the global population (World Commission on Environment and Development, 1987).

The most common criticism of sustainability has been that the concept is too broad and all encompassing (Marshall and Toffel, 2005). However, when defining the concept of sustainability it should be made clear that sustainability is not an end product. To sustain something is to keep it going, to continue a course. Sustainability is a process, the act of moving forward in a particular direction toward an end that is never likely to be realized due to the fact that it is constantly shifting and changing. A community cannot "reach" a permanent state of sustainability, but instead is continuously in pursuit of a new equilibrium. Those aspects which are highly valued will likely be addressed initially. For example, a community can have a sustainable economy, but be in need of addressing issues of environmental and social sustainability.

Sustainable development therefore is not a fixed state, but a process through which development is transformed to reflect both present and future needs (World Commission on Environment and Development, 1987). Success then becomes retrospective and the emphasis is placed on the process itself, on constantly learning, evolving, and improving (Bell and Morse, 2005). Within this dissertation, sustainability is viewed as a continuum, where as more factors (e.g. economic, environmental, and social) are addressed, sustainability is enhanced. Sustainable development is therefore any process through which sustainability is improved.

2.2 The link between sustainability and energy

The connection between energy and quality of life is direct and well-known (Li, 2005). As previously mentioned, access to energy is an issue of social equity, a necessity in order to meet basic human needs. The link between energy and sustainability is rooted in the connections between energy and social issues, such as access to clean water, lighting, heating and cooling, healthy living (Unander, 2005), and economic issues, such as capacity building and development (Miller, Doncaster, & Doukas, 2006; Ebrahimian, 2003). The recognition and strength of these links is in large part related to the level of development. On a global scale, energy access is currently a clear dividing line in terms of social equity, as there are portions of the world's population where energy needs have yet to be met and others where current rates of energy generation and consumption is not sustainable (Anielski and Winfield, 2002).

Given that sustainability includes working within the confines imposed on us by the natural environment, current energy needs cannot be universally met without changes to not only our consumption rates, but also to our generation practices (World Commission on Environment and Development, 1987). As a result, energy plays a key role in sustainable development as "a society seeking sustainable development utilizes only energy resources which cause [limited] environmental impact" (Rosen, 1995).

2.3 Sustainability and the community

A popular sustainability adage is "think globally, act locally". Sustainable community development and sustainable economic development are two of a host of "buzz-words" or phrases relating the concept of sustainability to the field of community development (de Beer and Marais, 2005). The unifying factor between these terms is that action takes place at a local level.

Ideally, a sustainable community is one that is able to maintain a balance between economic, social, and environmental aspects (Boyd, 2003). Characteristics of this balance include improving resource use efficiency without undermining future functionality, improving quality of life in an equitable fashion, and sustaining growth through innovation (Hughes and Johnston, 2005). This provides a challenge to conventional development, which has traditionally held a more anthropocentric/economic focus (Baker, 2006). The gap between conventional and sustainable development means that a shift to sustainable community development is not simple. What is required, especially within the North American context, is a shift in currently accepted structures, attitudes, and values as related to development; something not easily realised (Roseland, 2000).

Oftentimes federal and provincial/state governments view communities as the bottom of a top-down pyramid structure. In this top-down approach, priorities and initiatives are developed at the higher levels and passed down to the communities in a blanket approach. Communities are thus required to play predetermined roles, despite the fact that these roles may not be suited to, or in the best interests of, the community. This type of structure means development initiatives can be designed without consideration of unique local cultural and physical environments, which can result in implementation issues or failure at the local level. When the initial support or direction from the top is lost (e.g. loss of government funding); communities can be left unsure of how to proceed, lacking capacity to do so, or unwilling to accept responsibility (de Beer and Marais, 2005). In this way there are no long term community benefits.

Addressing sustainable development at a local level allows for communities to generate their own solutions to local problems, building local capacity and strengthening the economic, social, and environmental foundations of the community (Roseland, 2000). As opposed to a top-down approach it becomes the reverse, a bottom-up process where the community is a major player in the design and facilitation of development (de Beer and Marais, 2005). Common considerations of the bottom-up approach to sustainable community development include the specific needs of the community (de Beer and Marais, 2005); local opportunities, skills, talents, and assets (Rogers and Ryan, 2001); and long-term, inclusive community planning (Boyd, 2003). This leads to community-driven initiatives to address issues and solutions that build upon available social capacity and foster community integration (United Nations Conference on Environment and Development, 1992). It may seem daunting or inconsequential to address a *global* issue from the *local* level. However, given the many differences between communities within Canada and across the globe, it can be argued that enhancing sustainability locally also serves to address global sustainability, albeit on a small scale.

While communities can benefit from being engaged in the process of identifying what direction the community should take in terms of development, both in terms of qualitative and quantitative improvements, and how the community can move in that direction (Hamstead and Quinn, 2005), it should not be assumed that in this bottom-up approach there is no role for higher levels of government. On the contrary, government involvement in the form of incentives or support can help encourage communities. Helping a community to identify its own issues and determine how best to resolve them could be considered productive involvement on the part of higher levels of government. A solid local foundation of sustainable goals and plans can help establish links at the regional, national, or global levels, contributing to global sustainability (Boyd, 2003).

Within this dissertation sustainable community development encompasses a community-driven development approach, designed with local needs in mind and which relies heavily on inclusive community participation and the consideration of the local economy, environment, and culture.

2.4 The role of energy in sustainable community development

There are multiple factors that can contribute to sustainable community development, of which energy is one. A secure supply of energy from a sustainable source is seen as being a necessary component for development, a means to ensure quality of life and environment (Dincer, 1999). Socio-economically, a secure supply of energy can be tied to multiple positive aspects of development. For example, it can provide an essential service, build community capacity, and provide business and employment opportunities (Rosen, 1995). These types of socio-economic benefits could come from any secure form of energy generation, however in order to be deemed sustainable, environmental considerations must be accounted for.

From an environmental sustainability standpoint, both renewable energy and efficient energy use are required for sustainable development (Rosen, 1995). Thus, in addition to sustainable development requiring secure, affordable access to energy resources, that energy supply must be renewable and "green", with the generation having minimal negative social and environmental impacts, as well as the energy being used efficiently (Dincer and Rosen, 2005). If what we are striving for is a sustainable economy and environment, alongside an equitable quality of life, renewable energy can be seen as a means to that end, a tool to be used in its achievement (Vera, Langlois, Rogner, Jalal, and Toth, 2005).

2.5 Renewable energy, distributed generation, and community-driven energy

2.5.1 Renewable energy

Something which is "renewable" is commonly thought of as self-replenishing and inexhaustible. Sources of renewable energy replenish themselves naturally and, if managed properly, can provide a continuous source of energy. Renewable energy technologies employ a wide range of self-replenishing energy sources (e.g. solar, wood, ethanol, water, and geothermal) to generate energy in the form of fuel, heat, or electricity (Bull and Billman, 1999). There is a wide range of renewable energy technologies, from those that are both longstanding and well developed, such as hydropower, to technology that has recently emerged in terms of development and demonstration at the commercial level, such as biofuels, which generate energy from pre-existing by-products (e.g. animal waste, forestry biomass, and methane) (Islam, Fartaj, and Ting, 2004).

Whether renewable energy is considered relatively environmentally benign or environmentally friendly is dependent on how the associated infrastructure is built. Compared to non-renewable energy sources (e.g. fossil fuels) that emit greenhouse gasses and can produce potentially hazardous by-products (e.g. nuclear waste) any type of renewable energy is relatively clean. In terms of impact on the surrounding environment, renewable energy can range from having a large impact, such as facilities involving construction of large dams, to having minimal impact. While non-renewable energy sources have traditionally been easily accessible and viewed as relatively low-cost, the looming climate crisis is changing this perception. The growing realization is that the true cost of renewable energy sources, factoring in the economic, social, and environmental costs, is far less than that of traditional non-renewable energy sources (Bull and Billman, 1999).

2.5.2 Distributed generation

Within most developed countries centralized energy generation and centralized grid control has been the accepted practice. These centralized energy systems play an integral role in the Canadian economy, factoring into investment, trade, income, and employment (Islam, Fartaj, and Ting, 2004). In Canada, provincially owned utilities have traditionally controlled the small number of large scale generation stations (e.g. coal, nuclear, large hydro dams) that have dominated the Canadian energy scene. Currently, some provinces (e.g. British Columbia and Ontario) have started moving away from a wholly centralized energy system. Deregulation, the privatization of energy generation which allows for any privately owned generation station to sell electricity into the provincial energy grid, has opened the energy generation market in these provinces (Independent Power Producers Association of British Columbia, 2008; Ontario Power Authority, 2009). The deregulation of the energy system involves the decentralization of energy generation, or distributed generation: establishing a large number of generation stations that may use various technologies (Doukas, 2006). Larger scale generation will generally remain in the hands of utilities, while individuals, communities, and private companies take advantage of the smaller development opportunities.

Four technical factors contribute greatly to the argument in favour of distributed generation: infrastructure savings, reduced transmission loss, decreased line congestion, and increased energy security (Doukas, 2006). Energy infrastructure is expensive to install, maintain, and upgrade especially when transmission over long distances is factored in. Long transmission distances are a result of the distance between centralized energy generation stations and energy users, generally resulting in an approximate 7-10% loss of energy generated (Engle, 2006). Distribution of generation facilities means the amount of energy transferred over long distances can be reduced, owing to the development of localized sources of energy and subsequent reduction in required transmission distances. By situating the energy source closer to the user it can increase the efficiency of the overall distribution system and decrease the amount invested in transmission infrastructure. An increased number of generation stations also works to remove the pressure and congestion currently being placed on transmission infrastructure that was built at a time when energy demand was less.

The issue of energy security is key among these four technical factors. Rolling brownouts and blackouts, such as those experienced in places such as Ontario and California, can in part be attributed to failings of centralized energy grid systems that have become increasingly inefficient, vulnerable, and in need of upgrades (Doukas, 2006). Distributed generation has the potential to alleviate such issues by providing increased security with a more dispersed supply of energy, ensuring that if one generation station fails, there are others available to compensate.

There are also environmental and socio-economic factors driving distributed generation. Environmentally, this shift is occurring as a result of a change in attitude toward renewable energy technologies. Renewable energy generation technologies are often optimal when developed at the small or medium scale, making the best use of the resource, with fewer, less concentrated impacts on the surrounding environment (World Commission on Environment and Development, 1987). As a result, while concern over climate change instigates a growing demand for clean energy technologies, deregulation of the energy system and distributed generation can be seen as a promising choice to achieve these demands.

In terms of socio-economics, distributed generation has the potential to give an increased level of control and decision-making power to people and communities. This elevated level of control allows for communities to act in their best interests, with the majority of the benefits going to the community for local use. As such, energy generation is increasingly being recognized at multiple scales as a development tool.

Distributed energy generation can occur at multiple scales, depending on the energy potential available. For simplicity's sake, projects can be classified into one of two broad categories: net-metering and independent power production. Net-metering refers to a single user who offsets his or her energy consumption with a personal generation facility (Hydro One, 2006). These users operate on a very small scale in terms of the size of the project and the amount of energy generated, using renewable energy technologies (e.g. solar panels) to supplement grid usage. On average, the user will draw more energy from the grid than he or she produces.

Independent power production generates energy at a larger scale than net metering, selling energy directly to the energy grid. Independent power producers can be classified into three broad ownership types:

> *Private:* generation stations owned by an individual, co-operative or company producing power for profit.
>
> *Community*[1]*:* generation station is owned, directly or indirectly, by a community, group of communities, or municipality. Revenue generated is re-invested within the community.
>
> *Joint-venture:* combination of above; can also include those projects with government as a partner (e.g. First Nations/Federal Government projects).

Distributed energy generation also includes two roles for government. First, provincial utilities own and operate generation stations, including some small scale facilities. For example, Ontario's provincial generation utility, Ontario Power Generation, owns and operates three wind sites (7 MW), two solar sites (0.009 MW), two

[1] Community ownership is the focus of this dissertation and will be further discussed in Section 2.5.3.

biomass sites (6 MW), and twenty-nine small hydro sites (127 MW), in addition to their larger, more centralized generation projects (Ontario Power Generation, 2007). The second role of government is similar to that of a joint-venture. In addition to the generation of policy, governments can take the place of private investors in a joint venture, providing funding and expertise. The majority of these government partnerships within Canada are between the federal government and First Nations groups, through the Department of Indian and Northern Affairs (Indian and Northern Affairs, 2007).

2.5.3 Community energy

There are various interpretations of the meaning of community energy and varying degrees of community ownership. For example the Ontario Sustainable Energy Association defines community energy as sustainable energy projects "owned, developed, and controlled in full or in part (50% or more) by a community, group of farmers, First Nations group, or citizen's group" (2008, A). Other definitions include sources of non-renewable energy, such as cogeneration (Community Energy Association, 2006, A; Community Energy Association, 2006, B). For this dissertation community energy is defined as 100% controlled directly or indirectly by the community. The drivers, benefits, and barriers of community energy will be discussed generally, as well as specific to small hydro in Sections 2.6.5, 2.6.6, and 2.6.7.

2.6 Small hydro

2.6.1 Energy basics: system components, and economic breakdown

The basics of all hydropower, for any scale, are the same. Energy from flowing water is transformed into mechanical energy used to drive a turbine, which in turn drives a generator that produces electricity (Paish, 2002). The amount of electrical power produced (P) can be explained with the following equation.

$$P = eHQg$$

Where:
e = efficiency of turbine
H = head, or vertical drop (m)
Q = volume of water (m3/s)
g = acceleration due to gravity (9.81 m/s/s)

Source: (CanREN, 2006)

An understanding of fundamental electrical terms is required in order to discuss small hydro technology in further detail (see Table 1).

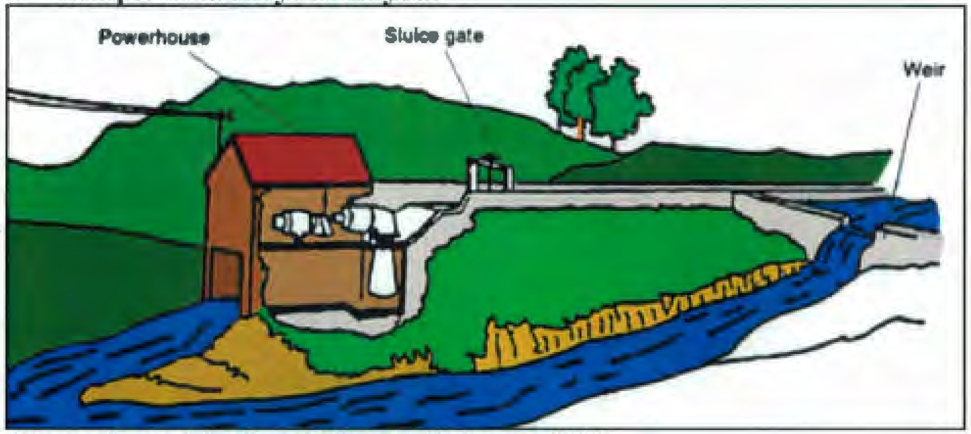
Table 1 - Basic Electrical Terms

Term	Definition
Watt (w)	▪ Unit in which electrical energy is measured ▪ Scales: kilowatt 10^3W, megawatt 10^6 W, gigawatt 10^9 W, and terawatt 10^{12} W
Kilowatt hour (kWh)	▪ Amount of energy consumed in an hour ▪ Function of energy consumed over a time period
Direct current	▪ Electrical current ▪ Able to be stored for future use
Alternating current	▪ Electrical current ▪ Most common for transmission in North America ▪ Runs directly from source to user ▪ Cannot be stored
Peak load	▪ Maximum amount of power needed at any moment

Sources: Davis, 2003; Ministry of Natural Resources, 2004; Monition, Le Nir, and Roux, 1984

Small hydro projects are designed and constructed on a case-by-case basis, typically with consideration of local needs and conditions, including the physical landscape, ecosystem type, and aquatic conditions. A simple small hydro layout can be seen in Figure 1. Flexibility of design means that the technology and materials used are flexible as well. However, despite potential differences in materials, design, and appearance, the basic system components are similar (see Table 2).

Figure 1 – Simple Small Hydro Layout



Source: Research Institute for Sustainable Energy, 2008

Table 2 - Small Hydro Components

Component or Term	Explanation
Dam / weir	▪ Required to maintain consistent depth of water and flow ▪ Keeps power generation consistent
Intake / sluice gate	▪ Directs water to forebay tank
Debris filter(s)	▪ Screen preventing debris from flowing into the system
Forebay tank	▪ Connects intake and penstock ▪ Allows for settling of fine debris
Penstock	▪ Carries water from forebay to powerhouse ▪ Can be above ground, buried, or remain under water
Powerhouse	▪ Building housing the turbine and generator
Turbine	▪ Converts energy from flowing water into mechanical energy to drive generator ▪ Vary in size, characteristics, and capabilities ▪ Basic turbine types o Impulse: simple design, high velocity, high head o Reaction: low flow, high pressure, low head
Generator	▪ Converts mechanical energy from turbine into electricity
Tailrace or draft tube	▪ Releases water from intake back into river ▪ Canal/pipe, above ground, buried, or within the river
Spillway / flood handling system	▪ Re-routes excess water from intake back into river ▪ Safety feature
Power-line	▪ System required to transmit energy from source to user

Sources: Government of Newfoundland and Labrador, 1984; Ministry of Energy, 1986; Paish, 2002; Ministry of Natural Resources, 2004

Variance in project scale and purpose results in a wide range of cost for small hydro. Relative to large hydro, small hydro projects are more costly to develop per unit of power generated. Hydropower projects that generate less than 20 megawatts (MW) of energy have a per installed kilowatt (kW) cost of between $4,000 and $6,500, compared to between $2,000 and $4,000 per installed kW for projects between 20 MW and 250 MW, or between $1,000 and $2,500 per installed kW for projects larger than 250 MW (Tester, Drake, Driscoll, Golay, and Peters, 2005). A breakdown of general costs can be found in Table 3.

Table 3 - Economic Cost Breakdown

Cost Type	Breakdown

Initial	▪ Planning and development
	  ▪ Engineering
	  ▪ Assessment and permitting
	▪ Construction and installation
	▪ Electro mechanical equipment
	  ▪ Turbine, generator, etc.
	▪ Energy grid connection
	▪ Unforeseen expenses

Annual	▪ Equipment depreciation
	▪ Operation and maintenance
	  ▪ Employment, monitoring, insurance, taxes, etc.
	  ▪ Replacement and renovation
	▪ Unforeseen annual costs
	▪ Loan payments

Sources: Hosseini, Forouzbakhsh, and Rahimpoor, 2005

2.6.2 Small hydro defined

There is no universally accepted definition of "small" hydro. Global, national, and provincial definitions vary anywhere from 2.5 MW to 50 MW (Pollution Probe, 2004). For the purpose of this dissertation, the upper limit of small hydro developments is set at 20 MW, an average of the accepted limits of small hydro within Canada, which vary between 10 MW and 30 MW (CanREN, 2006; International Small-Hydro Atlas, 2007).

Small hydro is often referred to as "run-of-river", as it utilizes the natural flow of water to generate electricity without needing to build large dams or create large reservoirs (Ministry of Natural Resources, 2004). However, this is something of a misnomer as there are several design types that can be used, of which run-of-the-river is only one. There are six main small hydro design categories (see Table 4).

Table 4 - Small Hydro Design Categories

Design Type	Description
Dam	▪ Use weir or dam to concentrate level of head ▪ Powerhouse incorporated into dam or placed downstream
Diversion	▪ Use structures (e.g. canals) to gain required head
Mixed	▪ Combination of dam and diversion schemes ▪ Requires some form of diversion
Run-of-the-river	▪ Generate power without inflow regulation
Daily regulation	▪ Power generated according to daily demand fluctuation ▪ Water stored in regulating pond during off-peak times ▪ Released during peak hours for increased energy output
Cascade	▪ Designed to make optimal use of river's energy potential ▪ Uses existing river falls and discharge
In-line hydro	▪ Use of pipes (e.g. municipal water systems) and water pressure due to elevation ▪ Dual function: reduction of pressure and generation of power

Sources: Ramos and DeAlmedia, 2000; Cowdry, 2005

2.6.3 Growth of small hydro

As with renewable energy as a whole, there is a growing interest in the development of small hydro. This section highlights this growing interest in small hydro, including examples of small hydro successes. Some areas have historical ties with hydro and are experiencing a resurgence of interest, while in other areas the developments are new. Growth is being seen throughout the developed and developing world and in both the private and public sectors. Private sector success has subsequently attracted attention from communities.

Within Canada examples from Ontario and British Columbia demonstrate two political jurisdictions where development of small hydro is being encouraged. Ontario now has over two hundred small hydro installations, in part as a result of the province's historical background in hydropower (Ontario Sustainable Energy Association, 2008, B). Renewed interest in small hydro as a climate change-friendly method of power generation has been accompanied by various provincial government initiatives, further encouraging a resurgence in small hydro development. For example, Ontario's Ministry of Natural Resources (OMNR) has channelled resources into developing the *Waterpower Resource Atlas*, illustrating undeveloped hydropower potential and identifying promising sites for development in Ontario (Ontario Ministry of Natural Resources, 2008). These initial site surveys completed by OMNR helps to complete one of the first steps in development: the initial assessment of resources. The completion of the initial assessment allows potential developers to determine whether or not there is local potential without paying for an initial site assessment themselves.

There is also both financial and advisory support for small hydro development within Ontario. Deregulation of the provincial energy grid began in 1998 with the Energy Competition Act (Ontario Energy Board, 2008). The Ontario Power Authority (OPA) has since established standard offer contracts for all forms of renewable energy (Ontario Power Authority, 2009). These contracts guarantee that privately generated power will be purchased at a set rate for a given period of time (Ontario Power Authority, 2009).

Groups such as the Ontario Sustainable Energy Association (OSEA) and the Ontario Waterpower Authority (OWA) exist to provide information and education, as well as lobby on behalf of small hydro development.

Within British Columbia a review of provincial small hydro resources has led to the creation of a database of potential sites for development as well as a general guide for how to develop small hydro (Sigma Engineering Ltd., 2002; BC Hydro Green and Alternative Energy Division, 2004). Similar to the OMNR Atlas, this provides easy access for potential developers to available sites. The British Columbia government and BC Hydro have also established a similar financial incentive program to Ontario's standard offer contracts (BC Hydro, 2009). This incentive has resulted in over four hundred applications for small hydro developments being filed since 1990 (IPPBC, 2008). Many of the applications under review, or those that have been approved, are from private firms; however there are also communities and regions within BC that have begun to express an interest in involvement in these small hydro developments. The Community Energy Association has been established as a support group for community energy, including guidance for community energy project development (Community Energy Association, 2007).

Canadian First Nations communities have also become involved with small hydro development as part of an overall First Nations commitment to clean, alternative energy projects (Indian and Northern Affairs, 2007). The Aboriginal and Northern Community Action Program run through the Department of Indian and Northern Affairs is a federal program that includes helping First Nations communities establish their own energy generation projects. These projects are most often joint-ventures between First Nations communities, the federal government, and the private sector (Indian and Northern Affairs, 2007). Major driving forces behind the involvement of First Nations in small hydro include providing a source of income or a community service, as well as an increased level of community control over local resources and essential services (Alward, 2007). Four cases, including the highly successful Umbata Falls small hydro project in Northern Ontario, are highlighted by the Department of Indian and Northern Affairs as examples which are being duplicated by other First Nations groups across the country (Indian and Northern Affairs, 2007). In the case of Umbata Falls, the Pic River First Nation, backed by the federal government, own 51% of the project, while the other 49% is owned by a private firm (Indian and Northern Affairs, 2007). The energy generated is sold to the Ontario provincial energy grid and the Pic River First Nation use their portion of the profits to support community infrastructure development and community programs (Indian and Northern affairs, 2007).

These examples show that a shift is occurring within the Canadian context. Small hydro success in Europe has helped influence policy shifts within North America. Many of the frameworks used within Canada are derived from examples from the European Union, where there has been heavy investment in renewable energy with a focus on small hydro (European Small Hydro Association, 2003). For instance, much of the background and context for groups such as OSEA has been based on the experiences from European nations (Miller, Doncaster, and Doukas, 2006). Recently in Europe there has been the development of the International Renewable Energy Agency (IRENA) to focus on renewable energy issues, advise members on frameworks, capacity, financing, technology, etc. (International Renewable Energy Agency, 2009). A study conducted by the European Small Hydro Association showed that the amount of electricity produced from small hydro within the European Union has more than tripled, from 11, 462 gWh to 39, 729 gWh between 1990 and 2001 (2003). While the energy generated from small hydro accounted for only 1.47% of the total electricity generated in the European Union in 2001, small hydro accounts for 10.80% of the total energy produced by hydropower, an increase from 4.14% in 1990 (European Small Hydro Association, 2003).[2] This increase came as a result of various development initiatives on the part of national governments (European Small Hydro Association, 2003). Interest in sustainability and concern for the environment are the primary drivers for renewable energy development in this context. The focus on hydro has been as a result of available resources (i.e. availability of water).

Within many countries in the developing world, from a community development standpoint, small hydro has seen considerable growth, with initiatives by local communities, governments, and non-governmental organizations. While the context is different, what is occurring is similar to the developed world context. For example, hydropower in Sri Lanka has had a strong historical presence which experienced a resurgence in the 1990s in the form of community driven development (Ananda, 2006). Small hydro developments have since been established as joint-ventures between government, communities, and development agencies for the betterment of local communities. Established to bring electricity to communities and increase community capacity, these initiatives have been successful, growing from four in 1992 to two hundred and twenty five in 2003 (Ananda, 2006).

[2] Within the European context, small hydro is considered to be less than 10 MW.

Another similar example is found on the Solomon Islands, where an Australian non-governmental organization called APACE has been helping isolated rural communities establish small hydro projects in an effort to increase community capacity through training and skills building (Jarman and Bryce, 2005). APACE has produced an eight step process for the establishment of these community driven small hydro projects which can be replicated and applied elsewhere by interested communities (Jarman and Bryce, 2005). One apparent difference between community small hydro in the developing world and the developed world is the emphasis on sustainable community development that is found in the developing world examples.

2.6.4 Community small hydro

Community owned independent power producers are owned 100% by a community, group of communities, or municipality. This can be through direct ownership, or indirect ownership (i.e. where a private generation firm is owned by the community). There are many factors that contribute to small hydro being an attractive choice for community energy development which will be discussed in the sections to follow, as well as the potential benefits and barriers of community energy and community small hydro. However, communities interested in small hydro should also give careful consideration to the opportunity cost of the development (e.g. what resources are changing or being lost as a result of the small hydro development). Opportunity cost can be considered both in terms of financial and physical resources.

2.6.5 Drivers of community small hydro

The development of small hydro, like other forms of community energy generation, may be driven by a number of factors. As the more localized factors may be unique, the focus of this section is on the general themes that are driving the establishment of both community energy projects overall and community small hydro in particular.

From a community point of view, energy development may be driven by environmental concerns, particularly those concerns associated with climate change (e.g. emissions from traditional energy generation). One role the community can play in addressing climate change is by increasing interest and awareness of the subject within local governments and councils, using this to inform planning and decision making (Community Energy Association, 2007). Community renewable energy developments are one local initiative that can be implemented to address global climate change by reducing greenhouse gas emissions from energy generation.

From a socio-economic standpoint there are two key factors driving community energy developments. In addition to generating energy, community energy developments can become a tool for local economic development from the sale of the energy and reinvestment of the profits into the community (Doukas, 2006). The level of economic benefit is dependent on the associated financial incentives, which come from provincial/state government and are dependent on the political climate. Additionally, a community-controlled source of energy helps improve security of energy supply for the community (EREC, 2004).

Small hydro has been described as perhaps the best example of a renewable energy technology to be used as a tool for sustainable community development, as a result of its demonstrated ability to create employment, increase economic activity, and protect the local energy supply (Etcheverry, Gipe, Kemp, Samson, Vis, Eggertson, McMonagle, Marchildon, and Marshall, 2004). There are two driving factors for selecting small hydro specifically: resource availability and the maturity of the technology. Hydropower currently supplies over 20% of the world's electricity, with Canada as one of the leading nations in both existing and potential development (IEA Hydropower, 2000). In Canada, water is an abundant resource across the country, making small hydro an attractive prospect for development.

From a technical perspective, small hydro is a mature technology that has been developed and refined through extensive demonstration, research, and development (European Renewable Energy Centres, 2002; Ontario Sustainable Energy Association, 2008, B). In contrast with other renewable energy technologies, the experience behind small hydro technology is readily available and cost-effective and boasts the additional benefits discussed below (Islam, Fartaj, and Ting, 2004).

2.6.6 Benefits of community small hydro

The benefits of community energy projects, including small hydro, are well-recognized, impacting various aspects of the community (Fisher, Iqbal, and Fisher, 2008, A; Fisher, Iqbal, and Fisher, 2008, B). Environmentally, any community development of renewable energy technology provides a source of clean energy for the community, decreases greenhouse gas emissions, and limits other pollutants associated with the more traditional forms of fossil fuel energy generation (e.g. pollutants which cause respiratory problems) (Cross, 2005; Doukas, 2006). The use of a local, renewable resource is said to foster the responsible use of natural resources and environmental stewardship (The Expert Group on Renewable Energy, 2005). Small scale development of renewable energy technology also means that there will be fewer environmental risks involved (Cross, 2005).

Specific to small hydro, these projects have minimal environmental impacts, most of which can be mitigated with careful attention to design and construction practices (CanREN, 2006). Small hydro can be designed to blend into the landscape, making it less obtrusive and more aesthetically acceptable (Islam, Fartaj, and Ting, 2004). There is minimal flooding, which decreases the ecological impacts commonly associated with large scale hydro (Schwartz, Pegallapati, and Shahidehpour, 2005).

From an economic standpoint the benefits of community-driven energy projects can be substantial. Revenue from energy generation can stimulate local economic growth and increase investment in community projects and programs (Doukas, 2006). There is a legitimate argument that any development of this type, be it public, private, or joint-venture, would bring money into the community. However, when the initiative is under community control, the decision-makers are able to ensure that all possible benefits remain in the community (Ontario Sustainable Energy Association, 2008, A). Benefits from decisions pertaining to the use of local skills, labour, and businesses during the planning and development phase, as well as the provision of services and distribution of revenue are most advantageous to the community when those decisions are made by the community itself (Holst, 2007). There is also the benefit from the multiplier effect, or how far project expenditures and/or project revenues (e.g. from purchases and wages) are spread within the community (e.g. part time jobs resulting from more business within the community). The multiplier effect is thought to be higher with community-driven developments versus private developments (Holst, 2007).

When compared to other, generally more intermittent renewable energy technologies, small hydro is also one of the most consistent and predictable in terms of the amount of power produced, and therefore the amount of revenue gained (Schwartz, Pegallapati, and Shahidehpour, 2005). Unlike other technologies, small hydro affords developers the ability to start, stop, store, and vary the power output in a very short period of time; flexibility which is especially useful in planning for peak periods of energy use (The Expert Group on Renewable Energy, 2005). Projects have a lifespan of fifty to seventy-five years, which affords small hydro the longest lifespan and lowest lifetime costs relative to any other renewable energy technology (Schwartz, Pegallapati, and Shahidehpour, 2005). Small hydro is variable in scale and design, accounting for various hydraulic characteristics, topography, and energy needs. Excluding administrative and/or regulatory approvals, construction and installation are short and relatively simple processes (Schwartz, Pegallapati, and Shahidehpour, 2005).

Further benefits of community controlled energy developments include local employment and control over organizational structure. The planning, installation, and maintenance of energy projects is thought to stimulate employment, both short and long term within a community (Miller, Doncaster, & Doukas, 2006). This generates additional income in the form of wages that may be spent within the local community, further improving the local economy (Doukas, 2006). Local employment opportunities may be increased during the construction phase to the extent that local labour can be used, as opposed to private firms bringing in outside labour (Holst, 2007). With community projects, there is potential for the community to make decisions regarding energy costs, for example, reducing energy costs for citizens; to use the energy generated to provide services for the town itself; or to use the energy to generate revenue to be invested into the community (Cross, 2005). None of these options can be assured when the development is under the control of a private firm.

Community energy developments such as small hydro can also foster improvements to community capacity, generating social benefits. Working through the preparation and development phases of such a project cultivates planning and organizational skills for those involved, as well as encouraging communities to establish goals and determine how best to achieve them (Cross, 2005). Education and skill levels in the community can be enhanced through this process, as well as through potential training programs that could coincide with the creation of new, high-skills jobs (Cross, 2005). Community participation also increases and strengthens social networks, educates citizens, and fosters community pride. Members of the community are thought to gain a better understanding of community priorities and values through participation in this development process (Doukas, 2006; Miller, Doncaster, & Doukas, 2006). Lastly, through taking an active role in enhancing the sustainability of the community, there is the potential for an increase in knowledge and acceptance of sustainable practices, which can lead to additional positive changes within the community (Cross, 2005).

2.6.7 Barriers to community small hydro

In general, the barriers to community energy can be divided into three broad groups: attitudes, public perception, and community resources; technological and bureaucratic barriers; and environmental barriers. Attitudes, technology, bureaucracy, and potential environmental impacts are barriers which are particularly applicable to small hydro.

Initially, a lack of awareness of the potential opportunities and incentives is often an obstacle to any type of community energy (Doukas, 2006). In many cases there are prevailing attitudes within a community regarding who is responsible for energy generation, the role the community can play in energy generation, and the available resources (e.g. hydro) and the type of technology (e.g. small versus large). Such attitudes can be difficult to overcome. For example, from a community standpoint, the fact that hydropower has traditionally been the jurisdiction of government or large utilities can present an issue (Islam, Fartaj, and Ting, 2004). As well, specific to small hydro, there are indications that this option is neglected or passed over due in large part to the poor public perception of large scale hydro (European Renewable Energy Centres, 2002). Impacts on environment and recreation, although present to a small degree in small hydro, are not present to the degree associated with large hydro, something which is generally not well understood (Sharma, 2007). This lack of understanding of the differences between small and large hydro projects has created public attitudes that serve to hamper small hydro development.

From a community standpoint, perceptions of risk can also present a barrier. Small scale energy developments can be seen as a risky financial investment due to high start-up costs and long payback periods, especially when it comes to small hydro. It can be a challenge to make the argument for long term profitability of small scale projects, making financing and loans a challenge especially in economically depressed areas (The Expert Group on Renewable Energy, 2005). The availability of financial resources can present a significant barrier to the development of community energy projects. The importance of this issue varies depending on the proposed energy technology and placement of development.

Once a community has made the decision to pursue a community energy development, there are a series of technical, regulatory, and bureaucratic barriers to overcome. The primary technical barriers are with the existing energy infrastructure, much of which has been in place for nearly a century. A potential project may have significant generation potential, but be impractical as a result of the interconnection requirements, which can form a significant and expensive obstacle (Neu and Martel, 2006). Until technological improvements are made, energy grids that were designed for centralized energy generation can be a technical barrier to development of new, distributed energy generation (Community Research Connections, 2006).

In certain areas, existing energy infrastructure will require massive upgrades over the next few decades, especially if it is to accommodate distributed generation. For example the Ontario provincial energy grid is currently a concern, due to inefficiencies as a result of its age, and the capacity is lower than what is expected to be required in Ontario in the future (Ontario Power Authority, 2008). As a result, Ontario's energy grid will be undergoing upgrades to refurbish infrastructure and increase capacity over the next twenty years (Ontario Power Authority, 2008). Given that there are upgrades required, there is potential to design these upgrades to accommodate distributed generation. Thus, while there are planning and cost barriers associated with technical upgrades to transmission facilities to accommodate distributed generation, once completed it not only allows for small energy development potential, but improves system reliability (Fisher, Iqbal, and Fisher, 2008, A; Fisher, Iqbal, and Fisher, 2008, B).

Additionally, in terms of technology, a great deal of expertise is required to plan and design small hydro projects. For example, small hydro can be particularly challenging when considering aspects such as variable or seasonal water flows and issues related to cold climates (e.g. freezing water and equipment damage). These issues can be mitigated, but at an increase to start-up and operating costs, requiring more capital (CanREN, 2006).

From a regulatory and bureaucratic standpoint, the process of acquiring various permits and licences, as well as regulations surrounding zoning, planning, and assessment can be another barrier to community energy development (Community Research Connections, 2006). Regardless of the chosen technology, the process involves multiple municipal, provincial/state, and federal government agencies. In Canada this may include the Canadian Environmental Assessment Agency, Fisheries and Oceans Canada, Ministry of Natural Resources, Ministry of Environment, the provincial energy utility, and the provincial energy authority. There is little intergovernmental standardization of regulations and codes, which makes this process difficult for each of the stakeholders involved in development. The process typically involves significant time spent obtaining approvals for plans, development, and installation, all resulting in additional costs for the developers. Planning and development processes currently in place are in large part oriented to suit a centralized energy market; making it difficult for small scale developments to get started (Community Research Connections, 2006).

When considering small hydro specifically, the regulatory and bureaucratic barriers can become increasingly complex. Because hydro is both a water and an energy policy issue there are additional administrative barriers within the planning process as a result of needing to meet the regulations for both sets of policy (Koch, 2002). Concern over potential environmental impacts related to small hydro adds additional constraints to the administrative process (Laguna, Houard, and Cahn, 2005).

While there are many examples of programs and policies surrounding small hydro development, an ideal system or framework has yet to be developed. Issues remain with existing frameworks not being place or technology specific. Areas where there are no policies also present an issue. For example, the province of Newfoundland and Labrador has no policy with respect to net metering or independent power production. Policy assessment and development needs to include targets, information, training, incentives, contact information, and knowledge mobilization strategies. This is needed at local, provincial/state, and federal levels. Financial incentives are also integral to development due to the capital costs associated with developing small hydro.

There is an absence of suitable resources to guide developers, especially communities, through the process of establishing small scale energy projects. There is a significant absence of guidance regarding the bureaucratic barrier. The resources that are currently available to potential developers fall into two broad categories: community energy planning and technical assessment.

Community energy planning guides, on their own or as part of guides to sustainable community planning are widely available. There are many examples, some designed at a local level, some by non-governmental organizations, some provincially, and others federally (Church and Ellis, 2007). However, these resources often tend to focus on the conservation and efficiency aspect of energy rather than the generation aspect. Other guides, such as the Ontario Sustainable Energy Association's *Community Power Guidebook* provide an overview of community energy, its benefits and barriers, and an outline of the development process for different renewable technologies (Miller, Doncaster, and Doukas, 2006). However, for interested communities the available guides can also present a barrier. For example, guides can be too place specific, focused entirely on the town or region where the guide was developed, making it difficult to transfer the information to different locations. Guides can also be too broadly focused in terms of the power source, giving a general overview of various technologies, without the kind of detail potential developers will need for a specific technology (e.g. small hydro), as there are differences in the processes for developing each generation technology.

Technical assessment guides are also widely available for aspiring developers, including detailed assessment tools that can be used to determine feasibility in terms of the potential generation capacity and financial aspects such as the pay-back period and the return on investment. Tools, such as Natural Resources Canada's RETScreen program, are detailed and well planned, but can also be seen as being relatively complex and geared towards educated or skilled users (RETScreen, 2006). The target audience for such tools is not necessarily a community at an early stage of consideration of small hydro. The lack of general assessment guides, technology specific guides, training, and certification resources are commonly cited as being significant barriers to community energy development (Ah-You and Leng, 1999; Community Research Connections, 2006). In many cases, low success rates for community energy projects have been attributed to the lack of available support and resources at the planning stage (Hain, Ault, Galloway, Cruden, and McDonald, 2005).

In terms of technical resource assessment, the potential impacts of climate change should be noted as a potential barrier, especially with regard to small hydro. The implications of climate change on small hydro are unknown. Climate change has the potential to impact hydro significantly and in a variety of ways (Alward, 2007). Areas where glacial melt impacts stream flow are likely to be the first to see the impacts, both for existing hydro developments and future developments (Alward, 2007). The potential for such changes presents a challenge for the long term planning, development, and operation of small hydro. For small hydro projects currently being evaluated, the validity of the existing planning and assessment tools used could be called into question, as these tools base projected energy outputs on historical stream flow data, which could alter as a result of climate change (Alward, 2007). Currently, assessment tools are not equipped to account for climate change. RETScreen, Canada's leading renewable energy assessment tool, has not factored in climate change to any degree as of yet, although this issue has been recognized and a dynamic performance indicator tool connected to actual climate data is under development (Ziegler, 2007).

Finally, there are environmental concerns regarding small hydro, as there would be with any disturbance to the natural state of a river. Of particular concern are the potential impacts on fish (Sharma, 2007), oxygenation of water, erosion, noise pollution, change in water levels, and negative changes in aesthetics (Paish, 2002). While technology, proper site selection, and mitigation techniques have all improved, no small hydro project can be considered to be without environmental risk.

While the environmental impact of small hydro is minor when compared to large damn projects, there is literature which questions whether the cumulative impacts of small hydro are equal to, or greater than, that of one large hydro project (Bonnell, 1997; IEA Hydropower, 2000). Cumulative impacts include the incremental impact of developments over a span of time (Bonnell, 1997). These potential risks require careful consideration to be given to initial site selection, design, and planning of small hydro, as well as to the development of hydro generation policy.

2.7 Literature Summary

Significant evidence exists to indicate why communities would be interested in exploring the development potential of community energy projects, in particular community small hydro. Growing concerns over the environment, coupled with interest in community development initiatives and distributed generation are helping to create a renewed interest in small hydro developments within Canada. Elsewhere across the globe in countries such as Kenya, Sri Lanka, and the Solomon Islands, small hydro has already been used to great success as a tool for sustainable community development (Waddell and Bryce, 1999; Ebrahimian, 2003; Ananda, 2006). In Europe, small hydro is one of the main prospects available to help nations meet their Kyoto targets for lowered greenhouse gas emissions (Paish, 2002). The use of small hydro as a tool for sustainable community development has enormous potential within Canada, due both to our historic development and use of hydro technology and due to the availability of physically, technologically, and economically viable hydro resources.

CHAPTER 3

METHODS

3.1 Theoretical context

As indicated in Section 2.1 'sustainability' has no one accepted definition. The latter half of the twentieth century was characterized by debates over sustainability and sustainable development and how to define these terms (Adams, 2006). Sustainability has become recognized for its holistic and elastic nature, making it difficult to define, but useful for accounting for many variables simultaneously. Global sustainability can be considered as a complex system with numerous interrelated scales, sub-systems, actors, and factors that need to be taken into consideration. This overarching system provides a frame for each sub-system (e.g. community-owned renewable energy generation). These sub-systems are linked (e.g. the role of community small hydro within the community as a whole), spanning and overlapping multiple scales, creating a complex and intricately linked system that is difficult to examine it in its entirety (Marshall and Toffel, 2005).

The focus of this dissertation is at the sub-system level: the development and use of small hydro by communities. However, as a result of linkages between sub-systems the context extends beyond the sub-system level. As discussed in Chapter 2, Sections 2.2 and 2.4, there is a well established link between energy and both sustainability and sustainable community development. Also discussed in Chapter 2, Sections 2.1 and 2.3, is the relationship between the community, sustainable development, and sustainability. What these four sections (2.1, 2.2, 2.3, and 2.4) indicate is the interconnectedness that accompanies sustainability. While the focal point may be one sub-system (e.g.

community-owned renewable energy generation), it is impossible to separate this specific segment from the community as a whole. Nor is it possible to separate the sustainable development or sustainability of a community from the overall global sustainability system. As a result of this interconnectedness and complexity, the contextual framework chosen for this dissertation is Complex Systems Theory.

Complex Systems Theory or Complex Systems Analysis provides a framework to help identify and analyze the fragmented and linked systems and sub-systems that make up global sustainability. The Complex Systems approach has been adopted by various disciplines to approach a range of topics (Beishon and Peters, 1972; Thrift, 1999). It is defined as a non-linear approach to the description, analysis, and understanding of a complete system including the physical, biological, ecological, and social aspects (Beishon and Peters, 1972; Amaral and Ottino, 2004; Complex Systems Society, 2008). This framework attempts to identify and understand systems with the hopes of being able to then better predict, control, manage, or adapt, although the non-linearity of the system makes prediction or control difficult (Beishon and Peters, 1972).

Within this theory the system is open, meaning it is inclusive and all encompassing, with many dynamic and changing relationships (Beishon and Peters, 1972).. Complex systems are characterized by a large number of self-organizing components, capable of continuous change and adaptation (Amaral and Ottino, 2004). As a result of these numerous components, nothing is linear (Holling, 2001), and the key to this approach is to see the system as a whole rather than focusing only on the individual aspects (Thrift, 1999). When studying and analysing a sub-system within sustainability it is critical to identify the parameters of the system from the bottom-up, attempting to delineate the self-organized network and the relationships within (Thrift, 1999; Holling, 2001). With Complex Systems Theory there is an added complication of incorporating environment and space, which are neither completely understood, nor predictable (Holling, 1978; Thrift, 1999; Jost, 2004).

While this dissertation focuses on one aspect of global sustainability at the local level, it identifies and explores a sub-system within the community level system: community-owned renewable energy generation. On its own this identified sub-system is both non-linear and multi-faceted, incorporating social, economic, and environmental factors. Through the use of Complex Systems Theory, the links from this sub-system to the community and to the global system are acknowledged. By identifying these linkages, this research helps to demonstrate the complexity of the system as a whole and its interconnected sub-systems.

3.2 Methodologies

3.2.1 Case study approach

This dissertation used the case study method, a primarily qualitative, in-depth study of a small number of illustrative cases for the purposes of understanding and providing insight into the subject of community small hydro (Berg, 2007). Interviewees from the case study communities played a supportive role, providing information to better explain the potential contribution of small hydro to sustainable community development.

There were a number of positive aspects to this approach. For example, the use of case studies meant that the design of the research was structured around the context and experience of the case study communities (Ritchie and Lewis, 2003). Use of the case study approach is considered to be an objective way of conducting research that allows for discussion based on real-life examples, allowing participants to draw from their own experiences, resulting in a diverse data set with integrated ideas and varied perspectives. The use of case studies also allowed for the retrospective exploration of past events (Ritchie and Lewis, 2003).

In designing this research framework it was necessary to recognize that this type of in-depth research can require a large resource commitment in terms of time, patience, people skills, and the ability to plan and execute what can be multiple methods at the same time (Cassell and Symon, 2004). Several steps were taken to minimize the potential impacts of these issues on this research. In terms of time, the number of case study communities chosen reflected available time and funding resources. The topic guide and questions (see Section 3.5.3) were developed to maintain a balance between an open discussion and the focus of the project.

An explanatory case study design was used, which allowed for the examination of the case study communities for a variety of influences, resulting in multiple perceptions being derived from the same set of questions (Ritchie and Lewis, 2003). This approach is linked to Grounded Theory, a theoretical approach that allows the results of the case study data collection to influence the generation of theory (Berg, 2007). Since the theory emerges as data are collected there is a potential limitation as there was no concrete theory present to help with the case study selection and question development (Berg, 2007). However, the positives of building theory from the results of data collection are thought to outweigh the limitations, because the emergent theory is reproducible within the constraints of the project (Berg, 2007). Grounded Theory will be examined further in

Section 3.4.1. Case study selection criteria are detailed in Section 3.5.2 and the details of the case study communities can be found in Chapter 4.

3.2.2 The indicator approach

At a basic level, an indicator is a clearly defined variable that is measurable either on a quantitative or qualitative scale (International Atomic Energy Agency, UN Department of Economic and Social Affairs, International Energy Agency, EUROSTAT, and European Environment Agency, 2005). Indicators are used in an attempt to understand links and relationships, providing a tool for collecting and communicating data in a comprehensible manner (International Atomic Energy Agency, UN Department of Economic and Social Affairs, International Energy Agency, EUROSTAT, and European Environment Agency, 2005).

The 1992 Earth Summit in Rio and the subsequent Agenda 21 document resulted in a global push to develop sustainable development strategies, and indicators to chart progress (Cartwright, 2000). As opposed to more traditional statistics (e.g. Gross Domestic Product), sustainable development indicators (SDIs) go beyond measuring outcomes and results and attempt to examine each subject from a more holistic point of view, including more qualitative environmental and social measurements. Sustainable development indicators focus on various aspects of sustainability, including: assessment, progress measurement, evaluation, and policy development (Segnestam, 2002).

In the field of sustainable community development, SDIs can be used for a variety of purposes, including: collecting baseline data, demonstrating changes over time, comparing progress, determining thresholds at which point negative impacts begin, and deciding targets for the future (Segnestam, 2002). Additional purposes include the ability to measure the impacts and effectiveness of actions and policies and the ability to forecast future changes (McCool and Stankey, 2004). There are multiple types of indicators, designed to serve different purposes (see Table 5).

Table 5 - Indicator Types

Indicator Type	Definition
Input	Monitor project-specific resources
Output	Measure the goods or services a project provides
Outcome	Measure the short-term results of a project
Indirect	Measure the long-term results of a project

Source: Segnestam, 2002

Within the context of energy, SDIs can also be divided into four broad categories: economic, environmental, social, and institutional (Vera, Langlois, Rogner, Jalal, and Toth, 2005). Economic energy SDIs examine how the generation and use of energy impacts the economic development process. Social energy SDIs focus on the impact of energy access on society and social well-being. Impacts are considered in terms of accessibility, affordability, and disparity. SDIs relative to the environment evaluate the overall impact of energy systems on the environment. Lastly, institutional indicators examine the availability and adequacy of the energy related institutional frameworks (Vera, Langlois, Rogner, Jalal, and Toth, 2005).

There are limits to the use of SDIs, as well as potential issues that need to be considered. One of the limiting factors is the lack of clarity and definition surrounding sustainability. When developing indicators this absence of clarity regarding the context within which sustainability is being used can lead to indicator choice that lacks a clear rationale and justification (Bulmer, 1989). Associated with this is the issue of achieving a balance between the needs of science and the needs of policy makers, as both have their own goals and requirements. Focusing too much on either side detracts from the usefulness or the reliability of the indicators, and renders their use ineffective (McCool and Stankey, 2004).

Other SDI issues are ones of practicality, such as the need to limit the number of indicators. Choices concerning whether to use a pre-existing indicator framework or to develop a new one, as well as which indicators are relevant to project goals, are unique to each case. There are also concerns with regards to the availability of data required, an issue experienced within this research.

The use of SDIs within this dissertation were necessary in order to provide quantitative data that illustrate what impact the small hydro facility had on the community. The SDI data collected were intended to demonstrate the sustainable development progress made by each case study community and to demonstrate the links between sustainability, sustainable community development, and energy. In order to be considered sustainable community development, there had to be positive impacts, or at least negligible negative impacts, on the economic, social, and environmental facets of each of the case study communities. The indicators selected address these three aspects and have been adapted from a number of internationally recognized SDI frameworks. These indicators can be considered outcome indicators, as the data collected illustrate the short-term impacts of the small hydro development on community sustainable development.

3.2.3 Mixed methodology justification

Two types of data were identified as necessary for this project: naturally occurring data and generated data. This required a varied approach to data collection. Generated data are those created by the researcher (Ritchie and Lewis, 2003). For this research the generated data were qualitative, collected through interviews. Naturally occurring data are quantifiable data which currently exist and can be found via methods such as observation and document analysis (Ritchie and Lewis, 2003). The use of sustainable development indicators allowed for the collection of natural data, both qualitative and quantitative.

3.3 Methods

3.3.1 Literature review

A primary literature review was conducted, including an examination of the development and application of small hydro technology, focusing on the North American context (see Chapter 2). Links were drawn between small hydro, renewable energy, sustainability, and sustainable community development. A secondary literature review was also conducted to examine existing examples of community small hydro within Canada and the United States. From these findings potential case studies were identified for a follow-up assessment based on the criteria listed in Section 3.3.2. From this list, four case study communities were chosen for in-depth study and key small hydro personal from each community were approached via e-mail and telephone for additional project details in order to further determine potential for use as a case study site (see Chapter 4).

3.3.2 Case study selection criteria

Potential case study communities had to meet each of the following criteria:

i) Community Ownership[3]*:* facilities had to be under the full control and ownership of the community. This means that the project is designed, developed, and owned by the community, or that 100% of the private utility shares are owned by the community or group of communities.

ii) Project size: the total energy output of each small hydro project could not exceed 20 MW of energy, consistent with the upper limit of the previously stated small hydro definition (see Section 2.6.2).

iii) Location: case study communities had to be in either Canada or the United States. While there are many case study examples globally, the subsequent application of this research is intended to be within Canada. Therefore it was important that the case study communities be generally contextually comparable to potential user communities in terms of economic, social, and political aspects. Each case study community is in a democratic country where there are established energy utilities, infrastructure, and regulatory processes; a large consumptive market for the use of energy; access to the applicable technology; and available financial resources for developers via financial institutions or government assistance.

iv) Operational: Case study small hydro projects were required to be operational at the time of this study, eliminating projects currently in the design or planning

[3] Where the community small hydro projects consisted of a number of projects, or projects had been refurbished, the most recently constructed facility, or component, was examined.

stage. This criterion ensured that all case studies could be compared on the basis of having experience with the development, implementation, and operations phases of small hydro.

v) *Community sustainability aspect:* each of the case study projects should have been designed with at least one aspect of the overall sustainable development of the community in mind.

3.3.3 Interviews: background and topic guide

The use of in-depth, semi-structured interviews was the primary method of data collection. Semi-structured interviews allow for a flexible examination of both broad and specific topics (Cassell and Symon, 2004). This "subject-centred" approach meant that while the topic guide focused on the key themes suggested to be important by the literature, the open structure allowed for interviewees to pursue variations on these themes, or to go in a different direction altogether (Ritchie and Lewis, 2003; Cassell and Symon, 2004; Berg, 2007).

There are some disadvantages to this method. While face-to-face interviews are thought to be best for gauging responses of interviewees, these interviews can be time consuming (both in terms of data collection and analysis), demanding for interviewees in terms of commitment, and expensive (Cassell and Symon, 2004). In allowing interviewees freedom to explore the subject, there is also a potential for digression, which can lead to data overload and inefficiency (Berg, 2007).

Purposive sampling was selected as the sample method. The aim with purposive sampling is to ensure that all the relevant aspects of the subject are covered by the interviews (Ritchie and Lewis, 2003). This method was selected as it allowed for interviewees to be selected on the basis of knowledge of the topic, which enabled the exploration and understanding of the central themes (Berg, 2007). In the case of this project, interviewees were selected based on their participation as members of various small hydro stakeholder groups associated with the chosen case study facilities (e.g. board of directors, project engineers, local environmental groups).

Qualitative sample sizes are generally smaller, as the point of saturation where little new information is gained from new interviews is reached fairly quickly (Ritchie and Lewis, 2003). There are also no requirements to ensure that the sample size is sufficient to provide estimates or statistical data, because that is not the aim of the data collection (Ritchie and Lewis, 2003). Various factors can influence the sample size needed, including a diverse population, a high number of criteria, or a high level of special interest groups. Based on preliminary exploration of the case study community stakeholder groups it was determined that a minimum of ten interviews per case study would be necessary, including representatives from as many involved stakeholder groups as possible.

The sample frame, or the method from which the sample was selected for the purpose of this research, was a combination of two methods (Ritchie and Lewis, 2003). First was the selection of participants as members of pre-existing organizations (i.e. identified stakeholder groups). The 'snowball method' was then used, where additional participants were selected based on referrals from other respondents (Berg, 2007).

Interviews in each of the four case study communities took place between April 13th and May 17th, 2008. A week was spent in each community conducting face-to-face interviews, with two exceptions where interviews were conducted over the telephone. A total of forty-eight semi-structured interviews were conducted with fifty-one participants. These included city/municipal employees, board members, utility employees, engineers, consultants, biologists, members of non-governmental organization, local politicians, and prominent citizens. Interview length ranged from twenty minutes to an hour and a half.

An interview guide was designed to focus the semi-structured interviews. The intention of an interview guide is to steer the interview, ensuring that each topic is covered, while maintaining flexibility (Ritchie and Lewis, 2003; Cassell and Symon, 2004). Two question types were included: content mapping questions, which are the simpler questions intended to lay the foundation of the interview, and content mining questions which were more in depth questions specific to the small hydro development process, as well as the drivers, benefits, and barriers. Content mapping questions consisted of general, widely framed opening questions, some focused questions, and perspective widening questions intended to re-examine issues from varying perspectives (Ritchie and Lewis, 2003). Content mining questions were the in-depth exploration of the more important aspects of what was touched on with the content mapping questions. These consisted largely of various probing questions designed to have interviewees elaborate, further explore, explain, or clarify (Ritchie and Lewis, 2003).

The literature review contributed to the development of the topic guide and questions in terms of developing the key themes. Survey questions used by the Pembina Institute (Whitmore and Bramley 2004) and the Ontario Waterpower Association (Leckie, 2006) were also used as a guide for question development. As a result of the flexibility of the semi-structured interview structure, the topic guide and questions could be tailored to focus on local characteristics particular to each of the case study communities. The topic guide and questions are summarized in Table 6.

Table 6 - Topic Guide

Introduction

- Opening remarks
- Review of study purpose and objectives of research
- Review of the role of participants
    - Recording of data
    - Confidentiality
- Written permission to record interview

Objectives

- How has small-scale hydroelectric power generation been used as a tool for community-driven sustainable development in rural Canada and why is it not more widespread?
    - *how* communities within developed countries such as Canada can use small-scale hydro as a sustainable development tool
    - *why* there has not been a more widespread adoption of small-scale hydro as a development tool
- Assessment of existing, successful community-driven small hydro projects to identify and examine the drivers and strategies behind their successes, and the potential applications for using small hydro as a tool for enhancing community sustainability.
- Examine the link between energy and sustainability within the context of the developed world.

Expected Outcomes

- Results of this project are directly relevant to the planning and preparation involved in the potential adoption and application of community-driven small hydro in other communities, as it will offer a template which rural communities can use to develop their own projects.

Opening Questions

- Please state the name of the organization that you represent, how long you have been affiliated with the organization, background and job description.
- Do you have / what is your connection to the ***insert hydro project name here*** project?
    - When did you first become involved?
    - In what capacity are you/your organization involved?

Topic One – Drivers

- GENERAL – What do you feel is driving interest in renewable energy development in your area?
- SPECIFIC - How long has your community been involved in small hydro development?
- GENERAL – What do you feel makes small hydro an attractive choice for development?
- SPECIFIC - Why was small hydro chosen over another method of energy generation?
    - History
    - Availability of other opportunities
    - Economics
- What were the key drivers behind your community's most recent small hydro development?
    - Economic?
    - Environmental?
    - Social?
    - Other?
- Which (if any) was the primary driving factor?

Topic Two – Planning and design process

- Who initiated the most recent development process?
    - Is there an energy board or council?
    - Goals?
    - How involved is the community in the local generation? How is information conveyed to them?
- Could you discuss the planning and design process that was involved in the development of this small hydro project?
    - What were the formal steps involved? (Pre-feasibility, feasibility, site release, EIA, permitting, construction, etc.)
    - Were there environmental considerations nitrated into the initial development?
    - Is there continued environmental monitoring?
- What role did **you / the community / your organization** play in this process?
- Were there any forms of public participation in the process? If so, what were they?
- What aspects of the planning process were successful?
- What aspects of the planning process were not?
- GENERAL – What do you feel are the factors a community would need to successfully develop a community energy generation project?
- SPECIFIC - Were there any factors that were key to the success of this project?

Topic Three – Barriers

- What were/are the barriers to planning and development?

- Financial
- Bureaucratic
- Public participation process
- Environmental
- Technological
- Public perception / attitude
- Resistance from stakeholder groups
- Responsibilities
- Other

- Which barrier do you feel presented the largest hurdle?
- Was the community as a whole impacted by these barriers? Or certain stakeholders over others?
- How were these barriers addressed?
- Were they successfully overcome?
- What actions or changes could help to improve the process / remove these barriers?

Topic Four – Benefits

- GENERAL – What do you feel are the benefits of having a community owned power generation project?
    - Are there any benefits that are specific to hydro?
- SPECIFIC - What have been the benefits of the project?
    - Environmental
    - Economic
        - Community services
        - Employment
        - Revenue
    - Social
        - Community capacity
        - Social networks
        - Education
        - Community attitude
    - Other

Topic Five – Sustainable Community Development

- Do you feel that the concept of being sustainable is becoming integrated into the community?
    - Plans
    - Policy
- Has community sustainability or sustainability been defined within your community?
- Does your community have a sustainable community development plan?
    - When was it developed, why and how?
    - Are there indicators to track progress?

- Is there a community energy plan?
    - Are there indicators to track progress?
- Is there an economic development plan for your community?
    - Does sustainability factor in to it?
    - Does energy factor into it?
    - Are there indicators to track progress?
- Do you feel that there is a link between energy and sustainability?
    - Is this a direct or indirect link?
- Has community-driven small hydro played a role as a tool for sustainable community development?
    - In what respect?
- Has small hydro had an impact on the overall sustainability of the community?
- Are the benefits spread evenly throughout the community? Or do they benefit certain stakeholders over others?

Topic Six – If Applicable (Details)

- SDI (numeric)
    - Renewable energy output in kW / percentage in total energy supply
    - GHG emissions
        - From project
    - Annual water withdrawals from the river (amount of water used for project)
    - Financial value / contribution to the community
    - Records of development / upgrade?
- SDI (y / n)
    - Were there environmental considerations integrated into the initial development?
    - Is there continued environmental monitoring?
    - Sustainable community development plan?
    - Community energy plan? Associated indicators?

Closing Questions

- Overall, do you feel that small hydro development has been positive for the community?
- What are your thoughts on additional developments of this type?
- Do you have anything further you would like to add?

With the permission of the interviewees, interviews were digitally recorded. It is thought that audio recording of an interview can be less intrusive than note-taking (Ritchie and Lewis, 2003). Note-taking can also give interviewees unintended clues as to what interviewers are looking for, which may take the interview in an unintended direction (Ritchie and Lewis, 2003). Each of the digital recordings was then transcribed for the purpose of analysis.

3.3.4 Selected sustainable development indicators

Eight sustainable development indicators were selected for this research, derived from various sources based on predicted data availability (Swedish International Development Cooperation Agency, 2002; Anielski and Winfield, 2002; International Atomic Energy Agency, UN Department of Economic and Social Affairs, International Energy Agency, EUROSTAT, and European Environment Agency, 2005). These indicators can be divided into impact indicators and indicators of community values and action.

Impact

Percentage of renewable energy in total energy supply: an economic indicator related to the promotion of renewable energy for security, diversity, and environmental protection. This is linked to indicators such as fuel shares and security of energy supply. Data required were the ratio of renewable to total energy supplied and the amount of electricity generated from renewable sources relative to total electricity use.

Greenhouse gas (GHG) emissions from energy production (tonnes): included the GHG emissions from the small hydro project itself and the GHG emissions from an equivalent fossil fuel source. This is an environmental indicator with direct ties to climate change and is linked to indicators such as energy use and fuel source.

Annual water withdrawals from the river for all activities (m^3, percentage of total resource): indication of the overall use of the river, including, but not limited to small hydro. Indicates changes in the flow and supply of water, the potential environmental strain on the river and the potential impact one user can have on another.

Financial contribution of small hydro to the community: dollar value the small hydro contributed to the community and how that was being invested. An indication of the scale of contribution to sustainable community development.

Community values and action

Integration of environmental considerations into project development (y/n): indication of concern over maintaining environmental integrity and minimizing impacts. Required data from project planning and EIA documents.

Continued monitoring of environmental considerations (y/n): ongoing monitoring of environmental indicators associated with project.

Sustainable community development plan (y/n) and associated indicators (y/n): indication of level of commitment to sustainable development. Data from community profile information and interview data.

Community energy plan (y/n) and associated indicators (y/n): indication of importance of energy issues and planning within the community. Data from community profile information and interview data.

3.3.5 Evaluation of methods

The key limitation of the case study method was the issue of complexity. Each case study community was unique, both in terms of the small hydro itself and in terms of the community context and the community's attitude toward sustainability. As a result, what holds true for one community does not necessarily hold true for another and general "lessons learned" may be difficult to transfer from the case study communities to other communities. Also, as a result of the complexity of the issue of sustainable community development and its connections to global sustainability, it is possible that the case study method of focusing specifically on community energy sub-systems did not allow for a broad enough exploration of the linkages to other sub-systems and to global sustainability as a whole.

The case study approach was also limited in terms of interviewing only those people involved in the small hydro projects as opposed to the community as a whole, leaving the examination of community sustainability incomplete. The complexity of not only the energy sub-system, but the community system, also made it difficult to compare the case study communities, all of which were at different points in their development and had different approaches to sustainability.

While the use of the case study approach and semi-structured interviews allowed for an open ended, in-depth study of community small hydro, the resulting data collected can be considered 'soft' and too open to interpretation to be definitive. As a preliminary examination of community small hydro within the North American context the data collected can be seen as providing a starting point for future research, describing the development process, the resulting benefits for communities, and raising questions surrounding previously acknowledged links between energy and sustainability. As an exploratory study this dissertation identified several areas for further research, including the overall connections between energy, development and politics, and energy and sustainability.

Despite its limitations the use of the case study approach was considered to be better suited for this research than a comprehensive review of community small hydro. The criteria used to choose the case study communities allowed for a controlled selection of communities. The four case study communities chosen were among the few identified that met each of the criteria. They also offer examples of different community structures, as well as different types and uses of small hydro technology. Given the limited availability of detailed data surrounding individual community small hydro facilities and the role the facilities play within the community, the use of semi-structured interviews allowed for the type of in-depth inquiry needed for this research. Because the key themes were unknown, the use of open ended, semi-structured interviews was considered to be more suitable than an alternative method such as closed-ended questionnaires.

It is possible that had communities which had attempted and failed development of community small hydro been included in the research, more could have been learned about the small hydro development process and which barriers are truly prohibitive to development. Each of the case study communities examined can be considered a successful example of community small hydro insofar as the projects had been developed and were operational. This was part of the site selection criteria in order to draw conclusions from positive examples for other communities. However, the potential lessons to be learned from unsuccessful projects should not be discounted and are an area for potential future research.

3.4 Methods of analysis

3.4.1 Analytical approach

Qualitative data analysis has many forms with no clearly agreed upon rules or procedures, giving researchers the freedom to design a process of analysis which best serves their purpose (Ritchie and Lewis, 2003; Berg, 2007). For the purpose of this research, the method of qualitative data analysis was a combination of features from Content Analysis and Grounded Theory. Both analysis types are similar in that they are rooted in the capturing, interpretation, and finding of substantive meaning within the data (Ritchie and Lewis, 2003). Content Analysis examines the content and context of documents and identified themes (Ritchie and Lewis, 2003). Themes are generally examined for the frequency of their occurrence and linked to outside variables (e.g. the stakeholder group the interviewee represents).

Grounded Theory places increased emphasis on the generation of theory from the data (Glaser and Strauss, 1967). There are a number of key concepts which underlie Grounded Theory. As opposed to fitting the data to a pre-conceived theory, researchers develop the theory from the data; categories are developed, and relationships are identified between the categories (Cassell and Symon, 2004). This is an inductive process that involves constant comparison throughout the data collection process, allowing data analysis and collection to occur simultaneously (Glaser and Strauss, 1967). Under Grounded Theory it is permissible for the data collection method (i.e. interview questions) to evolve or shift, allowing for the basic questions to be modified to suit each individual situation (Glaser and Strauss, 1967). Data collection and theory conceptualization continue until a saturation point is reached where new data are no longer being added (Ritchie and Lewis, 2003).

From the data general categories or themes were derived and examined. Links between themes were also identified, illustrating the complexity of each situation. Typically, links between interviewee-related data and outside variables are not examined as this is thought to have little or no bearing as the interviewees are not the focus of the study, but rather it is their association with the case studies that is relevant. The use of Grounded Theory allowed for the interview questions to focus on the unique aspects of each case study community, creating a dynamic data collection tool. Any theories pertaining to the data evolved from the analysis, as opposed to being pre-determined.

3.4.2 Analytical method

Analysis of qualitative data is done in order to transform large quantities of data into recognizable themes or categories (Berg, 2007). Qualitative research analysis is generally done in one of two ways: code and retrieve or *in situ* (Ritchie and Lewis, 2003). Code and retrieve involves the researcher developing categories or themes that are applied to the whole data set, sectioning off portions into different themes (Ritchie and Lewis, 2003). *In situ* looks at data portions separately, with each section requiring themes or categories to be conceptualized differently (Ritchie and Lewis, 2003).

As a result of the objective of finding the key concepts (themes) involved in the planning and development of community-driven small hydro, this research lent itself to the code and retrieve method of analysis. While code and retrieve is sometimes criticised for grouping data and comparing it outside of the context in which it originally occurred, this process allowed for a clear organization of data into key concepts and for determining relationships between these concepts (Ritchie and Lewis, 2003; Berg, 2007). Most importantly, code and retrieve remains grounded in the data and allows for the systematic and comprehensive coverage of the data set (Ritchie and Lewis, 2003). This allowed for an explanatory account of the data, finding patterns, and attempting to account for why these patterns exist (Ritchie and Lewis, 2003).

A variety of computer-assisted qualitative analysis methods exist to facilitate data analysis, including code and retrieve and code-based theory building software designed to help researchers group data into the major concepts or themes (Ritchie and Lewis, 2003; Berg, 2007). One of these software programs, NVivo, was employed to analyze interview data. NVivo is designed to facilitate analysis of interview data, allowing the user to classify, sort, and arrange information in such a way as to easily allow exploration of the key themes, ultimately leading to the development of theories and answers based on the data collected.

3.4.3 Sustainable development indicator analysis

Sustainable development indicators (SDI) are designed to assess change, providing information on changes and trends, often comparing data to either baseline data or target data (Segnestam, 2002). SDIs are decision-support tools, a set of variables which are determined to be important to the condition or process being assessed. As discussed in Section 3.2.2 sustainability can be difficult to quantify and equally difficult to measure. Because of this lack of clarity, the SDIs provided an opportunity to determine whether or not the small hydro projects studied contributed to enhanced sustainable community development (Corbiere-Nicollier, Ferrari, Jemelin, and Jolliet, 2003). The use of SDIs also allowed for the comparison of variables over space and time. If the same indicators are used in multiple locations, there is the ability to compare one location to another (e.g. comparison of the case study communities), as well as one location to itself over time (Cartwright, 2000).

3.4.4 Evaluation of analysis techniques

It has been argued that the use of SDIs is the most suitable way to measure and compare sustainability progress. Typically SDIs measure variables which are outside standard community statistics, such as environmental and social welfare. While SDIs have proven to be an efficient tracking mechanism, this only holds true if the data are available. While there was a consistent set of indicators applied to each of the case studies for comparative purposes, time series data proved to not be available for each community for all variables. This made tracking the long term impact of small hydro, as well as community sustainability progress over time, impossible. However, the available data did allow for a comparison of community sustainability relative to the other case study communities at the time of this research, giving an indication as to the overall level of community sustainability, as well as the role played by the small hydro facility.

Initial expectations of data analysis were that identified themes would be examined with limited links to external variables and influencing factors (e.g. interviewee relationships, see Section 3.4.1), however this was not possible. Each identified theme and resulting theory related directly to the community small hydro sub-system, but it was impossible to consider these themes individually without taking into account the influence of external factors linking them to the both the broader community sub-system and the larger system as a whole.

These external factors included those at the local scale (e.g. personal conflicts, values, and prejudices) and larger scale issues (e.g. political climate at the provincial/state, national, and global level). The local scale factors appeared to have a greater influence on the perception of interviewees, and therefore required careful consideration during data analysis. Given the complexity of sustainability and developing sustainable communities as recognized by Complex Systems Theory, the initial expectations of being able to examine the energy sub-system of case study communities without accounting for these external factors and linkages was unrealistic.

The chosen methods of interview data analysis, Content Analysis and Grounded Theory, were well-suited to the type of data collected. These analytical methods allowed for the identification and examination of themes and their frequency of occurrence within the data, making this both a flexible and inclusive process that allowed the researcher to find substantive meaning within the data.

CHAPTER 4

CASE STUDY COMMUNITIES

As indicated in Sections 3.3.1 and 3.3.2, four case study examples of community small hydro were selected on the basis of community ownership, project size, location, operational status, and connection to community sustainability. Two of the case study communities are in Canada and two are in the United States. While similar in terms of the selection criterion, these four examples differ in certain respects. Most importantly to this research were differences in basic community characteristics (e.g. income) and uses of the small hydro facility within the community.

4.1 Almonte, Ontario

The town of Almonte is part of the larger community of Mississippi Mills in eastern Ontario, an amalgamation of the town of Almonte and the wards of Ramsay and Pakenham (The Town of Mississippi Mills) (see Figure 2). The total population in 2006 was 11,734, with 4,649 of those people living in the town of Almonte (Statistics Canada, 2008, B). The unemployment rate is 5.2% and the median household income in Almonte was $78, 488 in 2006 (Statistics Canada, 2008, B).

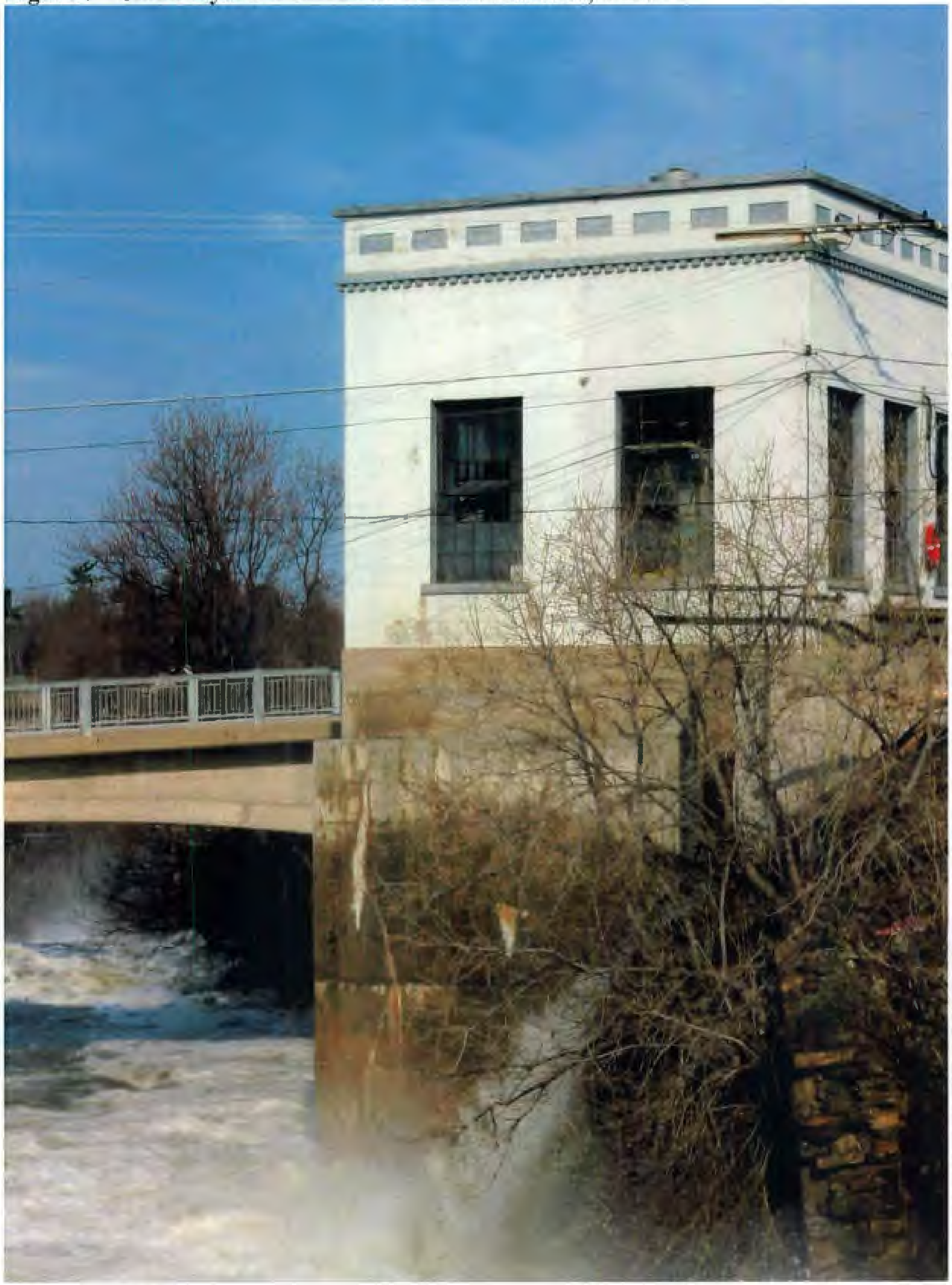
The Mississippi River, one of the major tributaries of the Ottawa River, is 175 km long. The overall drainage area for the river is 4,000km^2 (The Town of Mississippi Mills). The area experienced hydro development early on, beginning with the nineteenth century development of textile industries. The local development of small hydro for electricity was initiated in the late 1800s by a private developer for the purposes of providing street lighting (Mississippi River Power Corporation). The town of Almonte purchased Almonte Electric in 1901, and the small hydro facility has been upgraded and retrofitted several times since, ultimately reaching its present generation capacity of 2.4 MW (see Figure 3) (Mississippi River Power Corp.). This project is currently undergoing a relocation of the plant and expansion of generation capacity to 5 MW.

Privatization within Ontario's energy sector resulted in the formation of the Mississippi River Power Corporation, a private company of which 100% of the shares are held by Mississippi Mills (Mississippi River Power Corporation). However, as the original small hydro facility was owned by the Almonte, revenues from the small hydro facility go solely to the town of Almonte (Mississippi River Power Corporation). The company is run by a board of directors appointed by the Mississippi Mills municipal government, which includes a mix of skilled professionals, as well as a representative from the town council.

Figure 2 - Canadian Case Study Locations

Source: modified from Natural Resources Canada, 2003

Figure 3 - Small Hydro Generation Station. Almonte, Ontario



Source: Breen, 2008

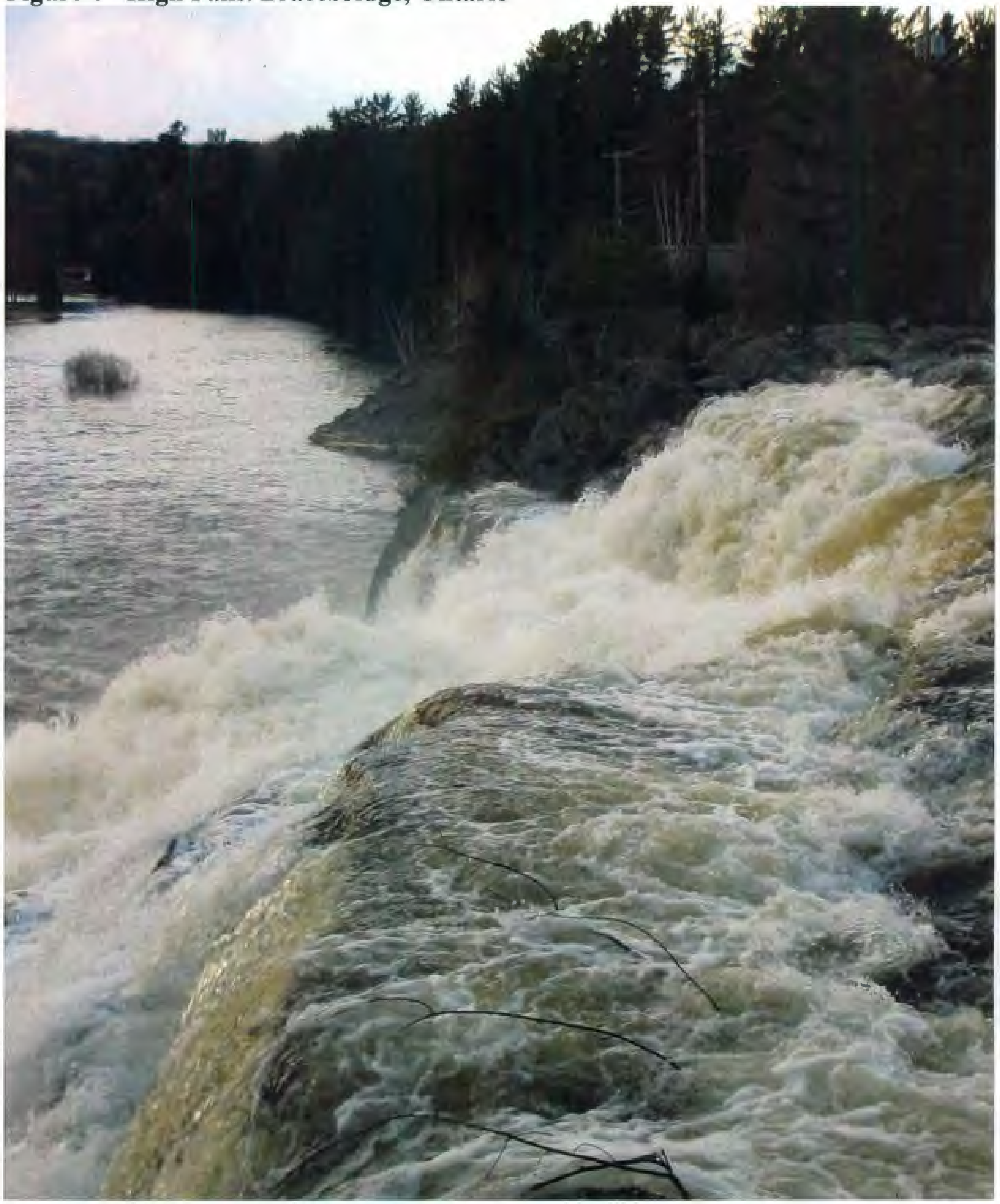
4.2 Bracebridge, Ontario

Bracebridge is a town within the district of Muskoka in central Ontario, (see Figure 2). Although the population was listed as 15,652 in 2006 (Statistics Canada, 2008, A), there was estimated to be an additional 9,320 seasonal residents (Bracebridge Economic Development Department, 2007). Among permanent residents the unemployment rate is 3.9% and the median household income was $59, 193 in 2006 (Statistics Canada, 2008, A).

The north branch of the Muskoka River runs 210km through Bracebridge from its headwaters in Algonquin Park to Georgian Bay with a total watershed of 4,660km^2 (ACRES International, 2006). The river's water flow is highly controlled, with forty-two water control structures, ten of which are used to generate electricity (ACRES International, 2006). Historically the river was central to the timber industry. Currently, the primary importance of the river is local tourism and, to a lesser extent small hydro.

In the late 1800s Bracebridge purchased their first small hydro plant to supply local power. The original company, Bracebridge Generation, expanded over the years to include four facilities: Bracebridge Falls, Wilson's Falls, High Falls, and Burk's Falls totalling 4.2 MW (Bracebridge Generation Ltd.). The focus of this research was High Falls, which in the post-privatization period has been the most recently upgraded facility. The second generator installed at High Falls in 2006 added 1,500 kW to the original 800 kW (Bracebridge Generation LTD., 2006) (see Figure 4). With Ontario's privatization of the energy sector, Bracebridge Generation became a part of Lakeland Holding Ltd., a private company whose shares are owned by several municipalities, with Bracebridge as the majority shareholder (65%) (Bracebridge Generation Ltd.). A board of directors is appointed to run the company, and is responsible to each of the municipal shareholders.

Figure 4 - High Falls. Bracebridge, Ontario



Source: Breen, 2008

4.3 Boulder, Colorado

The city of Boulder is in the foothills of the Rocky Mountains, north-west of Denver (see Figure 5), with a population of approximately 100, 000 people[4] in 2000. The unemployment rate is 4.8% with a median income of US$44, 749 (CAN $51, 581.79) in 2000 (U.S. Census Bureau, 2000, A).

Boulder has a long history of education and research and is home to such institutions as the University of Colorado, Boulder and the National Centre for Atmospheric Research (City of Boulder, 2008, B). This focus on education, together with a strong conservation ethic has encouraged a longstanding commitment to preserving the city's natural surroundings (City of Boulder, 2008, B). In recent years this conservation ethic has led to Boulder's commitment to improving local sustainability, including efforts to reduce greenhouse gases.

The development of Boulder's small hydro facilities began in the late 1970s and early 1980s (Cowdry, 2001). The city owns and operates eight small hydro facilities in total, seven in-line and one in-stream, producing a combined total of just over 20 MW (Gesner, 2007). The in-line facilities, such as the Silver Lake example (see Figure 6), are built into the pipelines of the municipal water system, with turbines installed on both raw and treated water lines. The in-stream, run-of-the-river facility is on Boulder Creek, west of the city. While the in-line facilities were the focus of this research, the in-stream facility was considered as well.

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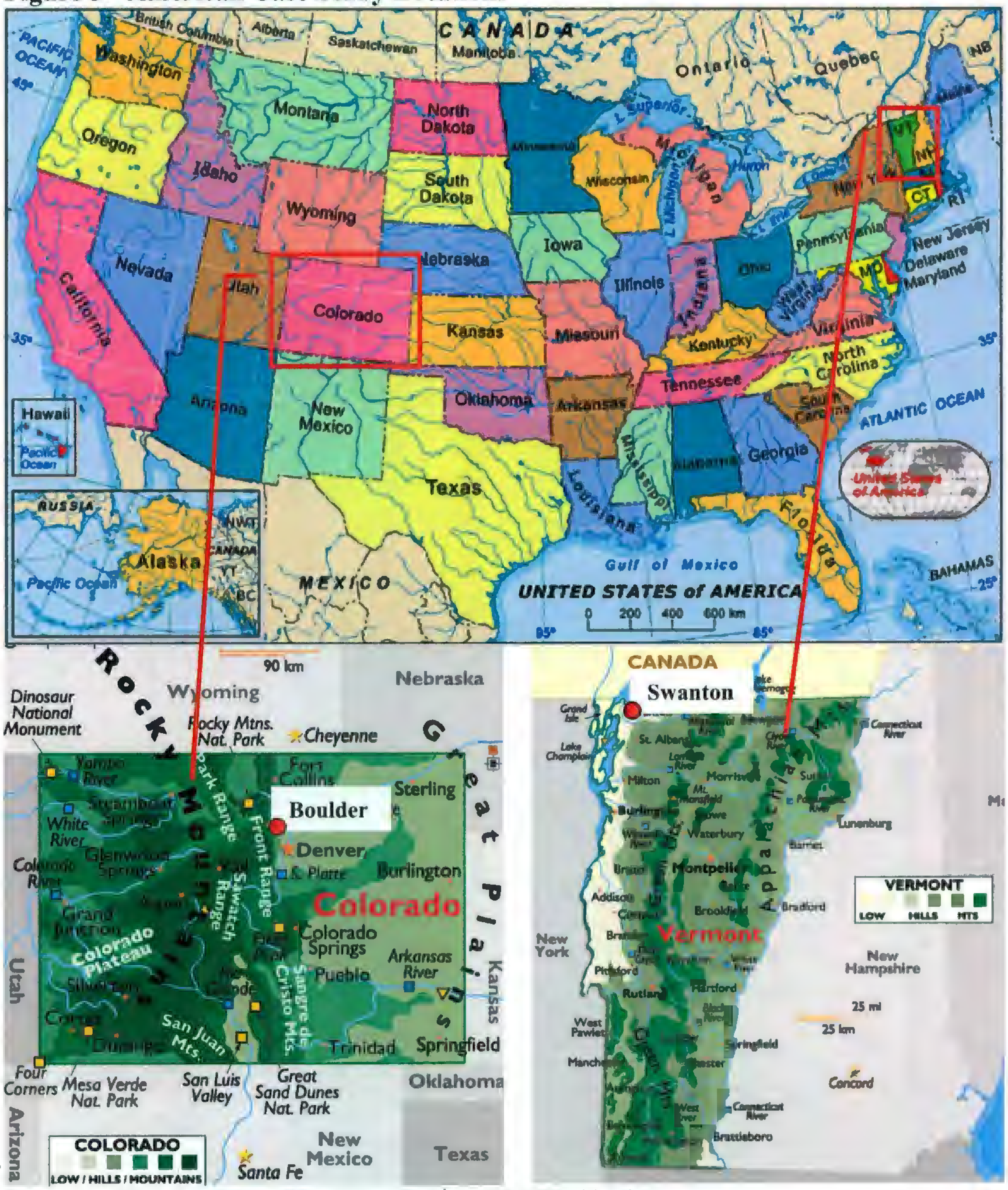
[4] Boulder was also an outlier among the case studies in terms of population and the type of small hydro technology. While these differences made it difficult to compare Boulder with the other communities, this case study demonstrates that community small hydro is possible in a larger community setting and without the use of rivers.

Figure 5 - American Case Study Locations



Source: modified from Natural Resources Canada, 2004; World Atlas

Figure 6 - Silver Lake In-Line Hydro Facility. Boulder, Colorado

Source: Breen, 2008

4.4 Swanton, Vermont

The Village of Swanton is located within the Town of Swanton in Franklin County (see Figure 5). Swanton Village and Swanton Town operate as separate entities, with the Village having control of the energy utility. In 2000 the Village had a population of 2,548 and the Town had a population 6,203 (U.S. Census Bureau, 2000, C; U.S. Census Bureau, 2000, B). The median household income was US$34,153 (CAN $39, 407.04) for the Village and US$41,086 (CAN $47, 406.60) for the Town, with unemployment rates of 6.2% for the Village and 4.4% for the Town in 2000 (U.S. Census Bureau, 2000, C; U.S. Census Bureau, 2000, B).

The Missisquoi River flows through Swanton from its headwaters in the Green Mountains of Vermont to its terminus in Lake Champlain and is 130 km long (Northwest Regional Planning Commission, 2007). The drainage area of the Lake Champlain watershed is 850 miles squared (U.S. Geological Survey, 2008, A). The use of the river by both the Village and the Town dates back to the development of textile mills established in the late 1700s.

Community involvement in hydroelectric power generation began in 1894 when the Village purchased the Highgate dam and began selling the energy for the benefit of the community (Swanton Village, B). The project began with the intention of using the electricity for street lights but power output was gradually increased to supply residential and commercial uses. Various upgrades have been made to the facility, the most recent in 1994 when a rubber dam was installed, and the reservoir size and dam elevation increased, enhancing power production to 9.5 MW (Swanton Village, A) (see Figure 7).

Figure 7 - Highgate Falls. Swanton, Vermont

Source: Breen, 2008

4.5 Case study community discussion

Different driving factors, community values, and development processes have meant that each of the community small hydro projects has developed differently and that the impacts on the communities have varied. The common factor among the four communities was that the majority of interviewees from each case study clearly indicated that, if developed properly, a suitable small hydro site can provide many community benefits. In terms of sustainable community development, it also became clear that small hydro projects offer additional potential beyond the obvious economic benefit, including the *opportunity* to be used as a tool to build a more sustainable community.

While not the defining factor, community history had an impact on each of the case study communities. For the three communities with a history of small hydro, this has meant that small hydro was an investment choice based on prior experience and investment, unlike other potential renewable power developments. In the case of Boulder, while the small hydro development had no precedent, the conservation and environmental ethic did. Boulder was characterized by one interviewee as "thirty square miles surrounded by reality...it's highly educated, highly liberal" (Boulder Respondent). Another interviewee went so far as to suggest that it was inappropriate to use Boulder as a case study, given its unique environmental and sustainability ethics. This local ethic led, in part, to the development of in-line hydro in Boulder as one more in a series of tools aimed at enhancing local sustainability.

Boulder was the only community without a longstanding history of small hydro development. However, despite the similar roots of the other three communities, analysis demonstrated that the four case studies were in different stages relative to one another with respect to community sustainability. In terms of the links between the community, the local small hydro facility, and local sustainability, a number of influencing external factors were noted by interviewees. Interviewees indicated that it is likely that factors such as community size, physical characteristics, local economy, local politics, cohesion, and education all played a role in how the small hydro was integrated into the community, as well as in the development of community sustainability.

Local community values appeared to play an integral role in community development, including community sustainability. While Boulder has had a longstanding conservation and environmental ethic, the other communities demonstrated a range of local values pertaining to sustainability and the environment. For example, within Bracebridge interviewees indicated that the local environment and watershed was critical to the local economy, due to the large number of seasonal residents, tourists, and retirees. This link made seasonal employment and the service industry important economically. However, while the appeal of the "soft wilderness" experience brought people to the area, the instability within the tourism sector resulted in a continued search for additional development opportunities. This appeared to create conflicts in values among different segments of the population (e.g. seasonal residents who value the natural area versus development of local industry). This was reflected in the conflict that resulted from the development of the local small hydro to be discussed in Section 5.2.

While sustainability did not appear to be in the forefront of the thoughts of the majority of the interviewees from the Swanton case study, it should be noted that preservation of the natural environment was mentioned by many interviewees as a commonly held local value. However, the issue of preservation was voiced by some interviewees as an argument against development of small hydro.

The level of community cohesion and sense of community was another factor influencing sustainable community development. Interviewees from each case study indicated that increased community participation and interaction in the community planning and development process resulted in positive outcomes for the community. Analysis of the data collected indicated that those case studies with strong levels of community cohesion and community improvement were working on enhancing local community sustainability, something which was reflected in the local community planning process and in their relationships with the local small hydro facility.

Other potentially influencing factors included local income and education levels. For example, census data indicated that Swanton was made up of predominantly younger families (U.S. Census Bureau, 2000, B; U.S. Census Bureau, 2000, C). Just under half of the population counted high school as their highest academic achievement and the community had the lowest median income of the case study communities (U.S. Census Bureau, 2000, B; U.S. Census Bureau, 2000, C). Such factors have contributed to a focus on what might generally be considered limited sustainability or the "basics" of community development (e.g. affordable services and employment), which may help to account for why a more holistic, explicit approach to community sustainability had yet to manifest itself. Bracebridge as well was similarly focused.

Almonte can be considered a 'bedroom community', with 46.5% of the workforce employed in Ottawa, as well as somewhat of a retirement community (The Town of Mississippi Mills). These factors contribute to a higher than average level of local organizational skills and volunteerism, something demonstrated in the experience and skills set of the small hydro board of directors.

Boulder is a highly educated community, with 30% of the population having a Masters or PhD (U.S. Census Bureau, 2000, A). It was also a very liberal, forward thinking, and wealthy community, all of which made it increasingly understandable as to why Boulder can be shown to be further along the sustainability continuum relative to the other case studies.

From the case studies it appears that the preservation of the local environment and the building of a vibrant, sustainable community may be more in the forefront of community thinking and planning where influencing factors such as available time, wealth, and skills of local community members characterize the community.

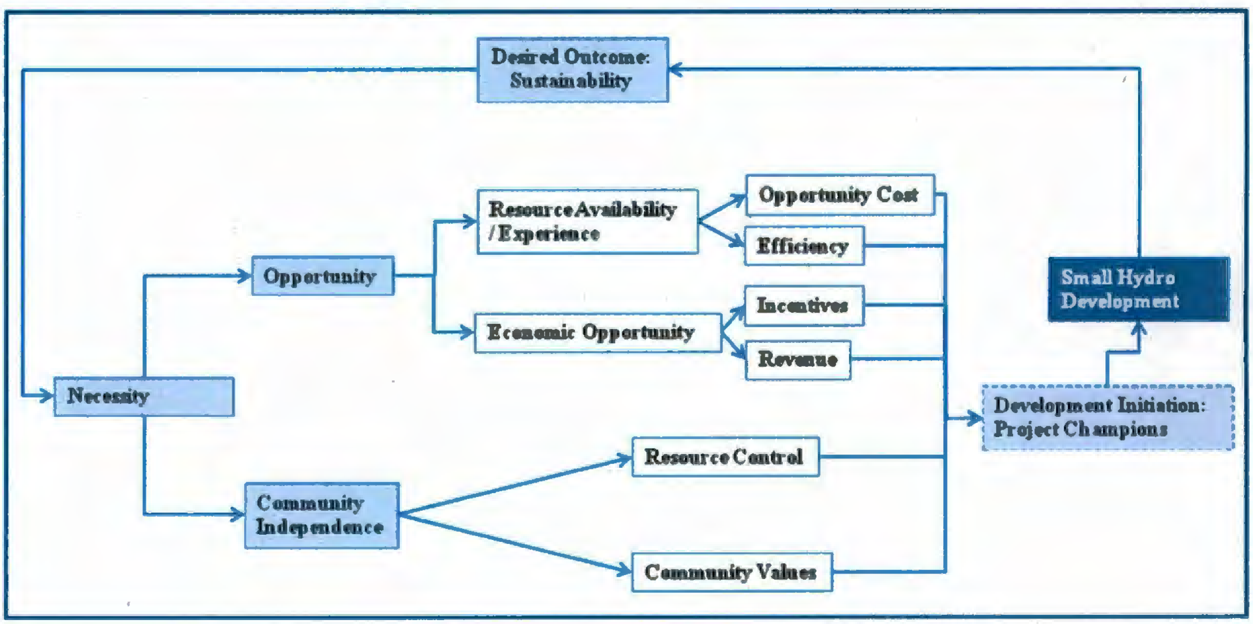
CHAPTER 5

RESULTS AND ANALYSIS

5.1 Factors driving community small hydro

Initial interview questions focused on identifying the key drivers of community small hydro (see Figure 8). Determining the motivating factors behind the development of local small hydro helps to illustrate certain community characteristics (e.g. focus on sustainability) that may lead to the development of small hydro, and also provides information that may be useful to other communities in order to stimulate this type of development. For each of the case study communities, sustainability, while defined differently, was the desired outcome and thus the primary driver of the small hydro development. Various forms of necessity proved to be a common secondary driver, fuelling the process in different ways (e.g. need to make efficient use of resources, need to address climate change, lack of alternative energy sources).

Figure 8 - Drivers of Community Small Hydro Development



The majority of interviewees saw continued community development as essential. In order to achieve this, finding the correct development tool(s) that made use of existing resources was critical. Suitable resources (e.g. water source, elevation, site availability, related energy infrastructure) were an obvious requirement for small hydro development and were readily available in each of the case study communities. As a result, available opportunity was both a prerequisite and a driver for community small hydro.

The relatively low opportunity cost[5] of small hydro development was indicated by interviewees to be a driving force, as a result of the history of small hydro development in the case study communities and the viability of alternate energy development options. Three of the four case studies (Almonte, Bracebridge, and Swanton) had a historical background in small hydro development, for both mechanical use and electrical power, "There are these small hydro developments available out there. So it seems like a logical choice" (Bracebridge Respondent). For these three communities there had been a history of investment in small hydro and thus most interviewees felt that upgrading existing facilities to maximize energy generation potential was preferable to developing alternative opportunities.

For these three communities, while prior small hydro experience was an important factor in the choice of small hydro, there were other considerations as well. Uncertainty combined with various issues associated with other alternative energy sources (e.g. lack of alternative resources, aesthetic concerns, cost, and efficiency) also contributed to why various interviewees claimed small hydro was chosen over the alternatives such as wind or solar. One interviewee observed that,

[5] Opportunity cost can be defined as the cost associated with other options

> "Wind remains far too controversial in terms of public acceptance. That statement is founded on the current battles...that are occurring in this state on wind project development. [The view on the ridgeline] remains too visual...for people to accept" (Swanton Respondent).

Comments pertaining to the use of *available* resources were often accompanied by comments that emphasized the *efficient* use of the same resources. Each of the case study communities demonstrated, either explicitly or implicitly, a need to make efficient use of available resources. This idea of efficiency flows directly from sustainability as an underlying driver of small hydro development. Making efficient use of available resources is an important step toward improving sustainability, even if "we didn't call it that 20, 30, 40 years ago, we thought it [just] made sense to make wise use of your resources" (Boulder Respondent).

Why develop small hydro? "We have the water...and we have this 30 foot head. So it's very practical to want to build this" (Almonte Respondent). Boulder in particular placed emphasis on the fact that not developing small hydro would have been a waste of a potential resource. Within the municipal water system the city had to incur the cost of installing something to reduce pipeline pressure. Traditionally pressure reducing valves are used, however in this case the in-line small hydros were used to both reduce pressure and generate energy.

As a driver, available economic opportunity drew by far the majority of comments from interviewees. Nearly every respondent stated that if the assessment of the resource (i.e. water source) indicated a new or enhanced revenue source for the community the project was of interest. "That was the main driving force for us...if we didn't increase our revenue then there was no sense in us [developing the local small hydro]" (Almonte

Respondent). This sentiment was echoed by many respondents in each of the case study communities.

Financial incentives were stressed by interviewees as an important part associated with the available economic opportunity. Many respondents felt that additional financial incentives provided by government for the development of small hydro was the reason their community had been able to develop this resource. These programs came in various forms, with the most popular being a power purchase agreement, in which a fixed rate was paid over a certain number of years for the power produced. Other incentives, such as feed-in tariffs, paid a higher rate for energy coming from a renewable resource. These government incentives have stemmed from wider political initiatives to address sustainability, security of energy supply, and climate change issues. Many interviewees indicated that, in addition to making development possible, government incentive programs designed to encourage renewable energy development made small hydro was more profitable as a form of 'green' power. As one interviewee noted, "green power is definitely what's being pushed in [Ontario]" (Almonte Respondent).

Boulder interviewees were the only ones who indicated a certain level of willingness to accept projects that had a longer than average payback period and less economic value, but which were considered environmentally responsible and enhanced local sustainability. However, while interviewees tended to focus on the financial gain, it is important to note the public nature of this economic benefit. Interviewees stressed the importance of the fact that small hydro revenues were being invested back into the community.

Community independence as a driving force was not as strongly emphasised, but its importance should not be discounted. The development of community small hydro afforded communities control over a local resource, resulting in an independent source of revenue and an enhanced sense of security not only in terms of income, but also in having some control over at least a portion of an essential community service. In Swanton this was noted as being particularly important, as the state of Vermont has the potential to lose two thirds of the state energy supply within the next six years as the current large scale generation contracts come up for renewal. "[The development of small hydro] was [about] having foresight to know that controlling your own destiny certainly makes more sense than putting all your eggs in someone else's basket" (Swanton Respondent). This perceived security and control resulted in those connected with the project (e.g. community leaders) having a heightened sense of community independence, a sense of decreased reliance on others (e.g. provincial/state financial aid), and increased local capacities.

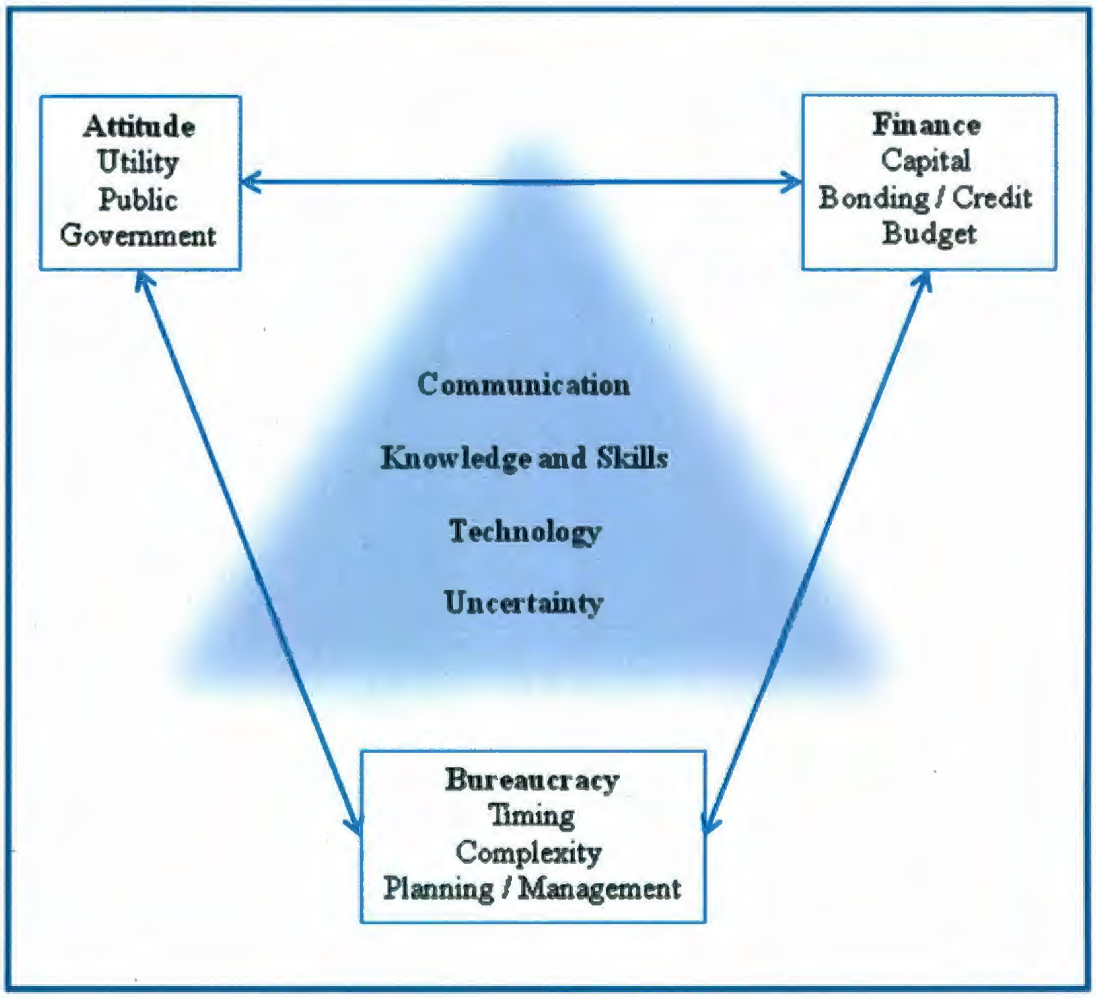
Certain interviewees felt that enhancing the overall sense of community independence put the community in a better position to enhance local sustainability. For example, Boulder has, "a stated goal, council goal of meeting the Kyoto Protocol by 2012. And I think our current council wants to see that...and actually go beyond Kyoto" (Boulder Respondent). This goal is a specifically stated community value. Small hydro has been one of the tools the city of Boulder has been able to use to work toward this goal. This link between community independence, community sustainability, and community vision was seen within the other case study communities, but to lesser and varying degrees.

As illustrated in Figure 8, prior to the development of small hydro, there was a particular individual or group of individuals that often played a critical role in initiating the project, as well as seeing it through the development phase and their subsequent management of the facility. Many interviewees were quick to identify such individuals or groups within their community. Many interviews contained quotes similar to, "I think the initial push came from a private citizen who was really interested in it..." (Boulder Respondent). The dashed line of this box (see Figure 8) is indicative of the fact that having a champion may not be necessary in each and every case. However, for the case study communities, interviewees stressed the importance of having champions who were motivated by one or more of the aforementioned drivers and who not only saw the opportunity presented by small hydro, but were willing to commit their time and energy to developing the idea.

5.2 Barriers to small hydro development

The barriers experienced by the case study communities varied widely, resulting in delays, increased financial cost, increased time commitment, and accumulated debt. Resulting impacts from barriers also included increased uncertainty and risk associated with the community small hydro development. The severity of the impacts also varied among the case study communities, ranging from stress and delays affecting project management to impacts on the entire community through increased energy rates. While the specific project development barriers were generally site and context specific, these barriers can be generalized into three groups relating to attitudes, finances, and bureaucracy. In addition there were several common factors (e.g. communication, technology, knowledge and skill levels, and uncertainty) which exacerbated these barriers. These are shown in the centre of Figure 9. While these additional factors can have a negative impact on project development and prove to be a barrier, as Section 5.3 indicates, some of these additional factors could shift from negative to positive, helping to overcome the barriers which they originally exacerbated.

Figure 9 - Barriers to Small Hydro Development



The attitude of major utilities towards community-owned power producers was one of the initial barriers to development mentioned by respondents. In three of the four case study communities respondents explicitly stated their perception of the major utility in their area as being hostile or uncooperative towards the development of the local small hydro projects. Such large utilities have centralized control over the grid, including the connection of small generation stations. As grid connection is what allows community small hydro to sell electricity, barriers to connection are significant to the development of community small hydro. "One of the barriers to putting in these [small hydro] plants was that the utilities did not want to do this. They thought that this was going to destroy the grid" (Boulder Respondent). Many respondents felt that utilities viewed the connection of small projects to the grid as an expensive inconvenience[6], therefore making the process difficult. Additional technical assessments for connection, long wait times, and higher than expected connection fees often resulted in long, costly, and unpredictable project delays, adding to project uncertainty. There were a small number of interviewees who indicated that their relationship with the large utility improved after the establishment of government policy developed to support small scale independent producers.

Government attitudes toward community small hydro were more complex as, in one respect, overall government attitudes in the case study locations appeared to be supportive of distributed generation, renewable energy, and community involvement. However, many interviewees did not see this upper level support translating into action on the part of lower level actors within government agencies, where most development delays and communication issues tended to occur. One interviewee observed that,

[6] This research did not include respondents from large utilities; therefore it was not possible to address this issue from the utility point of view (e.g. the impacts of connecting small generation stations on the energy grid).

> "There doesn't seem to be a connection between the prime minister or the premier standing up and saying 'we're going to support green power' and the government agencies following through on that. Some of them seem to be as difficult as they can possibly be" (Almonte Respondent).

Delays brought on by backlogs of applications, paper shuffling, and communication issues contributed to complications in the development process and were all cited by interviewees as common occurrences. However, there were some Bracebridge respondents who indicated that in their area the attitude of lower level government actors toward small projects was in the process of changing and relationships were improving, albeit slowly.

In terms of the barriers resulting from the attitudes of the general public, there were several factors at play. Respondents associated with project planning often felt that much of the public opposition to small hydro resulted from a combination of misperception and misinformation. However, there were other interviewees who felt that in some cases the project planners were misinformed, or dismissive, of the potential impacts of small hydro on the local environment.

Additionally, there was an element of NIMBYism (Not In My Backyard) as a result of the small hydro, "[Any time you propose change], doesn't matter if it's good change or bad change, [you are] going to have a NIMBY situation develop" (Bracebridge Respondent). NIMBY attitudes appeared to be exacerbated by a lack of communication, education, and information sharing. In the case of Bracebridge, there was a strong perception that the planning process had been handled poorly by project developers and decision makers, which eventually escalated into a conflict. A group of citizens living in the vicinity of the facility felt that the public had not been properly informed or consulted, and were concerned over the impact on the local environment. This group came together formally and organized public meetings, bringing the development of the small hydro project to attention to the local media, and attempting to stall or halt development.

In other case study communities it was suggested that the perceptions stakeholders had of each other both caused and exacerbated issues of communication and uncertainty. Dismissal of public concerns, perception of the opposition as "tree huggers", and the local utility board being viewed as an "old boys' network", were some examples of small issues brought up in various interviews which appear to have amplified the initial conflicts over small hydro development. Several respondents drew attention to the idea that earlier and increased communication between stakeholder groups might have pre-empted both conflict and the NIMBYism, or at least lessened their intensity.

Financial barriers included high capital costs, difficulties in obtaining bonding and credit, and problems accurately forecasting budgets. As with the previous barriers, these issues were affected by additional factors, such as initial lack of knowledge, uncertainty, and communication. Small hydro is capital intensive, something which was frequently mentioned in the interviews. Initial costs include facility research and design, construction, technology, and legal. An estimation of one million dollars per megawatt was given by a Bracebridge respondent as a general rule of thumb for this type of project. For project planners and consultants alike these high costs were an exceptionally challenging issue, most notably with regard to the cost of small hydro technology, "at this point being able to find affordable equipment for...small dams and damless diversions...I've worked really hard to find affordable equipment and it's still something I'm always on the lookout for" (Swanton Respondent). Raising the capital required for project development was a challenge for each community and respondents indicated that it would have been virtually impossible to proceed without at least a guaranteed power purchase agreement.

Two types of bonding were reported as another financial issue. Within the interviews bonding either referred to the ability of the community to obtain a secure loan for development, or to the assurance that should a contractor be unable to fulfill their commitments, the investor (i.e. the community) would be protected by a third party. Both types of bonding presented themselves as barriers. For example, in Almonte some interviewees indicated that for the board of directors, finding bonded contractors was an important criterion. However this proved to be difficult to find, with many contractors suggesting alternative protection to bonding, but few having bonding. This was frustrating as bonding was deemed necessary for the security of the town's investment, "we have to have bonding, because we haven't got the luxury of playing with the town's money" (Almonte Respondent).

Credit was another financial issue mentioned by respondents, including securing loans and having a separate, secure, line of credit for the project. As illustrated within the bonding example above, Almonte interviewees reported that their board of directors felt that it was inadvisable to use the credit of the community for the small hydro development. Instead, a separate line of credit was established for the Mississippi River Power Corporation, thereby limiting the financial liability of the community and decreasing community risk and the associated uncertainty.

Accurate budgeting was an additional concern, something each community struggled with to varying degrees. While initial budgets were established by project planners and contractors, interviewees indicated that these were never the final numbers. Escalating costs resulted from a variety of factors. For example, relating back to the aforementioned issues of attitude and conflict, the resulting delays brought about cost increases in terms of time and staff. In Swanton, project delays from waiting for bonding capability increased costs, resulting in project debt, as well as passing on costs to consumers in the form of energy rate increases. Cost increases also occurred as a result of increasing costs of materials and technology. Many interviewees indicated that changes to the budget added significantly to the costs of the projects and "these costs [can] become threatening...we're talking millions here and when you start doubling millions…" (Almonte Respondent). Escalating costs have the ability to curtail project design, something emphasized particularly by Almonte respondents. There is certainly potential that escalating costs have the potential to halt development should the costs increase to the point that the payback period is no longer acceptable.

'Bureaucracy' was most commonly noted by respondents as being the most difficult barrier to overcome. Interviewees highlighted problems associated with complex development processes, difficulties in obtaining permits, and with having approvals granted in a timely manner. The bureaucratic barrier can be easily linked to other barriers, most notably attitudes on the part of government and utilities and the issue of accurate budgeting. Bureaucratic issues were also complicated by issues of knowledge, uncertainty, and communication. Project delays resulted from many things such as the lengthy and complex development process, complications associated with obtaining permits, and continued requests for additional studies, all of which also added to the escalating costs of projects.

Interviewees for each case study community stressed that there was no comprehensive information package or guide for communities either contemplating or proceeding with small hydro development, creating a substantial upfront hurdle. One Swanton interviewee characterized this issue by comparing the process of small hydro development to the stream alteration process, "if I go to the State, to the website for example and I put in "stream alteration permit". I can download a stream alteration permit and it will tell me [what to] fill in; I want this, this, this and that information. But if I go to do small hydro there's no form. So...I don't know what they want." (Swanton Respondent).

This lack of clarity or logical process made it difficult for those interviewees involved in the development process to understand what types of permits were needed from which agencies. As a result, the process was seen by many interviewees as complex, time consuming, and confusing. A seeming lack of cooperation between government agencies (e.g. between the Ministry of Environment and Ministry of Natural Resources in Canada) and within government agencies (e.g. between management levels or geographical districts at one ministry) added to the confusion and frustration. The lack of clarity and guidance made hiring a consultant to help steer the project through the planning and development phase an essential project cost. Consultant costs rose with additional expenses such as the need for additional site studies, as well as with the various aforementioned delays, another factor impacting the initial budget.

Environmental concerns and associated permits were a large component of the bureaucratic barrier. Nearly every interviewee recognized the necessity of having an environmental impact assessment to preserve the environmental integrity of the site.

However, what was unacceptable was the seemingly unnecessary complexity of the process, "[the government] stands up in front of everybody and says we really want green power and go ahead. But then they give you 50 pages of things that you can't do" (Almonte Respondent).

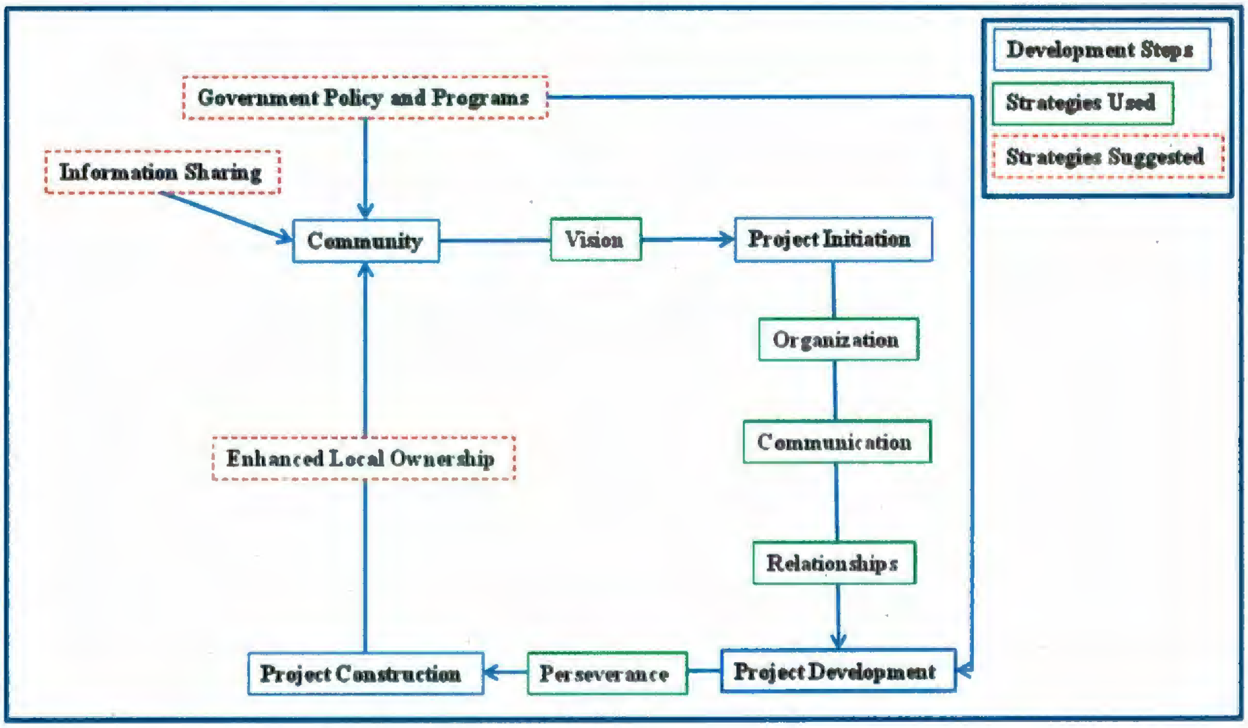
Additionally, there was a strong perception that small hydro, relative to other alternate energy sources, was unfairly treated. For example, the environmental impact assessment process considers small hydro (<20 MW) to be in the same category as large hydro projects (ranging up to multiple 1000 MW). Therefore, despite the differences between the two, large and small hydro projects are subject to the same requirements and assessments. This means that smaller community developments are placed under the same environmental study and financial obligations associated with larger projects, but without the technical expertise or the financial ability to cope. Upgrades to existing projects were subject to similar regulations as new projects, and exemption processes often proved to be just as time consuming as getting new projects approved.

The current development process also affords government agencies the ability to request additional environmental studies at any point, to delay approvals, or to revoke approvals, all of which can lengthen the development process. For example, a site with no major environmental issues, such as the most recent small hydro development in Almonte, took seven years to complete. Development time for the other projects studied ranged up to ten years. The perceived lack of cooperation between and within government agencies added to confusion and frustration. The bureaucratic barrier was universally cited and while it was clearly not insurmountable, interviewees singled it out as the most difficult barrier to address, as it is almost completely outside local control.

5.3 Addressing barriers

In addition to interview questions surrounding barriers to development, how to address barriers was a topic of considerable discussion during the interviews. Respondents offered their perspectives as to both how problematic these barriers were and how they were, or could be addressed (see Figure 10).

Figure 10 - Strategies for Addressing Barriers



Initiation of the development of the local small hydro project was a decision which often began with consideration of the goals of the community as perceived by project champion(s). Interviewees stated the importance of having a community vision, or set of community goals, in order to give decision makers a common understanding as to what direction the community would like to take. Having such a vision provided a strong foundation for action and was cited as important support for addressing barriers to individual projects. For example, Boulder's community vision included reducing community carbon emissions, of which developing small hydro was designed to be part. "People in Boulder generally believe in climate change and believe that local action can make a difference" (Boulder Respondent).

As the development of community small hydro is meant to be one part of an overarching community vision, it is important that the two are compatible. Therefore, community vision can help in the early stages to determine the viability of a project and secure community support. Some interviewees indicated that there will be cases where the vision of the community does not lend itself to the development of small hydro. In the face of conflicting interests or strong opposition it is important for stakeholders to remember that, despite strong arguments in favour or against the project, the decision should ultimately rest with the community. "At some point the best you can do, as a decision maker in the public entity, is put your best foot forward, put the best case before the citizens, and they have to make that decision. And you just have to let it go after that" (Vermont Respondent).

Interviewees also discussed strategies that were used to help projects move forward from initiation to development. The core of these strategies was good organization, communication, and relationship building. Respondents from each case study community felt that good organization was an essential strategy for overcoming barriers, particularly those associated with uncertainty within the development process. Organization incorporates the need for good planning and project management, specifically when it came to the identification and prioritization of issues that could potentially halt the project or render it uneconomic. Good planning played a critical role within the strategy of organization, including the need to plan for the unexpected, either within the development process or in respect to the facility design. Interviewees involved in planning indicated that unexpected delays should be anticipated from the onset, and accounted for in the estimated financial and time budget. Future changes critical to design elements, such as potential changes to stream flow as a result of climate change should also be considered.

Building positive relationships was arguably the most important tactic for dealing with barriers to small hydro development. This included building relationships with stakeholders in two categories: those who supported the project and could be encouraged to lobby on its behalf, and project consultants, engineers, and contractors. The first group includes stakeholders such as local government, First Nations groups, corporate partners, and local provincial or state representatives, as well as dynamic individuals, development agencies, local or special interest groups who could lobby on behalf of the project both in government and in the local community. Fostering relationships locally was indicated as being critical by many interviewees, particularly in small communities, "in their coffee shop discussions, running into people at the post office and the grocery store, at the bank..." allowing for information exchange and open communication (Swanton Respondent). When these relationships were developed in a positive fashion, they were reported as having provided important support and credibility to the case study projects.

The second group of relationships were necessary as a result of the complexity of the small hydro development process. It was often stated by interviewees that it would be impossible to get through the process without the guidance of a consulting or engineering firm and without a contractor. According to interviewees, when choosing both engineers and contractors the key factor was experience, "[permitting] is a hurdle but it's not an insurmountable one...if they hire the right people who have been through the process before" (Bracebridge Respondent).

In terms of experience, interviewees stressed that this should not only include experience with renewable energy, but a specific understanding of building small hydro projects and working with communities,

> "The challenge...is that if you don't have any concept [about] what you're going to do and how you're going to go about it you can be at the mercy of wolves. So you got to be careful and do your homework...partner with a firm that has a similar vision or plan that you have and that you can work with them, because it is critical to partner with someone that doesn't feel that you have unlimited resources…your relationship and who you're going to partner with is critical" (Swanton Respondent).

Effective communication was cited as a key strategy for both avoiding and addressing barriers, such as the aforementioned conflict experienced in Bracebridge. This included communication at every level from internal communication to communication with government agencies, utilities, and members of the public. To be considered effective it was said that communication needed to be open, transparent, and inclusive of all stakeholders. A variety of communication methods were cited by interviewees, the most popular being community meetings. These meetings were considered especially important to address NIMBYism and misperceptions of small hydro. Effective communication not only helped to address issues (e.g. misconceptions surrounding small hydro), but had the potential to help to avoid some issues all together, in particular where there were issues of misinformation that could significantly influence local perceptions and attitudes.

The above strategies were mentioned by many interviewees as methods of addressing barriers and working through the development process. However, regardless of the combination of the other strategies used, in order to get from the planning stage to the actual construction of the facility there was a continuous need for perseverance (see Figure 9). Perseverance was necessary to ensure the project went forward in spite of the barriers, and that it went forward with the community vision in mind. This was best summarized by one interviewee who said "whatever [the] steps were we had to do, we did them. We didn't balk at that" (Almonte Respondent).

Interviewees also suggested additional strategies that could have been used, as well as specific suggestions for how the bureaucratic barriers could be removed. To decrease local opposition, interviewees suggested improving the connection between the facility and the community by enhancing the feeling of local ownership of the small hydro. Feelings of ownership and attachment were thought by interviewees to decrease local opposition (e.g. NIMByism), by creating a sense of shared community responsibility and benefit associated with the project. The general idea was to make small hydro a valued part of the community as, "once it's there, people take it as being important and valued part of their community" (Bracebridge Respondent). For example, this could be achieved by transforming the facility site into a recreational area, thereby increasing its prominence within the community, as well as the overall sense of acceptance and ownership.

To facilitate future development of community small hydro, the creation of an online public forum was suggested, where representatives of communities with small hydro experience (e.g. project managers, board of directors, city councils, etc.) could share experiences with interested communities. This could include sharing information regarding the pre-qualifying of experienced consultants, engineers, and contractors and information surrounding equipment distributors and refurbishment. Ideas for design "extras" could also be included, such as Almonte's proposed green facility building. Almonte's proposed building design was intended to aesthetically suit the character of the town, as well as incorporating viewing windows into the facility, educational plaques, and a recreational park connecting to the town's existing river walkway. An online forum for sharing this type of information could help other communities facilitate the early planning stages and allow potential developers to get a realistic view of project development by learning from the experiences of others.

While beyond the control of respondents, changes in government policy and incentives were the focus of suggestions made by interviewees in order to help create a more user-friendly entry into the community small hydro market, as well as helping to diminish barriers to project development. The creation of incentive programs such as feed-in tariffs or power purchase agreements were highlighted, in order to provide long term security that decision makers can literally take to the bank when trying to secure financing for the project. Having a long term purchase agreement meant that projects were attractive to financiers and therefore able to go ahead, as highlighted by one interviewee who said, "we talked to different financial institutions and they all said: 'Hey, we'll give you the money because it's a very viable project'" (Almonte Respondent).

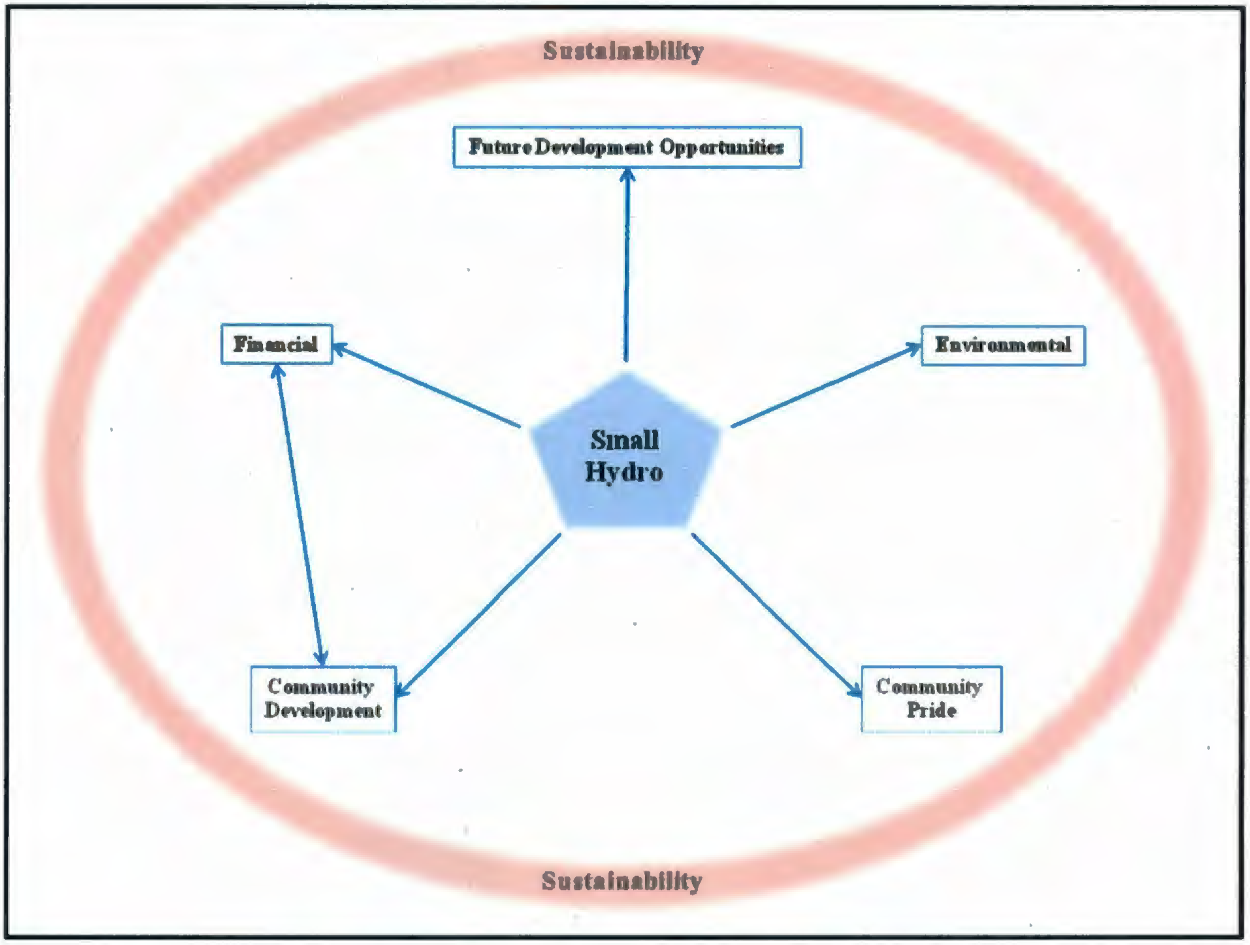
Interviewees also identified the need for government to review and streamline the small hydro development process. A comprehensive process could mean fewer delays and lower costs for communities. The most common interviewee suggestion was the creation of a government information package that includes a list of required permits and assigned contact information for government agencies. As one interviewee said, this would "give people the opportunity, give them clear guidelines, enable them to download a permit from the web and know what's expected of them...and have a timeline that's associated with it" (Swanton Respondent). A similar suggestion was the creation of a new government position to guide communities through the process and act as a go-between for the various government agencies.

Additional suggestions related to changes within government policy included requirements for government agencies to make decisions within specified time frames to minimize delays. In addition, respondents wanted assurance that once a decision was made it was final, as opposed to certain examples cited where approvals were revoked after they were granted. There were also several interviewees who suggested the creation of a class environmental impact assessment process for small hydro that would create an impact assessment system designed specifically to suit small hydro.

5.4 Benefits of community small hydro

It is important to emphasize that with *community* small hydro the benefits remain within the community and benefit community members. Data analysis revealed five general categories of benefits: financial, environmental, community development, community pride, and a general category of "other" potential benefits (see Figure 11). These benefit categories were not mutually exclusive and all relate to community sustainability. The particular connection between community development benefits and financial benefits is highlighted on the diagram, as this was emphasised during the interviews.

Figure 11 - Benefits of Community Small Hydro



The primary benefit of community small hydro was the financial benefits for the community. Both standard power purchase agreements and feed-in tariffs resulted in a long term, stable, and predictable source of revenue for each case study community. Most interviewees emphasized that the financial benefit was channelled into community initiatives such as infrastructure upgrades, lower taxes, lower energy and water rates, and funding for community recreation. It was important to these interviewees that the financial benefits remained local, "keeping...energy dollars in state and in our community" (Swanton Respondent), as opposed to channelling profits out of the community and even out of the state/province, as would typically be the case with large utilities or privately owned projects.

Community development was perceived by interviewees as the second most popular benefit of community small hydro. Small hydro projects can contribute to building social capital (e.g. networks, relationships, etc.), education of community members, service provision, tourism, and aesthetic improvements to the community. For example, in Almonte the small hydro plans included a cleanup of the park area surrounding the facility, as well as various other improvements to the area (e.g. creating an interpretive site, educational centre, and archaeological preservation) designed to promote the site as a unique educational and tourism draw.

Stakeholder enthusiasm and anticipation of local improvements played a large role in project development. This was exemplified by two Almonte respondents who noted that "it took seven years and I'm still enthusiastic about it because I know it's going to be good for the community" and that this most recent small hydro project was going to "put [them] on the map for being something different". While the majority of respondents felt the small hydro had a positive local impact, it should also be noted that in terms of community development, whether the changes were positive or negative was dependent on perception. There were some interviewees who felt that the benefits of having an unaltered river or waterfall outweighed the benefits of developing the small hydro project.

Analysis of interview data indicated various well-recognized links between enhanced community development and community financial benefits. Where the small hydro resulted in lower energy or water rates, certain interviewees felt that this was a factor that could attract people or businesses to the community. In the case where the small hydro design included green space, recreational trails, and educational components, interviewees felt that this attracted people to visit the facility, drawing them into the downtown area where there would likely be additional financial spinoffs for merchants and restaurants.

Employment was an important, but by no means a principal benefit of the project. Project construction provided some short-term employment opportunities, some of which were filled by community members and during operations each facility required a small number of specialized staff. Interviewees indicated there were some benefits to local construction and supply companies. Continued facility maintenance and upkeep was, in the case of one community, sub-contracted locally. However, none of the interviewees felt that employment was a primary benefit. As one Almonte interviewee indicated, "it's a backend benefit in terms of the dollars that it can put back into the community. It's a community project as opposed to being a private developer that comes in and does it" (Almonte Respondent). However, there was an indication of an overall multiplier effect, where employment-related benefits had additional spin offs within the community. For example, money going into the community from contractors purchasing supplies locally or from the wages of employment associated with small hydro contributed both income and additional employment benefits within the community.

Unlike financial contribution or employment, there were certain benefits that were not easily quantified, such as community pride, sense of community, and improved self-sufficiency. These benefits were often underemphasized or overlooked in favour of the more tangible benefits. While never indicated as primary benefits, benefits such as community pride was mentioned with such regularity by interviewees that they can still be considered important.

An enhanced sense of community, local ownership, responsibility, and self-sufficiency were all, to varying degrees, important benefits of community small hydro. Many interviewee comments regarding sense of community were centred on having a local office staffed by community residents, where it was possible for community members to interact with staff and have questions or concerns responded to by a fellow community member.

Local ownership and responsibility also resulted in the perception by some interviewees of increased local control over the power supply, as well as affording the community an enhanced position in their relationship with the large utilities. These factors contributed to an overall perception of improved self-sufficiency. While the small hydro projects did not create a wholly independent, self-sufficient community, many interviewees drew attention to the reduced dependency on the provincial/state or federal government for stimulating development.

Respondents, particularly from Boulder and Almonte, also drew attention to the pride that the community, or parts of the community, drew from the uniqueness of the local projects within the field of small hydro and in being able to demonstrate the facility to other communities and industry. There was however, discussion over how this aspect of local pride was often limited to those people who were directly involved in the projects, rather than the community as a whole.

An additional element of community pride came from having a relatively environmentally friendly source of power, complemented by a wide range of perceived environmental benefits. The most commonly acknowledged of these environmental benefits was the understanding of small hydro as a source of renewable power that provides power without emitting greenhouse gases. This benefit went beyond the local community, having broader implications in terms of reducing greenhouse gas emissions and addressing global climate change, "each kWh you generate [with hydro] means that you don't have to burn a pound of coal" (Boulder Respondent). Additionally, more site-specific environmental benefits were mentioned, such as the impact of the small hydro development on enhancing local green space.

However, while the environmental benefits were known, there was also acknowledgement of the business aspect of these benefits. With the exception of Boulder and, to a lesser extent Almonte, many interviewees viewed the environmental benefit from the perspective of having a marketable, and often saleable, "green" certification or credit. This benefit was as important financially as environmentally. Overall, the acknowledgement of environmental benefits appeared to lag in importance behind the financial or community development benefits.

The final benefit category discussed within the interviews was potential future development opportunities associated with community small hydro. These were the opportunities which were not currently being taken advantage of within the case study communities, but might be in the future. Respondents focused on potential benefits which were either primarily financial or community development oriented. One respondent suggested that the local energy rate system could be restructured in order to channel benefits to lower income families within the community or to encourage energy conservation. Additionally, the sale of renewable energy credits, or carbon offsets, from the generation of green power was suggested as another potential community revenue source, something which was already being taken advantage of by one community, and explored by two of the others.

In terms of additional community development opportunities, the establishment of commercial recreational industries (e.g. white-water kayaking) in conjunction with small hydro was highlighted as a complementary activity which could further enhance local tourism and employment. The concept of using community small hydro for local emergency preparedness (e.g. providing power to community centres in the event of a blackout) was mentioned by interviewees from three of the four case study communities. In this case, technical complications associated with small hydro meant that other energy sources, such as diesel generators, would likely be favoured for use in emergency situations. However, some case study small hydro facilities were built with black start capability, a type of emergency measure which allows the facility to restart following a power outage without the help of an additional energy source, helping to bring the energy grid back online.

In terms of the benefits of community small hydro, each case study community presented a different experience. However, a common thread between the four examples was that whatever the benefits were, they remained public, for the betterment of the community as a whole. Additionally, the ideas and suggestions from interviewees surrounding further growth and development were indicative of community benefits yet to come.

5.5 Sustainable development indicator data

The sustainable development indicator (SDI) data provide a snapshot of the case study communities at a single moment in time. Alongside the interview data, the SDI data analysed gave an indication as to the level of sustainable community development and the role the small hydro played in community sustainability for each of the case study communities. The indicators were identified for this research independent of the community. While each indicator was chosen for a specific purpose, because these specific indicator data were not collected by the communities, certain data were not available. The SDI data were collected from secondary sources, resulting in a single year's worth of data. As a result it was not possible to compare community progress over time. However, because the same SDIs were applied to each community, it was possible to compare the communities relative to each other in terms of sustainability and sustainable development. The SDI data have been divided into two categories: impact and community thought and action.

5.5.1 Impact SDIs

Percentage of renewable energy in total energy supply

Data for the *community* energy supply were not readily available, as this type of data are generally collected for service districts[7], provinces/states, or countries. As well, because the small hydro facilities are grid connected, it is impossible to determine the user. However, in order to demonstrate what percentage of each community's residential use was equivalent to the amount of power supplied by the local small hydro facility,

[7] Service districts can include one or more communities, in part or in whole.

Table 7 was created. The table includes the number of residential households in the community, the equivalent number of households to the amount of power produced by the local small hydro, and the resulting percentage.

Table 7- Percentage of Small Hydro in Local Energy System

Case Study	Number of Residential Households	Small Hydro Household Equivalent	Percentage Small Hydro
Almonte	4,581	800 (2.4MW) [8] 1,600 (5MW - upgrade) [9]	17% 35%
Boulder	39,596	7,127	18%
Bracebridge	8,568	3,700 (4.2MW)[10] 1,600 (2.3MW)[11]	43% 19%
Swanton	1,031 (village) 2,329 (town)	2,520	75%[12]

Sources: U.S. Census Bureau, 2000, A; U.S. Census Bureau, 2000, B; U.S. Census Bureau, 2000, C; Cowdry, 2001; Cumming Cockburn Limited, 2004; Statistics Canada, 2008, A; Statistics Canada, 2008, B; Mississippi River Power Corporation; Swanton Village Inc.

Greenhouse gas emissions from energy production (tonnes)

Unlike with large hydro, the lack of a reservoir means that generating energy from small hydro produces zero greenhouse gas emissions. It was not possible to calculate the greenhouse gas emissions resulting from construction, operation, and transmission as the data were not available. However, in comparison to the same amount of electricity being generated through a fossil fuel source such as coal, Boulder calculated that their small hydro facilities have displaced 213,333.27 tons of burning coal since the initial construction (Gesner, 2007). While such calculations were not done by the other case study communities, the US Environmental Protection Agency has an emissions calculator

[8] Current small hydro facility
[9] Upgraded facility under construction
[10] Total for all four small hydro facilities
[11] High Falls facility only
[12] In this case the percentage is for the district served by Swanton Village, including the Village, parts of the Town, and the town of Highgate.

which converts kWh into metric tonnes of carbon dioxide equivalents (U.S. Environmental Protection Agency, 2008). This calculator was used for each of the case studies to give an indication of the amount of carbon dioxide which would be emitted through the generation of the same amount of energy from fossil fuels (see Table 8). The total emissions of the four case studies can be compared to the annual emissions of 17,000 average automobiles (U.S. Environmental Protection Agency, 2008).

Table 8 - Small Hydro Carbon Dioxide Equivalent

Case Study	Year	kWh	CO^2 equivalent (metric ton)
Almonte	2007	8, 698, 447	6, 190
Boulder	2007	40, 966, 550	29, 151
Bracebridge	2009 (projected)	21, 811, 500	15, 521
Swanton	2006	58, 935, 955	41, 938

Source: U.S. Environmental Protection Agency, 2008

Annual water withdrawals from river for all activities

As discussed in Chapter 3, the intended purpose of this indicator was to illustrate the overall use of water in the rivers from all sectors, including small hydro. The amount withdrawn from the river would demonstrate changes in flow and available supply, indicating potential environmental strain from overuse, or the impact of one sector on another. While the annual water withdrawal was available for each of the small hydro facilities (see Table 9), additional water use data were not available. As a result, the small hydro water withdrawal data do not indicate a great deal on their own.

Table 9 - Small Hydro Water Withdrawals

Case Study	Maximum Small Hydro Withdrawal	Average River Flow
Almonte	28.5 CMS	35.2 CMS (2005)
Boulder	45 CFS 4 CFS 7 CFS 39 CFS 33 CFS 32 CFS 75 CFS (in stream) 32 CFS	Boulder Creek: 56.1 CFS (2007)
Bracebridge	27 CMS High Falls (G1: 11 + G2: 16) 10.5 CMS Bracebridge Falls 8.5 CMS Wilson's Falls NA Burk's Falls	23.1 CMS
Swanton	1,800 CFS	2,204 CFS (2007)

Sources: ACRES International, 2006; Environment Canada, 2006; Gesner, 2007; U.S. Geological Survey, 2008, A; U.S. Geological Survey, 2008, B; Almonte Respondent; Bracebridge Respondent; Boulder Respondent; Swanton Respondent; Swanton Village, A

What is important to take into account when considering water withdrawal for the purposes of small hydro is that facilities do not have to run at maximum capacity and have the capability to adjust to the changes in the river flow, meaning that at periods of lower flow, the small hydro facilities can intake less water or shut down all together. Also, once this volume of water is used to generate electricity it is returned unchanged to the river, resulting in a small section of the river with less water, or, in the case of Boulder's in-line system, no river impact at all.

Financial contribution to the community

Each case study community received a net economic benefit from the local small hydro facilities after operations and maintenance costs were taken into account (see Table 10). Case study communities used revenues in two different ways. The two Canadian case studies directly reinvested the revenue into the community through projects such as infrastructure upgrades. The two American case studies invested the money back into the utility, but in doing so reduced the cost of services to the local community through rate reductions.

There were limits to the data available, which made it difficult to compare the case study communities. It should be noted that there can also be a significant differences in revenue generated from year to year due to variations in water flow.

Table 10 - Small Hydro Financial Contribution

Case Study	Year	Revenue	Investment
Almonte	2006 2007	$615,087 $410,492	- $143,333 paid to Almonte - invested in upgrades to sewage treatment plant and infrastructure
Boulder	2006	$2,129,375 (USD)	- reinvested into utility operation and maintenance costs and debt service - offsets the cost of supplying drinking water / lowers rates
Bracebridge	2005/06 2008 2009	N.A. N.A $1,697,080 (projected)	$292,996 $325,000 $325,000 - Bracebridge receives 65% of the shareholder dividends - community investment: 25% to each of the following: public works, culture and recreation, unclassified, and general revenue – decrease taxes
Swanton	2006	$5,182,739 (USD)[13]	- revenue is reinvested into utility - Swanton customers have among the lowest average residential electricity bills for members of the Vermont Public Power Supply Authority[14]

Sources: N.A. (not available); Cowdry, 2001; Village of Swanton, 2006; Gesner, 2007; Litschko, 2007; Newton, 2008; Litschko, 2008; Kelly, 2008

[13] Revenue from electric sales to customers, street lights, and security lights. There is some variation in this because the utility buys some power in addition to what is produced.
[14] There is a question as to whether these low rates would encourage greater consumption; however there was no data available to answer this question.

5.5.2 Community thought and action SDIs

Integration of environmental considerations into initial project development (Y/N)

Each of the case study facilities were *required* to include environmental considerations in initial project development either through the Ontario Environmental Impact Assessment Guidelines (Almonte and Bracebridge) or through the Federal Energy Regulatory Commission (Boulder and Swanton). These environmental regulations were site specific and included such factors as consideration of sensitive or endangered species and the determination of a minimum allowable flow within the river. Because these actions were not voluntary on the part of the communities, it was difficult to consider this indicator as a measure of local environmental concern or sustainability.

Is there continued monitoring of environmental considerations (Y/N)?

Data for this indictor were taken from the stakeholder interviews and from interviews with facility operations managers. Three of the four case study communities have, or had previously, required environmental monitoring (Almonte, Bracebridge, and Swanton). Required monitoring is site specific. For example, in Almonte the focus was on aquatic life which could potentially be impacted by the facility. Monitoring included studies of fish population size and spawning areas. In Swanton, interviewees indicated that general environmental monitoring of river aquatic life had been required over a certain period of time, which had since passed and was no longer required. In the case of Boulder, environmental monitoring of the construction of the pipelines themselves was undertaken, but not for the in-line small hydro facilities specifically.

Within each of the case study communities there was constant monitoring of the water withdrawal from the in-stream facilities. Minimum stream flow requirements required the adjustment of water withdrawals to maintain a certain level of water within the stream (i.e. to ensure the use of the river is sustainable).

Similarly, the monitoring requirements were required either by provincial/state or federal agencies. Therefore this is not an illustration of local attitudes toward sustainability, but does indicate that overall the projects are considered sustainable according to current regulations.

Is there a sustainable community development plan (Y/N) and associated indicators (Y/N)?

Two communities had an official sustainable community development plan, one was working on a plan, and the other did not have one. However, in terms of a 'Yes' or 'No' answer as to whether or not communities had an official sustainable community plan it was difficult to give a clear answer.

Almonte and Boulder have official plans that state the incorporation of sustainability into the vision of the community (Town of Mississippi Mills, 2005; City of Boulder and Boulder County, 2008). For example Almonte's plan "presents a commitment to managed growth, *sustainable* development, sound resource management and environmental protection" (Town of Mississippi Mills, 2005) and in Boulder the continuously updated *"Boulder Valley Comprehensive Plan"* (BVCP) provides a general statement of the community's desires for future development and preservation of the Boulder Valley (City of Boulder and Boulder County, 2008). The principle of sustainability drives the overall framework of the BVCP. Both plans focus on incorporating various sectors into sustainable community development (e.g. environmental and economic), including objectives and goals. The major difference between the two was that while the Almonte plan had a schedule, no indicators were specified. Boulder did have some metrics for tracking progress, although further indicator development was seen as being needed (Boulder and Almonte Respondents).

The Town of Bracebridge has an Economic Development Strategic Plan designed to "strengthen economic growth in the community..." (Economic Growth Solutions Inc., 2002). There are some associated tracking measures with this plan (e.g. changes in population, permit statistics, etc.), however the majority of these were noted to be anecdotal and interviewees indicated that there was a need for improvement (Bracebridge Respondent). This plan is based on fostering economic growth; however some interviewees did note that the town was involved in a strategic planning process to develop a plan with a more sustainable focus (Bracebridge Respondent). This new plan includes substantial public consultation, in an attempt to determine an overall community vision, which not only incorporates sustainability, but reflects the wishes of the citizens (Bracebridge Respondent).

In addition to the town plan, Bracebridge is also part of the planning for the District of Muskoka. This plan demonstrates that at the district level there is a move to enhance sustainability, which will have an additional impact on sustainability within Bracebridge (Bracebridge Respondent). This plan is to be reviewed on a regular basis and modified as needed, but had no indicators. Additionally, a local grassroots group, Climate Action Muskoka, is in the process of establishing themselves and creating a sustainable vision for the area as well (Bracebridge Respondent).

Swanton did not have a sustainability plan. The Swanton Town and Village Municipal plan is designed to help guide decision makers to chart the future of community, with a vision of Swanton as a traditional New England settlement. The focus of this plan is on retaining character, economic development, and industrial growth (Swanton Planning Commission, 2005). There is no explicit mention of sustainability, nor are there indicators specified. Swanton is also a part of a larger regional plan, developed by the Northwest Regional Planning Commission, which provides a regional level guide for development aimed at preserving the "traditional rural character grounded in relatively self-sufficient, agrarian way of life with strong ties to land and community…" (Northwest Regional Planning Commission, 2007).

What this indicator demonstrates is that there are the beginnings of an overall move towards sustainable planning within the communities, with the exception of Swanton. Relative to the other case studies Boulder was further along with a well developed sustainability plan and the community's commitment to improving their sustainability indicators. Boulder was followed by Almonte and then Bracebridge. While Swanton's focus appeared to be purely economic, with no explicit mention of sustainability, there was however some implicit sustainability, such as a renewable energy development theme which is detailed below.

Is there a community energy plan (Y/N) and associated indicators (Y/N)?

Three of the four case study communities do not have a community energy plan; however that does not mean energy considerations are overlooked. Almonte has an energy component with a focus on conservation and decreasing light pollution within the larger community plan discussed above, although nothing was mentioned as to the generation aspect. Swanton also has an energy component within their community plan, discussing conservation and potential further development of renewable energy opportunities. There is also an energy component to the regional level plan which encompasses Swanton, although neither of the plans have any indicators. Bracebridge, however, has no energy component at the town level, although there is some mention of energy at the district level.

Boulder is the only case study with a separate, focused energy plan, the Climate Action Plan, in which "the vision of the Climate Action Plan is to guide Boulder towards a sustainable energy future that dramatically reduces greenhouse gas emissions from current levels, while meeting the needs of present and future generations" (City of Boulder, 2008, A). This plan includes a city carbon tax. There are also numerical indicators for tracking changes from year to year, although in some cases the metrics did not indicate positive change. For example, electricity consumption actually increased by 5.5% in 2006 (City of Boulder, 2008, A). These indicators are published in publically available reports.

5.5.3 SDI Summary

The use of SDIs was intended to provide quantitative data to help determine if the small hydro projects had an impact on the overall sustainability of the case study communities. There were some difficulties with the use of this method. Most notably it was not possible to determine the level of impact over time as these indicators showed only a snapshot of the communities at a particular moment, as opposed to changes over time. This was as a result of the dependence on the use of secondary data sources and the associated data availability. Another limitation was that the Y/N indicators required additional descriptive data for the Y/N to have any meaning. For example, while Almonte did not have a separate community energy plan, energy considerations were written into the main community plan.

With these limitations in mind, what did the SDI data indicate? Results indicated that the presence of the small hydro facilities had a positive impact on the sustainability of the case study communities through financial contributions and provision of clean energy in terms of percentage of renewable energy and the amount of greenhouse gas emissions being displaced. Thus in terms of impact on sustainability, there was an overall positive impact.

However, in terms of the use of small hydro as a tool that was *deliberately* designed to enhance sustainable community development the SDI data were inconclusive. For example, when considering the percentage of small hydro in the local energy system, small hydro carbon dioxide equivalent, and the financial contribution to the community, Swanton scored the highest. However, relative to the other three case study communities Swanton was the least developed in terms of community sustainability. Overall, for each of the case study communities there were few data that indicated that small hydro was purposefully being used as a tool for sustainability, but rather that increased sustainability came inadvertently as a result.

5.6 Emergent Themes

5.6.1 Politics and energy

In terms of the current global political agenda, the issue of climate change is quickly becoming critical. The political attention given to this issue ranges from dedication and commitment to good intentions and placation. While the development of community small hydro can be seen as compatible with a green energy approach, analysis of the interview data revealed an inconsistency between the development of political policy and the application.

Within Section 5.2 'bureaucracy' was highlighted as a common and troublesome barrier to community small hydro development. This resulted in comments similar to the following from an Almonte interviewee,

> "...the only drawback we've had is dealing with the provincial government and their organizations. They seem to take so long...you get on a tight schedule you have to wait so long for them to make a decision. And it's frustrating, very frustrating" (Almonte Respondent).

This frustration with the Ontario Government was particularly interesting because on one hand the government was seen by interviewees as responsible for these bureaucratic barriers, but on the other hand there was what appeared to be a very strong public commitment on the part of the Ontario government towards renewable energy,

> "Finding clean, affordable, and sustainable sources of electricity supply is a top priority of the Ontario government...By April 30, 2008, the program achieved 1,300 megawatts of contracted projects – surpassing the 10-year target of 1,000 MW in little more than a year" (Ontario Ministry of Energy and Infrastructure, 2009, B).

This inconsistency between policy and practice was seen in each of the case studies, where the political climate was supportive of renewable energy development, but practices within government agencies lagged behind. The amount of lag time between when policy was developed and when it was effectively implemented appeared to be proportional to the seriousness with which a particular government, or level of government, viewed climate change. This was well-illustrated by the Boulder case study, where the local level government passed Resolution 906 (the Kyoto Resolution), a commitment to addressing climate change and reducing community greenhouse gas emissions to 7% below 1990 levels by 2012 (City of Boulder, 2008, A). As a result, projects such as the small hydro developments were supported at the local level. Where the delays and frustrations appear to have occurred in this case was at the federal level (e.g. the American FERC process), where, at the time of development, commitment to addressing climate change was neither as specific or as driven as at the local level within the city of Boulder.

A similar situation was discussed by interviewees in Swanton, where in addition to gaining approvals from the FERC process, Vermont state agencies had to approve the project. This was seen by many interviewees as an arduous process for developers, as there was a perceived lack of guidance from state agencies for small hydro development and the resulting confusion increased wait times for permits. Those interviewees who displayed frustration with wait times for permits, were also frustrated with "two years of waiting for the legislature to create the necessary...laws on the books for the municipality to go out and bond the money..." (Swanton Respondent). These barriers demonstrated that while Vermont may have a longstanding reputation for being "innovative [and] green" (Swanton Respondent), many interviewees felt that the use of small hydro was not perceived as green by state agency representatives. "Many people, you know, call hydro green because it does not involve petroleum products. But there are impacts to fisheries and recreational use of the rivers...[and] water quality. And I think for some of the smaller projects you have perhaps a greater amount of impact per kW..." (Swanton Respondent).

Not all political issues occurred at the higher levels of government. For example, the Bracebridge case study illustrated the potential importance of local politics. As discussed in Section 5.2, the local conflict over the upgrades to the High Falls facility was as a result of what interviewees characterized as a combination of a poorly handed public participation process, NIMBYism, and misinformation. However, while Section 5.5.2 indicated that enhancing sustainability is beginning to be of interest at the local and district government level in Bracebridge, there was no indication within the interview data of involvement either the by town or the district in the conflict over the small hydro. This apparent lack of involvement on the part of local and district government occurred despite the fact that public concern rose to the level where a group of local people arranged their own meeting where "there was a good couple of hundred people...[and] subsequent meetings they attracted 50-60 people" (Bracebridge Respondent).

What was demonstrated by the case study communities was that local sustainable community development and use of tools such as community small hydro were at the mercy of government policy development, acceptance, and implementation at multiple levels. In terms of climate change and renewable energy, inconsistencies between government policy and action, and the resulting impact on development projects, is something that needs to be addressed. Only when this issue has been attended to will tools such as community small hydro be able to be used to their full potential.

5.6.2 Community planning and vision

For the communities of Boulder and Almonte, there was a more explicit link between the local small hydro and community sustainability. For the others, the link was incidental and in one case was unrecognized. As a result, the communities studied reflected a range of levels of sustainable development. This range can be thought of as a sustainability continuum. Interview responses showed a range of responses from deliberate sustainability plans encompassing social, economic, and environmental to no conscious plans for sustainability, but inadvertent improvements to local environmental and economic sustainability.

For example, from the interviews conducted in Swanton, the decision behind community small hydro development appeared to be primarily economic. And while a certain level of economic sustainability was recognized, there were also additional unrecognized enhancements to local sustainability by virtue of the nature of the technology itself and the use of a renewable resource. However, "the decisions to site hydro plants were made, by in large, in a time when it was either purely economics or simply a desire to have electricity" (Swanton Respondent), rather than a drive towards sustainability, something which with small hydro has only recently been linked.

At the other extreme on this sustainability continuum was Boulder, where the small hydro was consciously developed as one element within the overall community plan for efficiency and sustainability. With some of the in-line hydro developments the economic aspect was less of a consideration, with development going ahead on the basis of the principles of sustainability as defined by the City.

> "If you have water that's drinking water for the community...can you use it twice? Or more than twice? And...as it's coming down can you take power off of that? I think [small hydro development] was just a desire, a good western work ethic and efficiency ethic to make wise use of our resources" (Boulder Respondent).

Within the case study communities, there was a range of attitudes towards the use of small hydro as a sustainable development tool. Few interviewees had made the link prior to the small hydro development. While most made the link after the development (e.g. recognizing their inadvertent augmentation of local sustainability), there were still others for whom it remained unrecognized. Even within Boulder, local knowledge of the small hydro among the general public was thought to be limited, "There's probably a better awareness here but...If we asked everybody in this room how many people are aware of the hydro power that Boulder generates I'm not sure that they would know" (Boulder Respondent). What became clear was that the use of small hydro as a tool for sustainable community development depended largely on the values and direction of the community itself and the people involved in local government and local management of the small hydro. This raised questions of which factors contribute most in moving communities forward in terms of enhancing sustainability? Additionally, where sustainability is not recognized, how can the concept be brought to the forefront?

Community planning and vision, individuals or champions within the community, attitudes, knowledge mobilization, and risk tolerance were all factors that contributed to the communities approach to sustainability. These factors were identified in previous sections, including drivers (e.g. champions) and barriers (e.g. attitudes, knowledge, and risk). This drew attention to the ideas of planning and vision, how a community can position itself according to local values and means. The community plans overviewed in the SDI section demonstrated that the communities had established local visions, although it was apparent that those case studies that had advanced further in terms of sustainably (i.e. Boulder and Almonte) were those which had deliberately written sustainability into their community vision and were attempting to define what sustainability meant for the community. If and how a community uses small hydro as a tool, and if this tool is linked to sustainable community development, appears to be dependent on the underlying community vision.

5.6.3 Community energy and sense of community

One of the benefits of having a community-owned small hydro facility was the sense of community and community pride derived from the facility. Many interviewees expressed this in terms of individual pride, "I'm proud to come from a community that recognizes the value of [our small hydro]" (Almonte Respondent). Other interviewees saw it as a point of community pride, "among the people I [know within the community] there is a very deep understanding and appreciation of what [the small hydro facility] brings to us [as a community]" (Bracebridge Respondent).

While pride is intrinsic, often with no measurable financial benefit, enhanced community pride is positive for any community and its citizens.

> "I think there's an element of pride...in knowing that when you drive across the bridge you can point to that facility and say that's *our* local hydro plant...[even though] you may not know anything about hydro. I do believe that there is an element of pride in being able to say we're doing some of our own, we're producing some of our own [energy] needs here" (Swanton Respondent).

Community pride also factored into additional development and was a key factor which should not be overlooked, most notably because pride is an indication that there is local knowledge and understanding of community projects. The benefits of local knowledge, of having functional methods for transferring information (e.g. clear and open communication through community meetings), is thought to be another driving factor of development, which perpetuates itself in economic gains and further investment, enhanced learning capacity, and innovation (Goldstein, 2005).

It became clear from the analysis of the data that there was an issue surrounding knowledge mobilization within the communities. Many interviewees suspected that information and understanding surrounding the small hydro facilities, whether related to their construction or their operation, was limited. There were many potential explanations as to why there was greater understanding in some communities than others, but community size and cohesion were noted as particularly important characteristics. Some interviewees thought smaller, closer knit communities, as seen in three of the case studies, might find it easier to address building pride and sense of place due to the fact that "we all live here. We see one another on the street every day" (Almonte Respondent). Other interviewees pointed to the idea that the idea of acting as a community was important in the decision-making process, ensuring that citizens were informed and that the decisions made reflected their views, with the end result being a community that everyone had contributed to and of which people could be proud.

In addition to this sense of pride, was a feeling of responsibility to the community that had developed through these community energy projects, something which was not thought to exist in other, private or provincial/state energy projects. Interviewees who were project decision makers or board members spoke to the feeling of responsibility they had to ensure that these projects were developed in the best interests of their communities.

> "All the employees and board members are from here. And we have a definite interest in helping the community so…it's a good thing for the community and we're going to make sure that it's not just a hydro operation where we're just taking all the money. It goes back to the town. And we're going to...make the park better for the town." (Almonte Respondent).

The sense of ownership and accountability to the town illustrated by this quote, and by others like it, contributed to a sense of community.

Essentially, these community energy projects provided an opportunity for the communities to come together over a common project for the betterment of the community. In the long run it will be those people who had the closest contact with the small hydro that develop the most knowledge and pride. However there was a significant role for knowledge mobilization to ensure that some of that knowledge and pride did filter down to the general public. This type of knowledge mobilization depends heavily on the community structure and speaks to the importance of local communication, community involvement, and the means of building community cohesion. Depending on how small hydro is used, it could have varying impacts on the sense of community.

5.6.4 Energy and sustainability

During the interviews there were a series of questions surrounding the idea of a connection between people and their energy source. For example, do local people recognize the connection between the local small hydro facility and the energy they use every day? These questions were meant to explore the values and attitudes interviewees felt their community held toward energy and sustainability. This final theme, based on interviewee responses, explores the connection between people and energy.

Nearly every interviewee felt that there was a clear disconnect between people and their power source, meaning that when people turn on their lights or computer they give no thought as to the energy source, where it was produced or how it got to them, "all [people] know is that they turn the switch; if [the power] comes on that's good" (Bracebridge Respondent). Given that some of the energy was produced locally in a community-owned facility, this was surprising. Interviewees identified various possible reasons for this disconnect, focusing on the public's lack of information/education, lack of technical understanding, and attitudes toward sustainability.

Technically, each of these case study facilities feeds power onto a larger energy grid where it mixes with energy from other sources. This is necessary for the provision of a consistent, stable supply of electricity, but it does create the potential for a disconnect. As one interviewee mentioned "it's always been a sort of a mental conundrum for me that the power we produce just goes into 'the grid'. Which is like throwing it in a big swimming pool. And it gets co-mingled with everybody else's power..." (Almonte Respondent). This indicated that it is difficult for people to connect local energy generation to local energy use and local sustainability, when it was impossible to separate how much of the power used locally was in fact generated locally.

Another aspect of this issue was one of attitude towards sustainability and the idea that there were simply far too many things for the average person to consider and care about over the span of a day, that the source of energy they use was not one of them. “Right now, difficult economic times are going to divert attention away from that higher level thinking of sustainability and the focus will be directed to how am I gonna get through this week” (Swanton Respondent).

It is not only where the power comes from, but how it was delivered, which was something some interviewees felt the average person rarely considered. For example, the amount of technology required within Ontario to get “7,000 MW of power onto the grid seamlessly. So all the hospitals can run. So all the schools can run. So all the industry can run. So everyone can run their computer system. That’s an incredible task and it happens every day” (Almonte Respondent).

Due to changes in fuel sources and increased demand, several interviewees felt that people will become more interested in energy as, “energy is just going to go out of sight in price...Give it 5, 10 years and energy is going to change the way people operate period” (Bracebridge Respondent). While this may be both a logical and reasonable forecast, currently many respondents felt that the average citizen felt little connection to their energy source and were generally uninterested in making one.

CHAPTER 6

DISCUSSION AND CONCLUSIONS

6.1 Discussion

The purpose of this dissertation was to examine the use of small hydro as a tool for sustainable community development, as well as trying to understand why the use of this tool is not more widespread. Little research has been conducted on the links between energy, sustainability, and sustainable community development within the context of developed countries like Canada and the United States. This research was designed to examine these links through the use of Canadian and American case study communities, determining the impact of locally owned small hydro on these communities and providing their experiences as practical examples to other communities. Analysis of semi-structured stakeholder interviews and sustainable development indicator (SDI) data demonstrated that the case study communities had taken various approaches to the development of the local small hydro which resulted in diverse levels of sustainability. The case study communities exemplified that while the development of local small hydro was possible, and had been done successfully, the development process was complex and the barriers not insignificant.

Although broad and far reaching, the research findings and the resulting key themes discussed in Chapter 5 can be related to each other under the general concept of an energy disconnect. It is this concept that will frame the following discussion and conclusions. As discussed in Section 5.6.4, an energy disconnect refers to the idea that the connection between people and their energy source has been lost, and the connection between energy and sustainable community development has yet to be fully recognized or developed. Issues of missed opportunity, NIMBYism, absent or inappropriate policy, and conflict surrounding the development of community small hydro can be attributed in part to this disconnect. The following sections discuss this disconnect as it was demonstrated through the themes emerging from this research, as well as how this disconnect relates to the theory and literature framing this dissertation. Section 6.2 discusses the larger implications and interrelations of these research findings.

6.1.2 Identifying the energy disconnect

The energy disconnect has no single origin. A multifaceted concept, it is illustrated within this research through findings from the related fields of politics and policy, as well as within the broader scope of values and perceptions. Interview and SDI data clearly indicate that each case study community benefited from involvement in energy generation. As discussed in Chapter 5, community-owned small hydro has the potential to generate significant local benefits, not simply in terms of economics, but enhancements to social and environmental factors as well. These benefits extend to the provincial/state level, as well as to the national and even global level, in terms of reducing community reliance on development support from upper levels of government, increasing energy security through the distribution of energy resources, and helping to address climate change by increasing the percentage of energy supplied from renewable sources. Available opportunities from the wide range of benefits and the ability for communities to expand and enhance the role small hydro plays within the community demonstrate that small hydro has the potential to be used as a tool for sustainable community development.

Also identified was that, as a result of the energy disconnect, when it comes to the development of community small hydro as a sustainable community development tool there may be a significant amount of lost opportunity.

With respect to incentives and policy surrounding community small hydro, the bureaucratic barriers to development identified in the literature and from the interviews prompt the question of what motivates how government approaches the development of community energy projects? Political and public administration complexities, much of which was beyond the scope of this research, could offer explanations as to why the use of small hydro as a sustainable development tool by communities is not more widespread, why renewable energy policies have either not been re-assessed or not developed in the first place, and why such bureaucratic barriers remain so substantive. There are many examples of organized groups of private independent power producers within Canada and the USA, such as the Association of Power Producers of Ontario, the Independent Power Producers Association of British Columbia, and the Colorado Independent Energy Association. Some of these groups are associated with communities or community independent power producers, most are not. The fact that there are so many of such groups indicates that the independent development of small scale renewable energy resources can represent a shrewd business opportunity. While private developers are traditionally seen as being efficient and profit maximizing, community energy, on the other hand, can be considered to focus on community development, including social and environmental welfare, in addition to efficiency or profit.

Inappropriate or absent policy indicates a gap, or disconnect, between government thinking and the potential implications and benefits of community small hydro in terms of development and sustainability, not just for the community, but for the province/state and federal government as well. From this research it was not possible to ascertain where this disconnect originated. However, the disconnect was clear in many cases where interviewees noted that the existing policies and incentives were either implemented inefficiently or were inappropriate (e.g. subjecting small hydro to the same environmental impact assessment process requirements as large hydro).

This lack of recognition of the links between energy and sustainability was not only evident at the upper levels of government (e.g. policy makers), but at the community level, between project proponents, the community at large, the utility, and government agencies. Difficulties with community small hydro development, including the barriers concerning attitudes and the bureaucratic process (see Section 5.2) indicate that certain potential drawbacks of community small hydro development (e.g. increased work load for utility and government staff, technical complexities of adding multiple new sources of energy, and changes to the local environment) were at the forefront of the barriers to development. In this case the disconnect is exemplified by the lack of consideration or dismissal of the potential benefits from a sustainability point of view, as opposed to a more conventional development point of view (i.e. focus on economic and anthropogenic aspects). The conclusion that can be drawn from this is that there may be a need to re-assess the community small hydro development process. In particular, the needs of *all* major stakeholders need to be considered, including the utility, government agencies, and the community. In doing so it may be possible to negate or eliminate some of the aforementioned potential drawbacks of community small hydro development.

The majority of interviewees indicated that the typical North American consumer is characterized by the assumption that the supply of energy is and should be unrestricted, with little consideration of its source, transmission, or impacts. Access to energy is taken for granted. This represents a fundamental disconnect between the average person and the energy they use. The apparent exception to this was if the impact of energy generation was directly felt or seen by the consumer locally. In cases such as this, there appeared to be a gap between NIMBYism, or a knee-jerk reaction to change as opposed to consideration of the positives and negatives of a potential project, and valid environmental concerns. The disparity between NIMBYism and informed concern resulting in the denial of sustainable project development (e.g. community-owned energy generation) is indicative of another aspect of the disconnect between people and their understanding of energy use, energy generation, and sustainability.

Every type of energy generation has an environmental impact, some more obvious than others. The current demand for and consumption of energy indicates that people are generally willing to accept these impacts. For the most part, environmental concerns over power generation do not appear to be foremost in the minds of the general public unless the issue is controversial (e.g. nuclear power) or particular segments of the public are affected directly (e.g. the generation station is sited locally). When the impact becomes local, environmental concerns often become the reason that technology such as local small hydro is perceived as unacceptable, while a multi-thousand megawatt thermal plant or hydro dam is acceptable when it is outside the local field of view.

The overall implications of the energy disconnect on the bigger picture of sustainable development and energy in the North American context are discussed further in Section 6.2.1.

6.1.3 The energy disconnect and Complex Systems Theory

As discussed in Chapter 3, Complex Systems Theory is a non-linear approach used to identify, describe, and analyze systems and sub-systems, and was used to conceptually frame this dissertation. Complex Systems Theory lends itself well to identifying and analyzing topics within the field of global sustainability, as the global sustainability system is complex and ever-changing, made up of many interconnected sub-systems. The links between energy, sustainability, and sustainable community development, as discussed in Chapter 2, are representative of the complexity and interrelatedness of the sub-systems within global sustainability. While the focus of this research was on one sub-system (i.e. the development and application of community small hydro) the strength of the links between this sub-system and the system as a whole required a conceptual theory able to account for such dynamic and changing relationships.

As in the global sustainability system, sustainable community development is not linear; there is not one approach to sustainable development that suits each and every community, nor are there a specific group of factors or characteristics that will automatically lead to enhanced sustainability. Because sustainability has no start or end point, it can be seen as a continuum along which communities move toward some ever-changing point of equilibrium. There are infinite ways in which communities can approach sustainability. Given the various possible approaches, combined with the uniqueness of each community and community context, sustainable community development therefore becomes a process of identifying different elements and recognizing how these pieces can work together to enhance community sustainability.

While only part of the global system, a community is also made up of many sub-systems. As a result, approaching sustainable community development requires careful consideration of a complex set of factors and how these factors interact. The case study approach allowed for the identification and analysis of the small hydro sub-system and how it fit into each of the four different communities. The complexity of this sub-system was clearly illustrated by the community small hydro case studies, as each community was different in its use of small hydro and approach to sustainability.

While system complexity made examining a single aspect of sustainable community development challenging from a research perspective, it did illustrate the rationale for approaching such research from within the context of Complex Systems Theory. As a result of the many linkages and complexities, it is not possible to separate one sub-system from the whole. What made the energy sub-system difficult to analyze in terms of its links with sustainable community development was that many of these linkages remained unrecognized by interviewees, again highlighting the energy disconnect. For example, if small hydro is not identified as a tool that can be used to educate the community on energy generation and conservation, this potential use is lost. If the linkages between energy and sustainable community development are unrecognized by those with decision making power within the system it seems unlikely that these linkages will be properly developed or managed.

6.1.4 The energy disconnect and the literature

There is a significant body of literature that identifies and discusses the links between community small hydro, community development, and community sustainability. However, much of this existing research was undertaken within the context of off-grid communities in developing countries. The research carried out for this dissertation differed from this previous work by attempting to identify and examine these links in grid-connected communities within the developed context of Canada and the United States.

In terms of the drivers, barriers, and benefits associated with community small hydro, many conclusions drawn from this research were similar to those found in the literature. However, despite an overall agreement between the data and the literature for the majority of factors, there was one area where this was not the case. Enhanced ties between the communities and their local environment resulting from the development of local small hydro were commonly cited within the literature (The Expert Group on Renewable Energy, 2005). This enhanced tie can be linked to furthering community sustainability. However, the majority of interviewees from the case study communities did not believe that the development of local small hydro fostered any significant improvement to environmental ethics or environmental stewardship.

With the exception of Boulder respondents, concern for the environment or sustainability was not perceived as the primary driver or benefit of the project by the majority of the interviewees. Consideration of environmental benefits was cited by many as a secondary driver to economic and community development, while a minority of others considered the environmental aspect to be inconsequential. Recognition of environmental benefits also varied, ranging from being considered equal to the economic benefits to being unrecognised and purely incidental.

There are various possible explanations for this difference between the literature and the data, including the influence of the various community characteristics discussed in Chapter 4. However, the basics of this difference can also be demonstrated through the energy disconnect. In many examples described in the literature, a connection exists between the community small hydro development and community sustainability because in these settings energy security was an identified concern and the connections were intentional, explicit, and central to project development from the beginning. This type of explicit connection was only made in Boulder, where there was a strong link between the small hydro development and overall community sustainability. However, in the majority of the case study communities, while small hydro projects were linked with overall sustainability of the community, this was only recognized by some of the interviewees and was often only acknowledged post-development. This draws attention to the fact that the connection between the project, the local environment, and local sustainability is not always immediately obvious.

6.2 Conclusions

From the above discussion of the disconnect between energy and sustainable community development it is possible to go beyond the immediate implications, to discuss the bigger picture, both for community small hydro development and for sustainable community development.

Interviewees indicated that community small hydro development processes, including government policy and incentive programs, were in need of revision. In particular, policy that prohibits distributed generation and the establishment of independent power producers should be reviewed for various reasons. First among these reasons is the potential benefit to communities, should they be allowed to develop local renewable energy resources such as small hydro. Community small hydro and distributed generation is not necessarily in conflict with existing centralized energy plans. A distributed energy system can incorporate small scale, independently owned generation facilities together with existing large scale energy generation facilities, which generally remain under control of a centralized utility.

Interviewees indicated the importance of having comprehensive policies and incentives specific to community small hydro. This is necessary to account for the uniqueness of small hydro technology and the differences in developer needs, as communities require a different approach than a private company. An example of this would be recognizing the differences between small and large hydro in environmental impact assessment requirements.

There are significant, legitimate concerns regarding river rights and potential environmental impacts, many of which were raised by interviewees (e.g. fish, aesthetics, river flow changes). This draws attention to the fact that development of small hydro should not be permitted unless certain requirements are first met. For example, small hydro development should only be allowed to proceed after the completion of an appropriately designed stringent assessment of the potential site, all potential impacts, and design and technology choice. Such small hydro specific considerations would be meant to ensure that the local environmental impact remains as low as possible. While not all sites should be developed, poor past decisions and negative examples should not be reason enough to forestall all potential future development. In cases where development is historic, it may be possible to re-develop and augment old facilities, making them more efficient, more environmentally friendly, and therefore making the most efficient use of an existing resource. Policy and incentives specific to community small hydro will require existing programs to be re-assessed, and programs to be developed where there currently are none.

When amending or developing policies and incentives, the relationship between energy security and independent energy generation should be considered. Community ownership has an increased security value that private independent power producers do not. A community cannot move locations or simply close up shop. People live there, they work there, they have a long term commitment to being in that location, and it is in their best interests, and the best interests of the community, to ensure the long-term viability of any community project. Private companies have the ability to change production rates, relocate, or shut down all together in the interests of maximizing profit. While a community may be less efficient and experienced, a private firm will operate on the basis of profits and can leave when there are none. Energy conservation and strategies to reduce demand are counterintuitive to the philosophies of private firms where increased sales can be equated with increased profit. However, sustainable community development allows for the acknowledgement of the importance of the social and environmental benefits of decreasing demand.

Following on this idea of conservation and decreasing demand, analysis of data illustrated examples of the more esoteric, values-oriented aspects of North American society, seen particularly in the presence of NIMBYism. Many examples of the knee-jerk reactions to change associated with small hydro development that were found in the interviews were also seen in literature surrounding renewable energy technologies. The presence of this type of NIMBYism combined with the energy disconnect is indicative of current societal values surrounding overconsumption and sustainability: little change in patterns of consumption and resistance to making sustainable changes (e.g. building local, renewable, small scale energy generation as opposed to large scale fossil fuel energy generation). It is these values that are at conflict with sustainable community development and sustainability as whole.

In terms of the overall connection between sustainability and access to energy within North America, what was once considered a privilege (e.g. access to cheap energy) is now considered a right. This attitude does not lend itself to conservation or sustainability. As well, this attitude illustrates that the recognition of linkages between energy and sustainable community development has been lost sometime between the historic small hydro developments for basic rural electrification and the present day. This differs sharply from the developing world context where community small hydro is often the sole source of energy for a community, directly enhancing quality of life and providing development opportunities which would otherwise not have been available. These factors make the energy connection a great deal more apparent as it allows for those communities to develop with self-sufficiency and preservation of resources in mind. The question then becomes how to re-establish this link within North America?

In order to work past issues such as NIMBYism there is a need to work closely with all community stakeholders. Initially this can work to establish a connection between local demand and the need for energy generation, but will also help ensure that projects are developed with the minimal local conflict and impact possible. Part of this, which is especially important in the case of community-owned projects, includes a transparent process where people are well-informed and included. This relates to the larger discussion on North American values surrounding energy and sustainable community development by involving community members in decisions as to what tools (e.g. small hydro) should be used locally for sustainable community development. In developing a connection between people and their community energy source there is potential to enhance the local connection with energy to include factors such as demand management and conservation, helping to shift our current set of values to be more focused on sustainability.

There is significant knowledge of the environmental and sustainability issues facing the world. Climate change is happening. The ecological capacity of our earth cannot continue to support our growing demands; energy and otherwise. Yet, despite this, people, communities, provinces/states, and nations alike continue to ignore the connection between this situation and their actions. The energy disconnect is one small portion of this overall disconnect between people's lives and actions and the world around them. Some interviewees drew attention to the idea that these larger concerns are simply not on the radar of the average person, not something that they connect with their lives. This again emphasizes the need to work to change values and perceptions, in order to help people acknowledge the connection between environment, society, and economy, and that one aspect should not be blindly sacrificed "for the sake of" the other, given their interconnectedness. Serious consideration should be given to all trade-offs, not only economic, but social and environmental as well.

From a broader perspective beyond that of the community, sustainable development may require a new approach; not only in terms of new policies, but also new institutions. For the large utilities that dominate the energy sector, political goals of increased energy security, enhanced use of renewable technologies, and energy conservation are indicative of a need to both fully understand these new goals and to shift to new values. However, given that the current values system of over-consumption was the foundation for these large utilities, it is questionable how these institutions would approach a change in values. Any shift surrounding decreased consumption would restructure the supply and demand of energy, the product on which large utilities rely. In order to address the energy disconnect, a shift in the development of energy and the energy institutions are required, incorporating the generation of renewable energy on a community scale. In creating new energy institutions, it may be possible to re-establish the link between people, their energy sources, and their community.

6.2.3 Future research

In order to further the development of community small hydro within Canada, more research is needed to not only prove the benefits of community involvement, but to further identify and solve the critical barriers within the development process. Comparative research of the benefits of community versus private small hydro is necessary in order to illustrate the local development potential associated with community owned projects. A comprehensive study of small hydro in Canada would provide data which are currently unavailable, such as small hydro growth rate statistics, including the number of community versus private small hydro developments.

In terms of addressing the development process, there may be value in studying those communities which were interested in small hydro but either chose not proceed or were not successful in the development process. Such examples have significant potential to identify critical barriers with the development process.

This research also identified a need for an examination of what factors need to be in place to move communities forward in terms of enhancing sustainability (see Chapter 4, Section 4.5). It would be helpful to know which community characteristics contributed to an enhanced level of relative sustainability. This could be useful both in regard to the use of small hydro as a tool, but also in terms of general community vision and planning. Additionally, identification of such characteristics could lead toward a more comprehensive examination of the disconnect between consumers and their energy source. There are integral links between energy and sustainability which need to be re-established. Improvements to sustainability will require a shift in those values commonly held by North Americans. It is therefore important to determine the underlying causes of this disconnect in the interests of correcting it and helping to create a culture of conservation and sustainability.

6.2.4 Forward thoughts

Community small hydro policy development remains at the mercy of political understanding, acceptance, and application. Many issues discussed within this dissertation can be linked to power: how power is acquired, who has the power, and who is sharing power; both in terms of energy and politics. It is here that power is linked with opportunity. In those communities where there is potential for small hydro development there may be a lack of awareness of the available opportunities or the inability to develop these opportunities. In either case the lack of opportunity renders communities powerless to move forward with small hydro development.

Rural communities currently face many challenges including economic and physical vulnerability, out migration, job loss, and culture loss. In order to address these issues, build resiliency, and enhance independence, communities need tools. More importantly, communities need tools that not only help local development, but also help the community make connections with the world around them, recognizing the local impact on global issues such as climate change. And most importantly communities need the power and opportunity to identify and use such locally available tools as small hydro.

The recent global economic downturn had the potential to shift the focus away from sustainability and energy at a time when it was truly needed. However, political recognition of the potential of the energy sector to address the economic crisis is becoming apparent. For example, new policy, incentives, and support are being established in some provinces within Canada, such as Ontario's new proposed energy policy (Ontario Ministry of Energy and Infrastructure, 2009, A). Examples such as this demonstrate that this sector is now being recognized as an integral part of both economic and sustainable development.

Nevertheless, the need for a shift in attitude and values remains, as well as changes to traditional approaches to both energy generation and sustainable community development. Across Canada and the United States a combination of growing political interest and aging energy infrastructure means that the timing is right to make infrastructure upgrades and policy changes that can incorporate small scale generation potential such as community small hydro.

Apart from the technical strength of small hydro as a renewable technology, the strongest argument in favour of community small hydro is that a fundamental community benefit can be easily understood: making money. This foundation, combined with education on how to build on this foundation, can make moving forward easy. By recognizing and understanding the links between small hydro and sustainable community development, a community can build on the potential of the local small hydro, addressing not only economic, but also social and environmental issues within the community. In this way community small hydro can help address the energy disconnect.

Currently within Canada there are many communities with both the available small hydro resources and the need for sustainable community development opportunities. Within the field of small hydro the distribution of power is uneven, particularly in terms of communication and information, absent or lacking policy, and available financial incentives. As a result of this uneven distribution of power, the opportunity presented by community small hydro is being missed while privately owned small hydro development continues to increase, channelling potentially public benefits into private pockets and bypassing potential local social and environmental enhancements.

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