



# Heating Our Communities

A module of the  
**Renewable Energy Guide for  
Local Governments in British Columbia**

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Community Energy Association – the ‘first step’ for local government leaders  
addressing energy sustainability and climate change



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# Heating Our Communities

## Renewable Energy Guide for Local Governments in British Columbia

### About the Community Energy Association

The Community Energy Association is a charitable organization that assists local governments throughout BC to promote energy efficiency and renewable energy through community energy planning and project implementation. For information and many more local government resources, please visit: [www.communityenergy.bc.ca](http://www.communityenergy.bc.ca).

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## Acronyms Used in this Guide

BC	British Columbia
BCSEA	BC Sustainable Energy Association
CBIP	Commercial Building Incentive Program
CEA	Community Energy Association
COP	coefficient of performance
FCM	Federation of Canadian Municipalities
GHG	greenhouse gas
GJ	gigajoule
GSHP	ground-source heat pump
HRV	heat recovery ventilator
HVAC	heating, ventilation and air conditioning
km	kilometre
kW	kilowatt
kWh	kilowatt hour
LFG	landfill gas
MW	megawatt
MSW	municipal solid waste
NRCan	Natural Resources Canada
psi	pounds per square inch
REDI	Renewable Energy Deployment Initiative

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## Summary

Local governments can bring substantial benefits to their communities by encouraging and supporting the development of renewable energy for heating. Primary benefits include:

- significant greenhouse gas reductions. Space and water heating are major contributors to the emissions that cause climate change.
- local economic development through renewable energy job creation, infrastructure development and keeping energy dollars circulating locally
- potential air quality benefits
- increased local energy security.

### Renewable heating systems: from a single building to a whole neighbourhood

Renewable heating can be used at a small scale to heat a single building, or at a large scale, e.g. in a district heating system, for an entire neighbourhood. District heating systems distribute heat from a central source to a number of buildings in a flexible, efficient and cost-effective way, and are readily adaptable to a variety of renewable energy sources.

### Renewable heat sources in British Columbia

There are many potential sources of renewable heat in British Columbia.

Biomass and biogas	Heat pumps	Heat recovery	Solar
Combustion of wood-waste, landfill gas & municipal waste	Use small amount of electricity to extract heat from air, ground or water	Uses heat that would otherwise be lost in exhaust air or waste-water	Solar air and water heating and building design capturing the sun's warmth
Economic development opportunities	Can provide cooling as well as heating	Many different sources of waste heat	Available throughout BC
New technologies minimize air pollution	Applicable at a small or large scale	Excellent opportunities in recreation facilities	Applicable at a small or large scale

The Community Energy Association has identified four renewable heat sources likely to be of interest to local governments in the province, all of which use established and proven technologies.

### Supporting the development of renewable heat

Local governments can promote renewable heat in their communities by:

- establishing a district heating system, potentially through a municipal owned utility
- providing incentives for developers through the planning and permitting system
- using renewable heating within municipal buildings.

Energy Source	Suitability for District Heating Systems	Suitability for Individual Heating Systems
Ground-source heat pump	✓✓	✓✓✓
Air-source heat pump	✓	✓✓✓
Biomass	✓✓✓	✓✓✓
Biogas	✓✓✓	✓
Waste heat recovery	✓✓✓	✓✓✓
Solar water heat	✓✓	✓✓✓
Solar air heat collector	✓	✓✓✓

## Introduction

*Heating Our Communities* is one module of the Community Energy Association's *Renewable Energy Guide for Local Governments in British Columbia*. Other modules of this guide include *Governance, Utilities & Financing* and *Electricity*.

*Heating Our Communities* has been written for local government elected officials and staff interested in encouraging the use of renewable sources of energy for heating in communities. The information applies to both communities at-large and to local government operations.

Local governments can bring substantial benefits to their communities by encouraging and supporting the development of renewable energy for heating. Primary benefits include:

- significant greenhouse gas reductions (action on climate change),
- potential air quality benefits,
- local economic development through renewable energy job creation, infrastructure development and keeping energy dollars circulating locally, and
- increased local energy security.

Heating for hot water, and for the space heating of residential, institutional and commercial buildings, is a major energy consumer and source of carbon emissions in BC. Local governments have a critical role to play to help reduce the energy required for heating our communities by promoting energy efficiency. In addition, local governments are in a key position to facilitate the necessary shift from fossil fuels to the use of renewable sources for heating. Given global, national, provincial and community will towards action on climate change, local governments now have a pivotal role to take action on how their communities are heated.

The focus of this module is space and water heating for residential, commercial and institutional buildings in BC communities. Other uses of heat, which are not the focus of this module, include industrial processes, electricity generation and vehicle transportation.

*Heating Our Communities* aims to provide the reader with a sufficiently comprehensive survey of heating system considerations and fuel sources so that local government staff and officials may be able to enter into a discussion of the relevance of each aspect to their particular community in an informed way. Good heat system design and implementation will only occur after extensive planning has been undertaken. This module is the first step to understanding and crafting that process.

The module begins with a discussion of district heating systems, since these can be fuelled by all the renewable energy sources introduced in this guide. Furthermore, energy sources for properly planned district heating systems can be more easily adapted or changed over time, than individual heating systems, as new energy sources become available.

Chapters 2–5 introduce the four sources of renewable heat that the Community Energy Association has identified as most likely to be of significant interest to communities across the province. These are:

- Biomass and biogas
- Ground-, air- and water-source energy
- Heat recovery, and
- Solar energy.

Chapter 6 briefly introduces mechanisms and starting steps by which local governments can encourage the use of renewable energy for heating within their communities. For more detailed information on such mechanisms, please see *Renewable Energy Guide* Module: *Governance, Utilities & Financing*.

*Heating Our Communities* is not prescriptive — it will *not* provide comprehensive instructions as to whether, for example, a district heating system is appropriate for a community nor which technology and fuel source is best suited to a particular region's needs.

More and more communities are discovering the benefits of using renewable energy. Will your community be next?

# 1 District Heating

## 1.1 Introduction

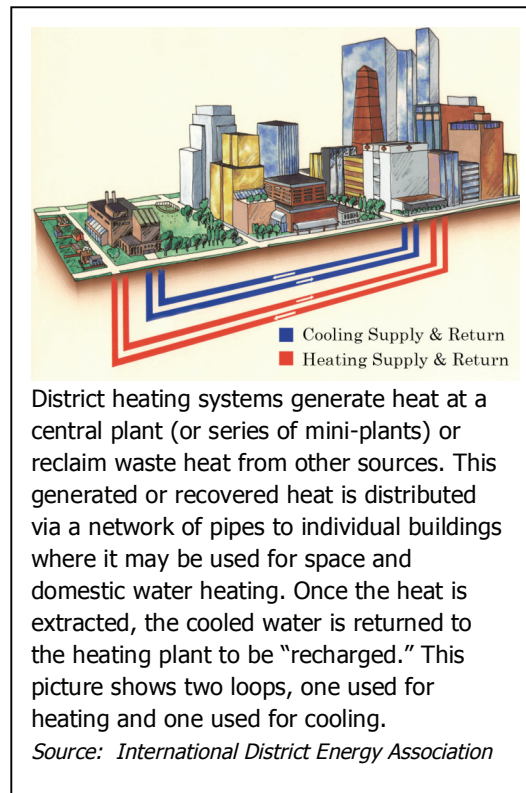
A district heating system (sometimes called a community energy system) is an integrated, large-scale and flexible way to distribute heat to a number of buildings. District heating systems are a primary mechanism through which renewable energy may be incorporated into a community.

Since the heat is provided directly by the district heating system, individual buildings do not require boilers or furnaces (although some may require a backup heat source, such as electric baseboards). Most systems built today use hot water as the means of distributing heat, although steam heating is not uncommon and was often used in the past.

District heating dates back to ancient Rome, and remains very popular in Europe. In North America, district heating has most often been used for university campuses and military bases, but there are several systems operating in municipalities in British Columbia, including the Cities of Vancouver, North Vancouver and Revelstoke. See Annex I for examples of systems installed in Canadian cities.

### 1.1.1 Benefits of district heating

There are many potential benefits that come from using a district heating system. From an economic perspective, the ability to use a variety of different fuel sources (renewable and non-renewable) allows for fuel switching. This ensures that the most appropriate fuel may be chosen at a particular time. From a system-efficiency perspective, a large central plant is typically more efficient than small individual heating plants. This means that less fuel may be required in the aggregate. From an environmental perspective, district heating systems can provide reduced need for fossil fuels, reduced greenhouse gas (GHG) emissions and cleaner burning of woodwaste. From the customer's perspective, district heating can result in lower heating and equipment maintenance costs and, especially for new buildings, may result in reduced space required for heating systems.



District heating systems generate heat at a central plant (or series of mini-plants) or reclaim waste heat from other sources. This generated or recovered heat is distributed via a network of pipes to individual buildings where it may be used for space and domestic water heating. Once the heat is extracted, the cooled water is returned to the heating plant to be "recharged." This picture shows two loops, one used for heating and one used for cooling.

Source: International District Energy Association

### Key Benefits of District Heating:

- Facilitates the use of renewable energy
- Connects multiple users with renewable heat sources
- Heat may be generated from a variety of sources
- Switching between fuels may be possible
- Capital and maintenance savings for customers
- All the benefits of using renewable energy
- Increased energy efficiency
- System can expand as more buildings connect
- Customers save space otherwise needed for boilers

### 1.1.2 Heat sources for district heating

The source of sustainable energy promoted or encouraged by a local government will often affect the kind of district heating system that can be constructed. While all the heat sources discussed in this guide can be configured into both district and individual (or stand-alone) heating systems, the general potential for each is shown in the table below.

Energy Source	Suitability for District Heating Systems	Suitability for Individual Heating Systems
Ground-source heat pump	M	H
Air-source heat pump	L	H
Biomass	H	H
Biogas	H	L
Waste heat recovery	H	H
Solar water heat	M	H
Solar air heat collector	L	H

(H=High, M=Medium, L=Low)

In many cases, it makes sense to consider integrating a number of different types of heat sources such as ground-source heat and wastewater heat recovery, instead of relying on a single source. For example, solar water heating and ground-source heat pumps can be combined in a district heating system.

### 1.2 Will District Heating Work in Our Community?

Zones characterized by high-density development, such as technology parks, malls and multi-unit residential clusters, are the best candidates for connection to a district heating system. Low-density developments (such as distributed single-family housing) are less suitable for district heating, due to the larger distances over which heat must be distributed.

#### Case Study: City of Revelstoke

The City of Revelstoke launched its district heating system in 2005, to provide hot water heating to local buildings in the downtown core. The system burns woodwaste from the Downie Timber sawmill and in addition to heating water, supplies low pressure steam for Downie’s drying kilns. The system provides lower energy costs and price stability to customers, reduces the amount of woodwaste being burned in the silo burner, and provides a financial return to the municipality.

Investigation of a potential electrical cogeneration and district heating project began in 2001. Reducing smoke and fly ash from the silo burner was a primary driver for the project, as well as a desire to reduce GHG emissions and generate economic activity. FVB Energy was retained to study the feasibility of both the cogeneration and district heating components of the project.

FVB’s report recommended a 3.0 MW cogeneration system. Concerns over softwood lumber exports, a rising Canadian dollar and financing delays, however, led to the cogeneration project being abandoned. The City of Revelstoke persevered with the district heating component of the project, based on a much smaller boiler plant. The first phase of the revised project was operational by 2005, serving eight buildings and the Downie dry kilns.

Financing was provided through a combination of loans, grants, and investment by the City. Total project cost was \$5.4m, of which the FCM Green Municipal Funds provided \$1.35m as a grant, and \$1.35m as a low-interest loan. A wholly-owned City subsidiary invested \$1.25m and the remainder was provided by investments by the City and local credit union, in the form of preferred shares.

During development of the project, the City underwent a steep learning curve. In addition to the demise of the cogeneration project, there have been other challenges. Boiler staffing requirements and a change in the wood supply have added to the initial projected expense. Ultimately however, the project has been very successful, and Revelstoke is now looking at expanding the system to service additional customers.

Key factors in a cost-effective district heating system are:

- availability of a low-cost heat source, and
- cost savings that can be achieved through reduced outlay on heating equipment.

New developments, where the purchase of heating equipment for individual buildings can be avoided, are ideal candidates for district heating. Existing buildings can also be good candidates for district heating, particularly if the fuel source is free or low-cost. Even using natural gas initially as the primary fuel may be cost-effective, when operations and maintenance are taken into account. This may be viewed as a temporary stage en route to a future, renewably-based district heating system.

### 1.2.1 Low-Cost Heat Sources

The most common sources of low-cost heat are woodwaste (discussed in Chapter 2) and cogeneration. Cogeneration is the simultaneous generation of electricity and useful heat. All electrical generation produces heat, but in most cases this heat is rejected into the atmosphere without being used. A district heating system can make use of this rejected heat to generate hot water or steam. In remote communities with diesel generators, heat can be recovered from the existing electrical plant, creating a cogeneration system. In other communities, a cogeneration plant can be built specifically to provide heat for district heating, with the electricity sold to a local customer or to the grid. In most cases, for a cogeneration district heating system to be cost-effective there needs to be a substantial summer heating requirement (i.e. municipal swimming pool, hospital, hotel, etc.) in order to make use of the surplus heat that will be generated year round.

Although cogeneration and the burning of woodwaste are the most common heat sources for district heating, there may be other non-traditional sources of energy that are available in your community. These may include landfill and sewer gas, municipal solid waste, wastewater treatment facilities, and waste heat from industry, refrigeration plants

or ice rinks. All of these renewable energy sources are described in later chapters of this module.

### 1.2.2 District Heating in New & Existing Developments

District heating is most cost-effective in new developments where the cost of the district heating connection will be partially offset by savings in boilers and other conventional heating equipment. Another benefit to the customer may be the additional space gained by not requiring a boiler room; the lease value of this extra floor space can dwarf other benefits. Most customers of the City of Vancouver's district steam system, for example, note that the benefits of their connection include the capital, maintenance and floor space savings. Couple these benefits with a low-cost fuel source, and district heating for new developments may be even more attractive.



Whether for new or existing buildings, the distance between customers and the plant is critical to system cost-effectiveness. The shorter the distance, the lower the cost of distribution piping. There is no fixed rule about the minimum distance, as it depends on building size, utility rates, climate and ground conditions. Generally, however, buildings should be within 200–300 metres of each other, and the plant should be no more than 1 to 2 kilometers from the largest buildings. Higher density development will improve the financial viability of district heating systems.

Another important consideration in the case of existing buildings is the type of heating system they currently have. Buildings with hot water heating may be easily converted to district heating, with a heat exchanger installed to take the place of the boilers. Buildings with other types of heating, such as furnaces, gas-fired rooftop units, or electric baseboards, may be substantially more difficult to convert.

### 1.2.3 What Does a District Heating System Cost?

Several years may pass between the initial feasibility study and final completion of a district heating system, and a substantial investment in study and design fees will be needed prior to starting construction. An initial scoping study to investigate whether there is any potential for district heating may be done for \$10 – \$15,000 or less. Much of the work can be carried out by local government staff, such as determining the availability and



Boilers to heat the hot water for North Vancouver's district heating system are located in a small area of a parking garage.  
Source: Community Energy Association

cost of fuel, the willingness of local building owners to participate, the likelihood of new development and distances between potential customers. Companies involved in developing district heating projects will often be willing to assist with early opportunity assessments at nominal cost. The Community Energy Association can also provide valuable help at this stage.

If the scoping study shows promise, a full feasibility study may be undertaken, involving

a detailed investigation of technical and financial aspects of the project. This may include building demand loads, plant configuration, piping distribution, fuel supply and energy costs as well as potential financing arrangements. The cost of a feasibility study can vary widely depending on scope and complexity. A relatively simple study looking at district heating from natural gas in a new development might cost \$25 – \$50,000, while a complex study for a district heating system combined with woodwaste cogeneration might be \$150 – \$250,000. Energy service companies may perform the feasibility study for free in exchange for the right to develop the project. While this may be a good way to undertake the project, be sure to have a clear understanding of what is involved before signing any contracts.

Construction costs will vary widely depending on the scope of the project, and will be different for each community. The following table includes numbers from actual projects. These figures are rough, but may help in a preliminary, in-house assessment of whether a district heating system is feasible for your community.

Free-standing building to house boiler plant	\$500,000 – \$1,000,000+
Natural gas hot water boiler plant, 4 MW	\$500,000 – \$1,000,000
Woodwaste hot water/steam boiler plant, 1.5 MW	\$1,000,000 – \$1,500,000+
Hot water distribution piping, existing development	\$800 – \$1400/metre
Building connections, existing properties	\$15,000 – \$90,000/bldg
Engineering, construction management and other project administration	10% – 15% of capital cost

Certain costs may preclude small communities from building a system, as the cost of connecting existing buildings is high. A number of larger customers is usually necessary to justify the cost of the boiler plant.

## 1.3 Regulations, Customer Billing & Other Considerations

### 1.3.1 Regulations

One of the most significant regulations with regards to district heating is the requirement for boiler staffing, as laid out in the *BC Safety Standards Act*. The regulation is fairly complex, with different certification levels based on boiler size and type, as well as a number of exemptions. This regulation requires continuous staffing of boilers over a certain size.

In general, high pressure (>15 psi) steam plants will almost always require continuous staffing and low pressure steam plants will also likely require continuous staffing unless the system is small. Hot water plants, however, will only require this level of staffing for large systems.

Continuous staffing would require five full-time employees. Although this is beneficial in terms of job creation, it will likely be cost prohibitive for all but the larger systems. For this reason, as well as to reduce heat loss and leaks, most new district heating systems utilize hot water rather than steam for heat distribution. There may be situations where generation of steam is a requirement, however, necessitating higher staffing levels.

Staffing requirements should be examined at the scoping study stage, and considered in detail at the feasibility study stage. Any assumptions regarding staff exemptions should be confirmed with the BC Safety Authority, which should also be contacted during the design stage to ensure there are no unforeseen staffing problems after the project is complete. Any staff required may also be offset by reductions in existing staffing needs in buildings connecting to the system.

Other regulations to be considered are emissions requirements and local zoning bylaws. These can generally be investigated at the feasibility study stage. There may also be a requirement to form a utility, which may require submissions to the provincial government and/or other authorities (see Module: *Governance, Utilities & Financing*).

### Case Study: City of North Vancouver Lower Lonsdale

In the late 1990's, the City of North Vancouver was undergoing a major redevelopment of the Lower Lonsdale area and the old shipyards on the waterfront. With a potential 280,000 m<sup>2</sup> (3 million ft<sup>2</sup>) of redevelopment, Council wished to create a sustainable legacy of community energy development. One of the significant concerns was the use of electric baseboard heat in multi-family buildings. To counter this, Council envisioned a district heating system integrated with the redevelopment of the area.

The City worked with BC Gas (now Terasen Gas Inc.) and BC Hydro to conduct an engineering study. This study indicated there were some serious challenges to district heating, including a lack of land available for the central plant and uncertainty over whether buildings would choose to connect to the system. In 2002 another feasibility study was undertaken with Terasen. This time the focus was on a distributed system utilizing mini-plants that would grow as the redevelopment expanded. This concept allowed the boiler plants to be located in building parking garages, resulting in much lower capital costs.

Construction began in 2004, with the first mini-plant installed in a community centre. Piping was installed by city crews, and done in conjunction with other roadwork where possible. A long-term agreement was signed with Terasen Utilities (now Corix) to build and operate the plants, which utilize high-efficiency condensing boilers and variable speed pumping to increase efficiency. In the first phase, 56,000 m<sup>2</sup> (600,000 ft<sup>2</sup>) of mixed use buildings were connected to the system. This is expected to increase to 93,000 m<sup>2</sup> (1,000,000 ft<sup>2</sup>) by 2007.

There have been a number of technical challenges in developing the system. The steeply sloping terrain caused problems with system pressures, requiring the mini-plants to be isolated from the distribution piping. And there have been challenges in getting the designers of the buildings to integrate with the low water temperatures of the distribution loop. The City is preparing a design guide to ensure design coordination between the buildings and the district heating system.

### 1.3.2 Customer Metering and Billing

A district heating system requires a system to measure usage and bill customers. How much the customer is billed will depend on the economics of the system. Each customer may benefit differently, based on the efficiency of their current system and potential maintenance savings.



Some district heating systems have negotiated rates separately for each customer, based on the building's consumption, efficiency and cost of connection. This may be appropriate in some situations, while in others it may be preferable to have a set rate or formula for reasons of transparency and consistency.

New customers may be expected to pay the cost of their connection, since they will see the capital savings from not installing heating equipment. Note that wiring for remote metering can be installed at the same time as the piping. This will simplify the metering and billing process.

### 1.3.3 Other Considerations

For information on local government mechanisms to encourage district heating in

your community, and getting started, see Chapter 6.

There are many other details that should be considered in planning a district heating system, most of which will be covered by the consultants during the feasibility or design stages. The following are a few items that the local government should consider.

- Consider opportunities to combine pipe installation with municipal roadwork or piping. Coordination with ongoing infrastructure maintenance may provide opportunities to reduce district heating installation costs, particularly when it comes to future expansion. Alternatively, the installation of the district heating piping may create an opportunity to do needed infrastructure upgrades, and perhaps leverage additional provincial or federal funding.
- Prepare a design guideline for new buildings wishing to join the system. District heating systems operate most effectively if the buildings attached are designed to certain standards. These same requirements can benefit the building owner in terms of reduced mechanical cost. Design guidelines, as well as a promotional brochure encouraging connection to the system, can be sent to the owner and mechanical engineers at the time of development permit. All mechanical engineering firms which commonly work in the municipality should be aware of the guidelines.
- Backup heat supply will need to be considered. District heating systems are very reliable (although regular maintenance is essential for reliable and efficient system operation). However, backup requirements in case of equipment failure, power outages, or pipe breakage will need to be considered. Some buildings, such as hospitals, will have a higher requirement for backup than others. Existing boilers within buildings may play a role in providing backup.

- Taxes may be a consideration for non-residential buildings. Residential customers do not pay provincial sales tax on heat.
- Integrate the district heating system into municipal growth plans, encouraging development in areas serviced by the system, and planning for future expansion. System design should be modular so that it can be extended to new users who wish to join the system at a later date. Consider a service area bylaw to ensure buildings connect to the district heating system (see Module: *Governance, Utilities & Financing*).

### **Case Study: Whistler Athletes Village**

As part of the preparation for the 2010 Winter Olympics, the Resort Municipality of Whistler is planning the development of the 29,000 m<sup>2</sup> Whistler Legacy Development, which will provide the Athlete's Village during the games and become a source of housing for residents once the games are over. Whistler has partnered with Terasen Energy Services (TES) to examine potential opportunities for renewable energy provision via a district energy system.

Because of Whistler's commitment to sustainability, the project examined a range of renewable heat sources for the district heating system. These included ground-source fields, solar, wastewater heat recovery, sewer heat recovery, landfill gas and municipal waste.

To make use of the various low-grade heat sources, the current design utilizes a low temperature district heating system — one that would operate at temperatures between 5° and 45°C. To extract the heat from this low temperature loop, heat pumps would be located in each building. The primary energy source for this system will be heat capture from treated wastewater effluent, potentially augmented by high-efficiency natural gas and/or landfill gas for peak heating events. Backup and/or auxiliary sources to the wastewater effluent may be provided by high-capacity open-loop ground-source wells set in a high-yield, low-demand, non-potable groundwater aquifer.

The system has several advantages. Low temperature sources such as earth energy and wastewater treatment can be used to heat the water loop. Two, large-diameter, un-insulated distribution pipes will be used (one for cooling, and one for heating), allowing for thermal efficiency improvements and thermal storage/buffering. The heat pumps are the property and responsibility of the building owner, reducing initial capital costs and future maintenance costs of the system. Cooling equipment within the buildings can also use the loop for heat rejection, serving as an additional heat source, effectively sharing energy between users.

Whistler is now proceeding with TES to develop the district heating system, with completion expected in 2009.

*Source: Hemmera Energy*

## 2 Biomass & Biogas

### 2.1 Introduction

Biomass and biogas are significant potential renewable energy sources for a wide range of energy needs, including heating, electricity generation and transportation fuels for communities in British Columbia.

Biomass refers to renewable organic matter, such as woodwaste, straw, peat, animal manure or municipal solid and liquid wastes. *Biogas* is created by the breakdown of *biomass*. Landfill gas is a type of biogas produced naturally by the breakdown of biomass from organic waste in landfills. Digester gas is a by-product of the decomposition of sludge at wastewater treatment facilities.



A backhoe feeds woodwaste into a chipper. This chipped biomass can be burned to generate heat and electricity.

*Source: Regional District Okanagan Similkameen, Public Works — Air Quality*

Throughout history, biomass has been the primary fuel for heating and cooking in most societies. Only recently have industrialized societies turned from biomass to fossil fuels and, even now, biomass is still used around the world for heating, cooking and the generation of electricity. In Canada, about 6% of electrical energy is produced from biomass, much of it from woodwaste produced by the pulp and paper industry. The widespread availability of biomass in forest-rich British Columbia (particularly in those areas affected by pine-beetle kill) makes it an attractive option for many community applications.

#### Key Benefits of Using Biomass & Biogas:

- Readily available source of renewable energy in many parts of the province
- Economic development for communities with woodwaste or other biomass resources
- Potential air quality benefits, depending on the fuel stock, technology used to extract energy and conventional method of disposal

There are many ways that biomass, landfill gas and the biogas produced in wastewater treatment facilities can be used. Some forms of biomass can be burned directly to heat water or create steam. This hot water or steam can, in turn, be used to heat individual buildings, for district heating or to generate electricity. Biomass can also be converted to oil or gas ('biofuels') by means of chemical processes. The product can then be used as fuel in boilers, electrical generators and vehicles. Landfill gas and other biogas can be burned directly, similar to natural gas or propane.

### 2.2 How Do Biomass & Biogas Heating Work?

#### 2.2.1 Direct Combustion

Many forms of biomass can be directly burned to generate hot water or steam. Wood residue from mills such as sawdust, chips, bark or hog fuel can be burned in boilers custom designed for the application. Fuel is automatically fed into a boiler, as required, by means of conveyors. Modern biomass boilers have sophisticated emissions controls, which if regularly maintained, result in minimal particulate emissions. These boilers are usually fairly large, ranging from 1.5 to 40 MW (1.5MW, for example, is sufficient to heat a mid-size office building). Boilers can generate hot water or steam, as required.

The most common form of biomass heating in Canada is through the direct combustion of woodwaste. Mills have a ready availability of



Revelstoke biomass district heating plant  
Source: Revelstoke Community Energy Corporation

### Case Study: The City of St. Paul

In the City of St. Paul, Minnesota, heating and cooling are provided to buildings in the downtown through a biomass-fuelled district energy system. This wood-fuelled combined heat and power (CHP) plant provides heat to District Energy St. Paul and electricity to Xcel Energy. It is the largest wood-fired CHP plant serving a district energy system in the United States.

Since the creation of its district energy system, St. Paul has experienced improved air quality, as smokestacks, cooling towers and chimneys on individual buildings in the heating area have been eliminated.

City officials have also found that using "green waste" (e.g. park trimmings) as fuel in an efficient burner with sophisticated particulate control provided significant air quality benefits over simply land-filling the downed material (which creates methane gas) or backyard burning both of which had been an uncontrolled source of unhealthy air pollution.

woodwaste and also a need for heat, usually in the form of low pressure steam. By burning their waste wood for energy, mills can reduce the costs of disposal and environmental liabilities associated with using silo burners. Sawmills typically produce more waste wood

than they can use for heating, so additional heat may be available for other users or for a district heating system. Where sawmills are unable to use the woodwaste, they represent an important potential source of fuel.

Municipal solid waste (MSW) can also be burned to generate heat. This can reduce pressure on landfills and reduce air and GHG emissions. MSW contains many toxic substances; care must be taken to eliminate or mitigate toxic air emissions. In the past, plants burning MSW have been criticized for their harmful air emissions, but modern plants, with appropriate fuel pre-conditioning systems, can reduce emissions to well below provincially regulated levels. The waste-to-energy facility in Burnaby is one of two waste-to-energy plants in Canada and consumes 20% of the Greater Vancouver Regional District's waste, while meeting strict environmental protection standards.

### 2.2.2 Anaerobic Digestion

Anaerobic digestion is the breakdown of organic materials by bacteria in the absence of oxygen. Anaerobic bacteria (typically using sewage, manure or other wet organic materials as the feedstock) produce a gas composed mainly of methane and carbon dioxide. The biomass feedstock is placed in an airtight container (an anaerobic or bi-digester) where the biomass breaks down. Proper disposal of the resulting bi-products (which may include white and black liquors as well as gas) is very important. While other bi-products will not be discussed here, the resulting gas can be used, with minor modifications (scrubbing), in boilers or electrical generators. While anaerobic digestion has been a relatively slow process historically, taking 30–40 days to complete, a number of designs have been developed that can operate at a variety of temperatures and shorten the time requirement significantly.

Landfill gas (LFG) occurs naturally through anaerobic digestion within a landfill site. In many Canadian landfills, this gas is allowed to escape into the atmosphere. LFG is about 50% methane and 50% carbon dioxide, and is a potent GHG as well as a local air pollutant.

To mitigate this, LFG may be collected and flared (burned) to reduce the environmental and local air quality impact. Once collected, LFG can also be used for more useful purposes such as heating or electricity generation. To optimize the energy value of the LFG, it should be cleaned, dried and compressed prior to utilization in equipment. Compression, an energy intensive process, may not be required in systems located at the landfill site. For an example of where LFG is successfully being used, see the *Vancouver Landfill* sidebar, in section 2.3.



Hartland landfill gas plant produces 1.6MW of green power; \$200,000/yr royalty to the Capital Regional District

Source: Capital Regional District

Digester gas is formed by anaerobic digestion in wastewater treatment plants. Typically, the methane gas produced is used to heat the building in which it is located. Excess digester gas is often flared. There may be opportunities to use this gas to heat nearby buildings, or for electrical generation. See the *Prince George Waste Water Treatment Facility* case study in the *Electricity* Module for a good example of this.

### 2.2.3 Gasification

Gasification is the production of gas from biomass by adding heat to the process without sufficient oxygen for combustion. This causes the biomass to gasify into a mixture of hydrogen and carbon monoxide, known as *syngas*. Gasification is not as advanced a technology as direct combustion or anaerobic digestion and research is still ongoing, although there are commercially available units.



Illustration of the Nexterra district heating system for the Dockside Green residential development on Victoria's inner harbour.

Source: Nexterra Energy Corp.

A plywood mill, run by Tolko in Heffley Creek, uses a woodwaste gasification system to produce heat, which is used to heat hot water and to dry veneer. The Dockside Green development in Victoria has indicated an intention to use a centralized woodwaste gasification plant to provide renewable heating to the community. Although syngas has less than half the energy density of natural gas, gasification may become the preferred biomass extraction method in the future and may also be an important source of hydrogen for fuel cells.

### 2.3 Will Biomass & Biogas Work In Our Community?

Key factors in the cost-effective use of biomass for heating are the availability of fuel and a nearby use for the heat generated. Communities with available supplies of woodwaste, a wastewater treatment plant or a municipal solid waste gathering facility, and agricultural communities with supplies of animal manure, are the most likely candidates. Woodwaste is best used in a direct combustion boiler, while manure is more suitable for anaerobic digestion.

To be economic, the biomass supply should be relatively close to where heat is needed, particularly for direct combustion. Transporting biomass up to 50 kilometres from where it is sourced may be cost-effective.

### Case Study: City of Vancouver Landfill in Delta

The City of Vancouver's Landfill in Delta is a municipal solid waste landfill with a catchment area which includes approximately 90,000 businesses and residents. The landfill is owned and operated by the City of Vancouver.

The landfill has had an active landfill gas (LFG) collection and control system in place since 1991. The purpose of this original system was to collect and flare the LFG, in an effort to control odours and reduce methane (greenhouse gas) emissions. LFG was also used to heat and provide hot water for the landfill's administration building.

Recognizing that there was good potential for heightened energy recovery through the beneficial use of LFG, the City issued a request for proposals in January 2001. During this same period, City Council approved a LFG system expansion at the landfill, at a cost of approximately \$1,750,000. Maxim Power Corporation was the successful proponent, and its proposal to finance, design, build and operate a cogeneration facility which uses the landfill's LFG was accepted.

In January 2003, Maxim and the City signed an agreement whereby Maxim would construct a system which would allow Maxim to pipe the LFG to Can Agro's greenhouses, located 2.5 kilometers south of the landfill. Once the LFG arrives at the greenhouse, it is burned. This process generates 40 GWh of electricity per year, which Maxim sells to BC Hydro as "green power," and 100,000 GJ of heat, which it sells to CanAgro's greenhouses. The City, in return, receives approximately \$400,000 in revenues from the project, which it uses to offset the cost of operating the landfill's LFG collection system.

The Vancouver Landfill is expected to operate until 2040, and generate LFG well into the future.

*Source: City of Vancouver*

Local governments can foster community economic development opportunities by connecting biomass heat producers with potential heat consumers. Where heat cannot be used by the facility that produces it, there may be options for a district heating system to serve other buildings in the community.

Greenhouses may provide synergistic business opportunities, as they require large amounts of heat and are sometimes flexible in their location.

Landfill gas is one of the easiest and most cost-effective types of biogas to use for energy generation, particularly if the gas is already being collected and flared. If it is not currently being collected, its energy potential may provide an economic justification for doing so. Because landfills are not often located near other buildings or facilities, LFG is usually used for electricity generation. Even if electrical generation is the primary objective, surplus heat will be available and may be used for heating.

Examples of good economic development synergies include the Port Mann landfill site in Surrey, where LFG is used to run the burners that cure wallboard in a nearby factory; the Jackman Landfill in Langley where it is used by an adjacent business for the production of brewer's yeast and piped to enhance plant growth in a nearby greenhouse; and the Coquitlam Landfill, where the gas is used in an adjacent newspaper recycling facility.

### 2.4 Economic Considerations

Type of system	Capital cost	Potential Value of Energy Generated*
1.5 MW woodwaste boiler	\$1.5 – \$2.5 million	\$250,000 – \$300,000 per year
Small (1800 m <sup>3</sup> ) anaerobic digester	\$500,000	\$40,000 per year
Medium size (4 million tonne) landfill gas collection, processing & equipment modification	\$4 – \$6 million	\$250,000 – \$750,000 per year

\* Based on natural gas cost of \$10.00 / GJ

Biomass heating systems can have favourable economics, particularly if the biomass is available at a low-cost and the heat can be utilized on site. Economic feasibility can vary greatly based on the cost of biomass fuel, plant location, type of system and use of the heat. The following examples are given to

illustrate potential costs and savings, but should be treated with caution. More detailed scoping and feasibility studies should be performed before proceeding further.

## 2.5 Air Emissions

A common concern about the use of biomass for energy is its impact on air quality. The burning of wood and municipal solid waste has traditionally been one of the main causes of poor air quality in some regions of BC, resulting in bans on backyard burning, wood burning fireplaces and solid waste incinerators. Suggesting that biomass be burned for energy generation raises reasonable questions about air quality and environmental benefits.

Whether using combustion, anaerobic digestion, or gasification, biomass plants *do* generate air emissions, including nitrogen oxides, carbon monoxide and particulate emissions. The levels of these contaminants are provincially regulated, however, and use of advanced emission controls in well maintained systems can reduce levels to well below required limits. Air quality concerns from residential wood heating are further discussed in section 2.6.1 which follows.

It is important to consider what would otherwise happen to the biomass. If it would be burned in silo burners or deposited in landfills, then there may be a significant air quality benefit to using it for energy generation. This kind of air quality analysis was a primary driver for the establishment of a biomass-based district heating system in Revelstoke to divert woodwaste from the local silo burner.

As noted in the *Direct Combustion* discussion above, MSW presents special emissions concerns due to toxic substances that are present in the waste stream. Here, strict emission controls, treatment and monitoring are necessary to meet stringent provincial regulations.

In addition to air contaminants, attention should be paid to any liquid discharge from a biomass or MSW plant, to ensure there is no risk of ground or other water contamination.

The use of biomass for energy is considered GHG neutral as carbon naturally cycles through trees and plants. While it is stored by them while they are living and growing, carbon dioxide is eventually released when they die, to be re-absorbed into growing plants. Burning biomass reduces GHG emissions if it displaces fossil fuel burning and if it does not contribute to net deforestation.

Finally, LFG is composed of approximately 50% methane, which is twenty times more powerful a greenhouse gas than carbon dioxide. Since LFG would either escape to the atmosphere (including substantial amounts of methane) or be flared (releasing CO<sub>2</sub>), burning LFG for energy does not result in net carbon emissions. Indeed, where LFG is used to replace fossil-fuel energy, landfill gas use reduces emissions.

## 2.6 Applications for the Community & Local Government

There are many applications for biomass and biogas, both as stand-alone installations and in district energy systems, throughout the community and in local government operations. For information on local government mechanisms to encourage use of biomass or biogas in your community, and getting started, see Chapter 6.

### 2.6.1 Residential Buildings

Residential buildings, whether multi-unit or stand-alone houses, are good candidates for biomass heating due to their space and water heating requirements. Wood-burning stoves and fireplace inserts are common throughout the province and while many serve simply a decorative function, many are used as an active heat source, particularly in rural areas. It is likely that as the price of conventional heating fuels increases, the use of wood for heat will increase.

Most older fireplaces and wood-burning stoves are highly inefficient and produce serious air pollution. New stove technologies, including the development of advanced combustion stoves, catalytic stoves and pellet stoves, have significantly boosted heat-output and reduced air quality concerns. Pellet stoves (and boilers,

for larger multi-unit residential buildings) are able to operate automatically, controlling heat output and emissions with a high degree of precision. The use of these technologies should be encouraged. In addition, the Ministry of the Environment has literature available on its website that relates specifically to increasing stove efficiency and decreasing smoke. This can be used to educate members of the community.

### **2.6.2 Commercial & Institutional Buildings**

Using biomass to heat air and water for commercial and institutional buildings, as described in the preceding section, holds promise, particularly as the price of conventional heating sources increases. Commercially sized boilers are available and can generate hot water or steam, as required. In the event that biomass is selected as the fuel of choice, consideration must be given to how, where and at what cost the fuel will be stored.

Biogas heating is attracting private sector interest. Greenhouses are locating near landfills and wastewater facilities for the heat produced by the burning of LFG and digester gas. Although this is still a relatively new idea in BC, industries with heat-related industrial processes are beginning to consider the importance of their neighbours as potential energy providers. The exploration of the potential for combined heat and power production as a business opportunity is also occurring.

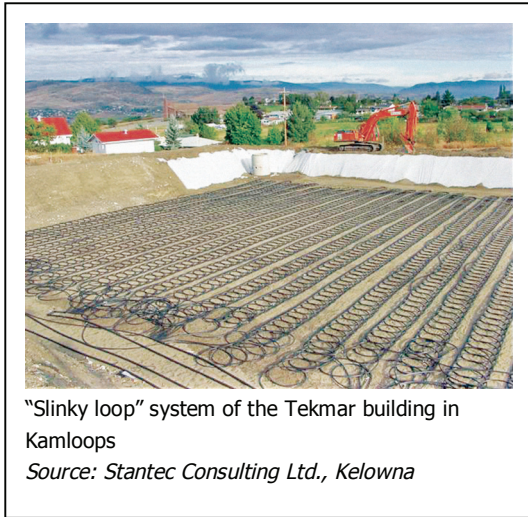
Local governments can help enable relationships between the producer of biomass or biogas fuelled heat and consumers of the heat, creating tremendous potential for community economic development. To facilitate this, proactive consideration should be given to adjacent energy uses and potential for synergies when issuing development permits and rezoning.

### **2.6.3 Local Government Operations**

As a low cost and usually local fuel source, biomass and biogas heat are attractive options for use in heating municipal buildings. Where

landfill gas capture is possible, the local government may already own the fuel supply. Several local governments in British Columbia already use or sell landfill gas for heating, while the City of Revelstoke has made use of woodwaste from a local sawmill to heat buildings (see case study on page 4).

## 3 Ground-, Air- & Water-Source Heat Pumps



### 3.1 Introduction

The world we live in is surrounded by sources of heat that are often considered to be too low a temperature to be useful. The air, ground, lakes and ocean all contain heat, but the challenge is finding a way to extract it. Heat pumps are a technology that extract this heat.

#### Key Benefits of Using Heat Pumps:

- Very efficient use of the heat source
- Wide variety of applications
- Applicable at a small or large scale
- Well-established, proven technology
- Use electricity, which in BC is generated from largely renewable sources

Heat pumps open the door to a wide range of opportunities for recovering heat from otherwise unlikely sources. This section discusses heat pumps in relation to ground-, air- and water-source applications, while the use of heat pumps for other heat recovery applications is discussed in the *Heat Recovery* chapter, which follows.

### 3.2 How Do Heat Pumps Work?

A heat pump operates in a similar fashion to a refrigerator, which uses a compressor to

change a refrigerant from gas to liquid and back again. During the refrigeration process, heat is extracted from inside the refrigerator and rejected through the coils, located at the back or the bottom. An air conditioner works similarly, extracting heat from a house and rejecting it to the hotter outside air. In both these processes, the aim is to cool the space, without much concern about what happens to the rejected heat.

A ground-source heat pump (GSHP) uses the ground to provide heat in the winter and cooling in the summer. It has long been considered a highly energy efficient and environmentally clean space-conditioning system. Associated emissions result from electricity generation required to operate the pumps; passive solar and solar hot water space heating may be environmentally cleaner from that perspective.

There are currently approximately 45,000 GSHPs in Canada, and the estimated growth rate is 40% per year. Local examples of GSHPs include the Oakridge Shopping Centre, the Vancouver International Airport terminal, as well as residential communities like Sun Rivers in Kamloops.

A heat pump works on the same principle, but the primary aim is to make use of the rejected heat to heat air or water, which is then used to heat a house or building. The process may be reversed as needed, so that most heat pumps can be used for either heating or cooling.

Heat pumps require energy (usually electricity) to operate. The efficiency of a heat pump is measured by its coefficient of performance (COP), which is the ratio of heat output to energy input. The COP is related to the difference between the source and output temperatures; efficiency is higher when the temperatures are close together. For most applications the COP ranges from 2.0 to 5.0, meaning two to five times as much heat is produced as input electricity is required.

### 3.3 Types of Heat Pump System

Heat pumps have been around for many years. The concept was developed in the mid-1800s and the first heat pumps were manufactured in the 1930s. Their main use has been to heat houses and buildings.

#### 3.3.1 Ground-source Heat Pumps

Ground-source heat pumps (GSHP) use the earth's natural heat as a source of energy for heating and cooling buildings. Their popularity has been limited by a high upfront cost of installation. This is changing, however,

##### Annual Cost of Heating a Mid-sized Single-family Home: Electricity, Gas & Ground-source Heat

**Electric heat** (100% efficiency):

$$12,000\text{kWh} * \$0.06/\text{kWh} = \$720$$

**Gas furnace** (90% efficiency):

$$43.2 \text{ GJ} / 0.90 * \$12.00/\text{GJ} = \$576$$

**Ground-source heat pump (GSHP)** (COP 3.0):

$$12,000\text{kWh} / 3.0 * \$0.06/\text{kWh} = \$240$$

**GSHP comparison:** Use of a GSHP would create annual savings of

- \$480 (over electric heat)
- \$336 (over gas heat)

##### Assumptions and notes:

Calculations are based on a mid-sized home in the Lower Mainland with a heating load of approximately 12,000 kWh of electricity, or 43.2 GJ of gas per year

Assumed prices: electricity \$0.06/kWh, gas \$12.00/GJ

If gas rates increase, the use of GSHP would create additional savings compared to a gas-fired appliance.

A gas furnace efficiency of 90% has been assumed. This is higher than most older furnaces, but is appropriate for new gas furnaces, which must comply with new provincial efficiency regulations.

##### A heat pump by any other name...

Heat pumps are used in a variety of applications, with a number of different heat sources. As a result, the terminology can get confusing:

- **Ground-source heat pumps** use the earth as a heat source. They are sometimes called **earth energy systems** or **GeoExchange™**, and sometimes even **'geothermal'**, although this last usually refers to the direct use of hot water from volcanically active geological formations.
- **Water-source heat pumps** (also known as **pond-loop** or **lake-loop heat pumps**) use a standing body of water (such as a lake or the ocean) as a heat source. However, the term **'water-source heat pump'** is sometimes used to refer to **water-loop heat pumps**, which are systems that use a water loop to distribute heat around a building, but which do not use a water body as a heat source.
- **Air-source heat pumps** use the air as a heat source.

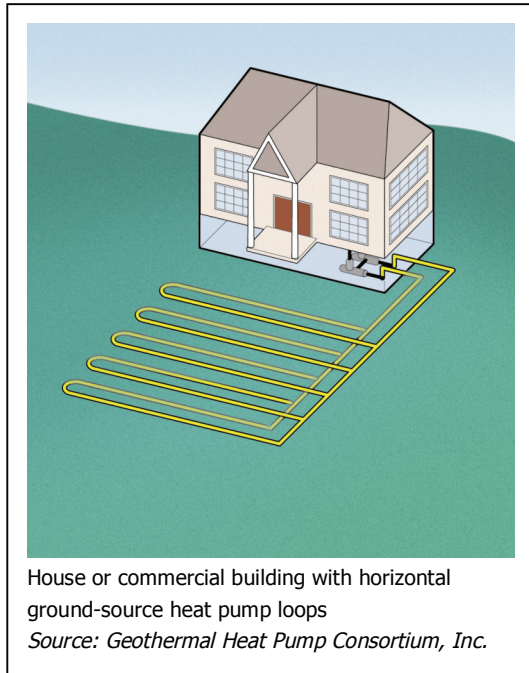
This Guide focuses on heat pumps that use the earth, a body of water, or air, as the heat source.

with energy price increases and a shift in attitudes towards climate change and renewable energy. The number of ground-source heat pump systems installed has recently skyrocketed in British Columbia.

The benefit of ground-source heat pump systems in comparison with air-source heat pumps (described below) is that the ground temperature is relatively stable throughout the year, as compared to air temperatures. Higher ground temperatures in winter and cooler temperatures in summer mean improved efficiency throughout the year compared to air-source heat pumps.

In BC, the more common closed-loop systems extract heat by placing pipes in the ground and circulating water-based liquid through them. The pipes (known as ground fields or loops) are laid out in either a horizontal or

vertical configuration. Horizontal fields are shallow, typically 2–3 metres in depth, but cover a large area. Vertical fields are deep,



usually 50–100 metres, with each drill-hole typically 3–5 metres apart. Vertical fields require much less area, but drilling costs can be high depending on the type of rock or soil involved. Horizontal fields are generally cheaper to install and have the benefit of being re-charged by the sun, but require a larger property in order to have sufficient room for installation.

In the less common open-loop configuration, groundwater is used directly. Once the heat is extracted, this water is discharged back into the subsoil, aquifer or water body from which the water was originally withdrawn. Care must be taken to ensure that the water is returned without contaminating or depleting the water supply.

### 3.3.2 Water-source Heat Pumps

Some heat pumps use water directly from lakes, ponds or the ocean as a heat source. These are known as water-source heat pumps, or pond-loop or lake-loop heat pumps, and work in much the same way as a ground-source heat pump. The difference is that the heat transfer 'loops' are in water, rather than in the earth. Water source heat pumps should

only be used where there is sufficient water depth — usually 2–3 metres minimum.

Closed pond (or lake or ocean) loops do not directly use water from the water body, but circulate a heat transfer liquid through tubes that are laid in the water body. These loops are often cheaper to install than ground-source loops, as drilling and digging costs are avoided.

Some water-source heat pumps use an open-loop configuration, in which water is pumped from the source (such as a lake or well) to the heat pumps, where heat is extracted before discharging it back into the aquifer or water body from which it was originally withdrawn. Care must be taken to ensure that the water is returned without contaminating or depleting the water supply. Furthermore, there are potential difficulties with dirt or minerals in the water, which may damage equipment. In the case of seawater, corrosion resistant piping and heat exchangers will be necessary. And smaller water bodies such as ponds may freeze during winter.

Finally, it should be noted that the term water-source heat pump is also often used to refer to 'water-loop heat pumps', which involve the use of heat pumps connected to a boiler and cooling tower within a building. These systems are popular in small commercial buildings. While such systems have potential energy efficiency benefits, they are not considered renewable energy, and so are not discussed further in this guide.

### 3.3.3 Air-source Heat Pumps

The most common type of heat pump is an air-source heat pump, commonly found in houses and small commercial buildings. This type of heat pump extracts heat from the outside air and delivers it into a room or ventilation system for a building. For cooling, this can also work in reverse as an air-conditioner using the same equipment.

The efficiency of these units varies throughout the year, with the efficiency dropping as the outside temperature drops. In very cold weather (around -25°C) the efficiency will drop below 1.0, meaning it requires more

electricity input than the amount of heat that comes out. As well as lower efficiencies, the capacity of the equipment also drops in colder weather and the unit may suffer from icing and other climatic problems. Because of this, most air-source heat pumps have a cut-out temperature of about -10°C, below which auxiliary electric or gas heat is used.

These systems are best used in mild climates where the efficiency remains high throughout the year and use of auxiliary heat is minimized; coastal BC, Vancouver Island and the Okanagan are the best locations in BC for this technology, although heat pumps will work in colder areas of the province as well.

Air-source heat pumps typically range from a \$1,500 – \$2,500 premium over a conventional furnace and air conditioning unit. One-half to two-thirds of a home heating bill, or about \$400 – \$500 per year, is the reasonably expected saving, with the pump system paying for itself in three to six years.

### **3.4 Applications for the Community & Local Government**

This section outlines heat pump applications in residential, commercial, institutional, local government and district heating. For information on local government mechanisms to encourage use of heat pumps in your community, and getting started, see Chapter 6.

#### **3.4.1 Residential Systems**

Most ground-source heat pump systems have been installed in houses. In these systems, a vertical field is usually used due to property space limitations. Water is circulated through the field and picks up heat from the earth. Once inside the house, heat is extracted from the field loop and may be used to heat air which is distributed by a fan and ductwork. Heat may also be rejected into another water loop inside the house and distributed through an in-floor radiant heating system. Domestic hot water can also be supplied from (or pre-heated by) the system for additional savings, although at some additional installation cost.

According to the Canadian GeoExchange Coalition, a ground-source heat pump system for a house will usually cost \$10,000 – \$25,000, depending on the size, location and loop-configuration.

#### **Case Study: Sun Rivers Golf Resort Community**

The developers of the Sun Rivers Golf Resort Community, located just outside the City of Kamloops on the Kamloops First Nation Reserve, have added a new twist to the traditional concept of providing a heating utility.

Sun Rivers bills itself as “Canada’s First Geothermal Community” and provides to its residents a ground-source heating and cooling utility, based on individual vertical fields and pumps.

In this community, the ground-source heat exchange system is used for space heating and cooling as well as well as hot water pre-heating. The system was included by the developer as part of the infrastructure costs of the community. Corix Utilities, a private utility company, operates a comprehensive range of utilities for Sun Rivers, including sewer, water, gas and electricity, and owns the underground grids, including ground-source loops.

Savings range from two-thirds to three-quarters of the heating bill, or \$400 – \$700 annually, over that of a conventional natural gas-fired furnace. Incorporating domestic hot water heating can add \$100 – \$200 to this saving, but with an additional up-front cost. While additional savings will be found if air conditioning is used, in most of British Columbia these gains are usually small. With paybacks of up to 20 years or more, residential ground-source heat pump systems require a significant commitment from the homeowner.

One solution to the high installation cost has been large-scale projects that install dozens of individual fields in a development at one time. Some developments have taken advantage of this economy of scale in BC, including the

Wilden Estates development in Kelowna and the Sun Rivers development on the Kamloops First Nation Reserve, referred to in the sidebar (see Annex I for more information). Developments like Wilden Estates and Sun Rivers are successful demonstrations of how renewable ground-source heating can be successfully used to heat our communities.

### **3.4.2 Commercial & Institutional Systems**

Commercial heat pump systems often have better economics than residential systems, as they are larger and typically use more energy for both heating and cooling. The requirement for cooling means that heat rejected into the ground in summer (cooling season) will help recharge the field for heating during cooler periods.

Ground-source heat pumps can be compatible with a variety of different mechanical systems. Often the ground field will only be sized for part of the load, with a boiler and cooling tower installed to handle the coldest and warmest days. These hybrid systems can help keep the capital cost down while optimizing energy from the ground.

Commercial buildings with sufficient property area can use horizontal fields (school playing fields are ideal and parking lots are a possibility) while buildings in denser areas may require vertical fields.

Commercial ground-source heat pump systems vary widely in cost, based on size of the system, as well as type of building, climate and ground conditions. A rough estimate for a system for a small office building might be \$80,000 – \$100,000. Simple payback is typically 10–15 years, but may be lower as the price of conventional energy increases, and for buildings with higher energy use. A proper engineering study using energy modeling tools should be deployed to ensure a sound decision is made.

### **3.4.3 Local Government Operations Municipal Buildings**

Heat pumps can be used in most existing municipal or regional buildings. Rooftop

heating/cooling units commonly found in small buildings can usually be replaced with air-source heat pumps. For existing buildings, this should be considered when the equipment is due for replacement. In larger buildings, water-loop heat pump systems can be considered for new construction. These systems are best suited to buildings with large internal cooling loads to maximize heat transfer.

Ground-source heat pump systems can be considered for most new municipal building projects. The economics will be best for buildings with both heating and cooling requirements, long operating hours and adequate space to install a ground field. In existing buildings, those with water-loop heat pump systems (for heat distribution) or low temperature heating systems may have potential ground-source applications.

All ground-source heat pump projects should include in the design team an engineer or installer with ground-source heat pump experience to ensure proper system design and sizing.

### **Ice Rinks & Recreation Facilities**

A relatively new use for ground-source systems that is gaining in popularity is in public ice rinks. Ice rinks reject large amounts of heat from the refrigeration equipment, even in winter time. This heat can be captured and used for space and domestic water heating.

An energy-wise alternative may be to use ground fields where the rejected heat may be stored until required by the heating systems. This makes much more efficient use of the heat recovered from the ice rink. If the ice rink operates in summer, the cooler temperatures of the ground field will also improve the refrigeration equipment efficiency.

**Case Study:  
South Cariboo Recreation Centre**

The South Cariboo Recreation Centre is a hub of activity in 100 Mile House, BC. It includes a 2,600 m<sup>2</sup> ice arena with over 600 spectator seats, a 500 m<sup>2</sup> lobby and viewing area which overlooks the rink, offices and a curling rink. The centre was designed as a total system which integrates many elements – rather than a building with many systems that work in isolation from each other. It is a state-of-the-art facility, boasting an integrated ground-source heating and cooling system.

The ice rink area and concrete bleachers are heated with a radiant floor heating system through heat piping which is embedded in pre-cast concrete. The change rooms are ventilated through a heat recovery ventilation system. The lobby, viewing and office areas are heated and cooled with several conventional ground-source heat pumps, which are connected to the horizontal ground loop in the field behind the building.

Eight water-to-water heat pumps are used in place of a traditional ice plant. The pumps reject heat either into the radiant floor heating system or to the earth loop, based on the temperatures in the building. The forced air heat pumps in the office space and the water-to-water heat pump that produces hot water for showers and flooding the ice are also connected directly to the ground loop; they extract from or reject heat into it, as required. The refrigeration system of the curling rink has been connected to the ground-source heating system.

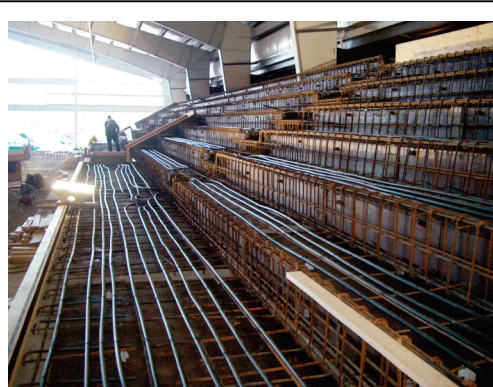
The main difference in cost between this system and the type that would be conventionally installed in similar recreation centres is the cost of the ground loop (~\$105,000). The total incremental cost was estimated at \$119,000. To offset some of the up-front cost, the installation received a \$60,000 Commercial Building Incentive Program (CBIP) grant from Natural Resources Canada. With the ground-source system, annual energy savings are estimated to be approximately \$48,000. The simple payback of the system is estimated to be approximately 2.5 years.

*Source: Geo-Heat Centre Bulletin, September 2005*



South Cariboo Recreation Centre ice rink: Ground-source loops before the concrete is poured; these loops cool the ice. Additional loops under the concrete heat the ground to prevent permafrost.

*Source: Al Richmond, South Cariboo Arena Society*



South Cariboo Recreation Centre: Ground-source heating loops to warm the concrete bleachers.

*Source: Al Richmond, South Cariboo Arena Society*

Although only a few such facilities have been built in BC, including the South Cariboo Recreation Centre (highlighted in the box, above), the incremental cost for an ice rink which incorporates ground-source heat pump technology is in the range of \$150,000 – \$250,000, with annual savings of \$40,000 – \$60,000.

Ground-source systems have been used effectively in multi-purpose recreation facilities and can be configured to simultaneously serve the heating and cooling needs of different areas. Examples of facilities in which these systems have been used include swimming pools, gymnasiums, day care centres, running tracks and offices.

## 4 Heat Recovery

### 4.1 Introduction

There are many sources of heat produced by society that are underutilized or deliberately discarded. Sometimes this is due to location of the heat, difficulty or expense associated with using it, lack of awareness that it has value as a heating resource or lack of awareness of how to utilize it. Often this heat is wasted simply because using gas or electricity for our heating needs has been cheaper and more convenient.

Increasingly, however, there is a greater awareness of the value of waste heat sources, and with higher energy prices and new technologies, it is easier to cost-effectively make use of them. Waste heat recovery is one of the most cost-effective renewable energy forms, and opportunities to take advantage of this untapped resource can be found all around us.

#### Key Benefits of Using Heat Recovery:

- Makes use of energy that would otherwise go to waste
- Many different sources of waste heat
- Generally cost-effective
- Well established, proven technologies

### 4.2 Heat Recovery Opportunities

The most obvious way to take advantage of waste heat is to recover it directly from a high temperature source, such as an industrial facility. Although this is the simplest method of heat recovery, it is not likely to be applicable to most local governments.

Industrial facilities often use waste heat for other internal processes, or are located too far away for recovery to be practical. In addition to industrial sources, there are many other potential heat sources which may not be as obvious.

#### 4.2.1 Exhaust Air Heat Recovery

Most buildings have exhaust air systems that remove odours and contaminated air from certain areas such as washrooms, laboratories and workshops. Buildings that have a large

requirement for fresh air (e.g. swimming pools, theatres) must exhaust large amounts of air. In all of these cases, the air being removed is at room temperature, while it must be replaced with air of a different (often colder) temperature from the outdoors. By using a heat exchanger, the exhaust air can be used to heat or cool the incoming fresh air.

A heat recovery ventilator (HRV) is a small self-contained exhaust air heat recovery system generally used in houses and practical for smaller municipal offices. New houses that are well built with tight construction require a ventilation system to bring in fresh air (often through the furnace) to avoid mould and other health related issues. Use of an HRV will reduce costs associated with heating this fresh air. HRVs are a requirement of R2000 houses, and generally good practice for any new house being built. They provide good indoor air quality without sacrificing energy efficiency.

An HRV typically costs between \$500 and \$1000 for a residential system, and installation may cost a similar amount. While one of the principal benefits of an HRV is improved indoor air quality, savings will also accrue and are estimated at about \$150 – \$250 annually, with a payback of six to ten years.

Exhaust air heat recovery systems can capture between 30 and 80% of the available heat, depending on the type of system. The best applications are in buildings with central exhaust fans (rather than lots of small individual exhausts) and 100% fresh air fan systems. For local government buildings, the most likely candidates for this technology are recreation facilities, theatres, maintenance shops and sewage treatment plants. Ideally the exhaust and fresh air supply ductwork will be in close proximity. In existing buildings, the feasibility of heat recovery will depend on the existing systems and their configuration. For new buildings, systems can be designed from the start with heat recovery in mind, thereby reducing the cost.

### 4.2.2 Heat Recovery from Refrigeration Systems

Large-scale refrigeration systems, such as those found in ice rinks or refrigerated warehouses, generate a large amount of heat as it is extracted from the ice or frozen goods. This waste heat is typically rejected to the atmosphere. There is often an opportunity, especially in ice rinks, to make use of this heat for space or water heating.

Heat rejected from refrigeration systems is a fairly low temperature heat source, typically around 30°C. This can make it difficult to use, as building heating systems are often designed to operate at temperatures of 60° – 80°C. In an ice rink facility, there are many uses for low temperature heat, however, including ice melting, frost prevention and preheating of fresh air. Space heating can also be done using radiant heating systems or water loop heat pumps. With the addition of equipment such as heat pumps or desuperheaters (heat exchangers in the heat pump, typically used to heat water), heating domestic water up to 60°C can be achieved. Payback varies, but for new construction it is generally in the 2–4 year range.

Typically, an ice rink will have more waste heat available than is required by the building. As such, it may be practical to use the recovered heat in another building. Swimming pools are the ideal situation for this, as they have large heating loads, can utilize low temperature heat, and are often located in the same vicinity. To maximize the usage of waste heat, a heat storage system such as a ground field may be considered to store the recovered heat until it is needed. See the preceding chapter for more information on heat pumps and ground-source heating.

### 4.2.3 Combustion Heat Recovery

Older natural gas boilers typically operate at a combustion efficiency of 80–82%. The remaining 18–20% of the energy is lost up the chimney flue. Flue temperatures are generally kept high to prevent corrosion from flue gases. It is possible to extract heat from these hot flue gases by installing a heat exchanger, sometimes called a flue gas economizer.

Depending how much heat is extracted, flue gas temperatures may drop to the point where condensation occurs. This results in very efficient operation, but requires special corrosion resistant components.

Flue gas heat recovery is only practical on large, existing boiler plants. Steam systems are ideal, as they have high flue temperatures and a steady flow of low temperature boiler feed water. In new construction, this technology is generally not applicable, as condensing boilers with manufacturer certified efficiencies of +95% are now available at a lower cost.



Heat recovered from natural gas-fired boilers heats the Vancouver Aquatic Centre swimming pool.  
*Source: City of Vancouver*

There are likely not many applicable systems for this technology in local government operations, but older or large facilities may be candidates. The City of Vancouver has installed one of these systems in the Vancouver Aquatic Centre, with the recovered heat used to heat the swimming pool. A case study is available from Natural Resources Canada on this project.

### 4.2.4 Wastewater Heat Recovery

Wastewater collected from showers, sinks and toilets is not very hot, but it *does* contain useful heat that can be extracted, particularly if heat pumps are used to raise the temperature. Heat can be extracted from wastewater at various points in the collection and treatment process, including as the water drains from a sink or shower, sanitary pipes

within buildings, sewage pipes in the ground, or at a wastewater treatment plant.

### Sewer Heat Recovery

The simplest form of wastewater heat recovery is the use of greywater heat recovery on sanitary drain pipes in buildings. There are a number of commercially available systems, which work by running cold water through a pipe wrapped around the sanitary pipe. When water flows down the drain, it pre-heats the incoming cold water prior to it entering the hot water tank.



Heat recovery chillers at Okanagan College  
*Source: Community Energy Association*

For houses, these systems save about 25% of the hot water bill, or about \$50 – \$60 annually, with an anticipated payback of two to five years on specific products. Return on investment is better in multi-unit residential buildings, where a single unit could serve multiple suites, or in facilities with a high hot water load (e.g. many showers), such as recreation centres.

Heat can be extracted from main sewer pipes, using either a pipe wrapped around the sewer pipe or heat exchangers inside the sewer pipe. Water temperatures in sewer pipes are much lower than within buildings, so a heat pump would be needed to raise the temperature to a useful level.

Heat extracted from sewer pipes could then be used in a low temperature district heating system (see the Whistler case study, above). This type of system has been used in Europe and Japan, but is untested in Canada. It is under consideration by a number of BC

### Case Study: Okanagan College

In 2003, Okanagan College was undertaking a comprehensive energy retrofit of the KLO Road Campus in Kelowna. College staff expressed an interest in utilizing waste heat from wastewater treatment to heat the College buildings. Adjacent to the College the City of Kelowna owns a wastewater treatment plant which discharges clean water at temperatures between 12° and 22°C throughout the year. Although this water is not hot enough to provide heating directly, the College proposed to use heat pumps to extract energy from the plant.

The existing campus heating system utilized hot water boilers 24 – 40 years old, nearing the end of their life expectancy. These boilers provided hot water to all the campus buildings. An engineering feasibility study recommended a new hybrid system consisting of heat pumps and new high efficiency boilers. The heat pumps are capable of meeting the entire heating load when the outdoor temperature is above freezing, and 60% of the overall heating requirements. Two of the existing boilers were kept in place for use on very cold days.

Wastewater is pumped from the wastewater treatment plant to the college boiler plant, a distance of approximately 500 metres. This piping system was the most significant cost in the project, and any further distance would likely have made it unfeasible. After heat is extracted from the water, it is returned to the treatment plant and discharged. Besides providing heat, the wastewater is also used as a source of cooling for three campus buildings.

The total project cost was approximately \$1.5 million, with annual savings of \$100,000. At 15 years, this is a fairly long simple payback. However, when life-cycle costing is considered, there is an overall financial benefit over the life of the equipment. In addition, providing a replacement for the aging boiler plant was an important consideration for the College. The project was included as part of the comprehensive retrofit, and was operational in 2004.

municipalities. The most likely application of sewer heat recovery for local governments is as part of a broader low temperature district heating system.

## **Sewage Treatment Plant Heat Recovery**

Large volumes of water are discharged from sewage treatment plants, with temperatures typically ranging from 12° – 22°C. This is a large source of low grade heat that can be extracted using heat pumps and used to heat nearby buildings or in a district heating system.

Although heat recovery from sewage is a relatively new concept, a system of this type is being used to heat the Okanagan College campus in Kelowna, and is proposed for the Athlete's Village district heating system in Whistler.

Heat recovery is a possibility for most local governments that have wastewater or sewage treatment facilities. Limiting factors will be the proximity of buildings to the treatment plant. To be cost-effective, the plant should probably be within 500m of adjacent buildings or district heating pipes.

## **4.3 Applications for the Community & Local Government**

Heat recovery is the low-hanging fruit of renewable heat sources, and opportunities to use it abound. As the value of waste heat is recognized, this area is receiving increased interest and attention. For information on local government mechanisms to encourage use of heat recovery in your community, and getting started, see Chapter 6.

### **4.3.1 Residential Buildings**

Heat recovery ventilators are generally used in houses and smaller buildings. While they are effective in all situations where there is a temperature differential, they are of particular value to those areas of the province that experience significant variation between the internal and outside air temperatures.

A wastewater heat recovery system for multi-unit residential buildings is an elegant, efficient solution for preheating domestic hot water. The technology is simple and can be applied to both new and existing building stock.

### **4.3.2 Commercial & Institutional Buildings**

Heat recovery from exhaust air is applicable to most commercial and institutional buildings, with those that require large amounts of ventilation air being the best candidates. In addition, larger facilities and operations that use large-scale refrigeration systems, including food storage/processing centres and warehouses with refrigeration units, would benefit from the use of exhaust air heat recovery systems.

The best opportunities for heat recovery from wastewater are in buildings with high domestic hot water loads. Enterprises such as laundromats, car-washes, hotels and hospitals would all benefit from the application of this technology. In all planned construction, these systems should be integrated from the design phase to ensure proper functioning.

Local governments can encourage companies producing waste heat to locate near those with a heat requirement, and vice versa. Such 'eco-industrial networking' has good potential for community economic development.

### **4.3.3 Local Government Operations**

Flue gas heat recovery is a practical application in larger municipal and public buildings which have large boiler plants. Any public institution that discharges large amounts of water, including sewage treatment plants and showers in swimming pool change rooms, is a good candidate for wastewater heat recovery.

## 5 Solar Energy

### 5.1 Introduction

The sun is the most significant source of energy available on earth. The total solar energy that reaches earth each day dwarfs all other forms of energy used by humans. Given its abundance, solar energy is vastly underutilized as an energy source. It is clean, plentiful, renewable and easy to access. Solar energy can go a long way to meeting the heating needs of communities.

It is sometimes thought that solar heating is not appropriate in BC, due to cold temperatures and lack of sunshine. While the Canadian climate may not be as optimal for solar heating as Florida or Mexico, an enormous quantity of solar energy still reaches us throughout the year.



There are four main methods of using solar energy: solar water heating, solar air heating, passive solar heating and photovoltaics for electricity generation. Solar water and air heating, as well as passive solar design are discussed in this Chapter. Photovoltaics are discussed in the *Electricity* Module.

#### Key Benefits of Using Solar Energy:

- Clean, renewable energy source
- Available through most of the province
- Financially viable over life-cycle
- Can be applied at a small or large scale
- Well established, proven technology

### 5.2 How Does It Work?

#### 5.2.1 Solar Water Heating

The sun's energy can heat water either for domestic or commercial water use, or for indoor space heating.

Solar water heating is accomplished by using solar collectors to heat water (or a water/antifreeze solution) as it passes through the collector. Solar collectors consist of rows of copper or plastic tubing mounted on a panel. A pump and heat exchanger transfer the hot water to a storage tank. This pump is often controlled by a solar photovoltaic panel since the pump requirements match the sunshine available. If the water is not hot enough (on very cloudy or cold days), electricity or gas may be used to provide additional heat.

Solar collectors are typically mounted on a building roof, away from objects or structures that might shade them. Some collectors are motorized and able to track the direction of the sun, but as these mobile systems involve a high cost, most collectors are fixed in place. As a rule of thumb, solar collectors should face south and be mounted at an angle equal to the latitude (e.g. 50° above horizontal for Vancouver), but collectors mounted at slightly different angles or directions can also function well.

There are three main types of collectors:

- **Glazed collectors** are insulated on the back and sides to keep the heat in. On the front they have a glass (or clear plastic) cover which allows the sun to enter the collector. The air inside the

collector heats up and helps to keep the water in the tubes hot. This allows them to be used even when outside air temperature is cold. Glazed collectors are appropriate for applications where water temperatures of 30° – 70°C are required, such as domestic hot water, space heating or year-round swimming pools. Glazed collectors are the most common type of solar collector used in Canada.



Evacuated tubes are commonly used in commercial facilities

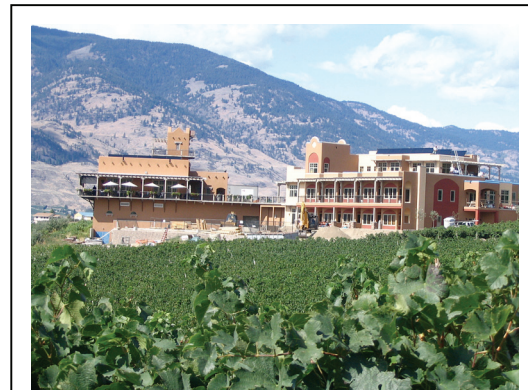
Source: Swiss Solar Tech Ltd.

- **Evacuated tube collectors** have liquid-containing tubes encased in a glass vacuum tube. This provides very good insulation for the tubes, virtually eliminating heat loss, and enables them to generate very hot water even in cold climates. They are considerably more expensive than glazed collectors.
- **Unglazed collectors** have no glazing to keep the heat in. For this reason they will only work in relatively warm weather, when less heat is lost to the outside air. They are appropriate for heating water up to a temperature of about 30°C. These types of panels are most often used for heating residential swimming pools, which only operate in summer and do not require very hot water. The main advantage of this type of collector is its low cost.

Solar hot water systems can also be used for space heating particularly with in-floor radiant heating systems. In the past solar hot water systems have most often been used for heating swimming pools or domestic hot

water, as these loads are continuous year-round. However, there is increasing interest in the use of solar hot water systems for space heating or even for cooling. Such systems work best in milder climates, and usually need to be backed up by a secondary heating system.

Regardless of the application, some form of storage is almost always required, since sunshine is not consistent. For swimming pools, the pool itself may be used for storage, but in other applications, a storage tank will be required. Depending on the system, a source of backup heat is usually required for periods of low sunshine.



Burrowing Owl Estate Winery and Guest House, Oliver — Ground-source and solar hybrid system: 30 solar panels for domestic hot water, building heat and ground-loop support

Source: Swiss Solar Tech Ltd.

## 5.2.2 Solar Air Heating

Sunlight can be used to heat air required for ventilation, prior to its entry into a building. This is done by suspending a large, dark coloured metal panel on the south face of a building. The panel is perforated with small holes which allow the air to pass through. Sunlight heats the panel, which in turn heats the air as it passes through the holes. The air is drawn up the side of the building, gathering heat, to a fan intake near the roof. In summer, when heating is not required, a bypass allows air to enter the fan intake without passing through the panel.

A solar air heating system has the added benefit of reducing heat loss through the wall that the panel is mounted on. This is because

heat lost through the wall is re-captured by the air flowing past it. In summer, the panel also helps keep direct sunshine off the wall, thereby reducing cooling loads.



Solar wall at Seaquam Junior Secondary School in Delta, BC  
 Source: Conserval Engineering Inc.

Solar air heating is most commonly used in industrial facilities, as these have large ventilation requirements and wall areas without windows or shading. Any facility with a requirement for heating of ventilation air and a south (or close to south) facing wall may be a candidate for this technology. In new buildings, solar air heating panels can take the place of exterior cladding, offsetting some cost. Solar air heating systems are also available for houses, though the market is less well-established than for industrial facilities.

### 5.2.3 Passive Solar Design

The way a structure is designed, the materials that go into its construction and cladding, and its orientation (e.g. north-south or east-west) can have a significant impact on a building's heating and cooling requirements. The goal of a building that has been designed with passive solar heating in mind is to capture heat within the material of the building and to slowly release it when the sun is not shining.

Building design considerations for passive solar heating will always include an emphasis on south facing windows and the inclusion of appropriately sized thermal mass (such as masonry, concrete or adobe) in the walls and floors. The building's thermal mass will act as a solar collector, heat storage or battery and distribution system.

One of the most cost-effective ways to reduce energy use without increasing construction costs is by incorporating passive solar design. Any building can be constructed using passive solar design principles. As relatively unobstructed access to the sun may be a challenge in dense urban areas, however, incorporating this design principle into new neighbourhoods and areas with large lots may achieve the greatest gains. Passive solar design is an evolved science and when properly employed has the potential to significantly reduce the amount of energy required to heat the building. Thoughtful passive solar design which is integrated with appropriate solar access protection may be one of the key ways to meet heating requirements in the future.

### 5.3 Cost of Solar Systems

The cost of solar systems can vary significantly based on geographic location, collector type, and how much of the total load is intended to be met by solar. In new construction, costs are lower and may be offset by reductions in the cost of conventional heating equipment (e.g. boilers). The following examples are guidelines to the cost and payback of solar heating in different applications:

Residential pool system, unglazed collectors	\$4,000	7–9 year payback
Residential domestic hot water system, glazed collectors	\$5,500	25–35 year payback
Municipal pool	\$100,000 – \$200,000	8–12 year payback
Solar air, industrial	\$120,000 – \$150,000	3–5 year payback

### 5.4 Applications for the Community & Local Government

There are many applications for solar heating, both water and air, throughout the community and in local government operations. For information on local government mechanisms to encourage use of solar water and space heating in your community, and getting started, see Chapter 6.

### 5.4.1 Residential Buildings

Residential buildings, whether multi-unit or a single house, are good candidates for solar water heating due to their high consumption of domestic hot water compared to non-residential buildings. For houses, a typical system consists of two to four collector panels located on the roof, with a storage tank next to the regular hot water tank, which provides backup. For multi-family buildings, it is necessary that there be a common domestic hot water system, rather than individual hot water tanks in each unit.

Outdoor residential swimming pools are a good application for unglazed collectors. As these pools are usually only used seasonally, unglazed collectors can provide sufficient heat to maintain temperatures throughout the summer and extend the useful season from the spring into the fall.

New and retrofitted houses are introducing solar-heated water for space heating, e.g. through in-floor water coils.

### 5.4.2 Commercial & Institutional Buildings



102 solar panels and heat recovery system, heating water for the hotel, on the roof of the Best Western Inn, Kelowna. In addition to solar technology, the system recovers waste heat from the hotel's air conditioner to help heat the water in summer.

*Source: Swiss Solar Tech Ltd.*

In the private sector, buildings with high domestic water loads such as hotels, laundromats, car washes and hospitals

#### Case Study: Best Western Inn, Kelowna

In 2000 and 2001, the Best Western Inn, located in Kelowna, installed 102 solar hot water collectors on its roof and two five-ton heat pumps into its basement. In 2004, the hotel installed a 55 ton ground-source heat pump. This kind of alternative energy installation is the first of its type on a Canada-based hotel.

Once the sun heats the water-glycol solution contained in the roof-top solar collectors, this energy is transferred via a water-to-water heat exchanger, to heat hot water for the hotel's 147 guest rooms, hot tubs and a swimming pool. In conjunction with the heat pump, the hotel is able to produce 100% of the energy needed to heat its water and significantly lower the electrical bills for cooling during the summer. During the winter, the system provides 20% of the total energy needed for heating, with the hotel's boiler supplementing the system at that time. Savings to the hotel are estimated at \$32,000 per year.

The total cost of the 2000-2001 installation was \$258,000, of which \$200,000 was the cost of the solar hot water system. \$53,000 of the total was defrayed by a federal Renewable Energy Deployment Initiative (REDI) grant. The ground-source heat pump cost \$80,000.

Additional water heating is provided through the hotel's chiller and laundry waste heat recovery systems. Heat produced by the hotel's 100-ton air conditioner is used to help heat water in summer and a heat exchanger, connected to the laundry's drying vents, is used to heat the water for the hotel's washing machines. The energy required to run the laundry is further reduced, as the hotel uses water extractors to remove the maximum amount of moisture from the laundry before it is dried and, once in the drier, a moisture control setting ensures that dryers run for as short a time as possible.

More than 90 tons of carbon dioxide is saved from going into the atmosphere as a result of the systems installed in the hotel, based on the natural gas that is displaced by renewable alternatives.

*Source: Swiss Solar Tech, CanSIA*

provide the best opportunity for solar hot water systems.

Space heating using solar-heated hot water is also a possibility, and is best incorporated from the outset in the design of new buildings.

For solar air heating, warehouse and industrial facilities with high ventilation requirements are the best candidates. Not only is there available wall space, but the lower wall insulation typically found in these types of buildings means a greater benefit will be experienced in recovering wall heat loss.

### 5.4.3 Local Government Operations

Energy consumption is one of the major costs at swimming pools in municipal recreation centres. Public swimming pools are one of the best uses of solar hot water systems for local governments. They have steady, year-round loads, require relatively low temperatures and domestic hot water requirements are also quite large, adding to the available load. Swimming pools also have large roof areas, providing a good location for the collector panels. Outdoor pools with only seasonal use may be able to make use of unglazed collectors to reduce costs. Other buildings with high domestic hot water loads, such as recreation centres, are also good candidates for solar water heating.



Energy saving Conserval SolarWall on the City of Toronto Vehicle Maintenance Garage. The south wall of the building is covered with 613 square metres of solar cladding. The system has reduced heating costs, enhanced indoor air quality and improved the overall appearance of the building.

Source: City of Toronto

### Case Study: Hyde Creek Recreation Centre, Port Coquitlam

In 2004, the City of Port Coquitlam completed an energy retrofit of its Hyde Creek Recreation Centre by installing a high efficiency boiler, heat recovery system and a solar thermal system.

42 solar thermal panels were installed, primarily for use in heating domestic water, but with the capability of heating the pool in the future. Two heat reclaim units were also installed to recover some of the heat lost through pool evaporation. One unit redirects recovered heat back to the pools, while the other directs its recaptured energy to heat hot water for the facility.

This retrofit resulted in a 44% reduction in natural gas consumption and total annual cost savings of \$40,000 – \$50,000. Savings from the solar panels are estimated at \$4,000 annually. The City of Port Coquitlam worked with the following partners: British Columbia Infrastructure Project, Coral Engineering and Quantum Lighting. It received additional assistance from the Renewable Energy Deployment Initiative (REDI).

Source: Greater Vancouver Regional District

While solar hot water systems can also be used for space heating in almost any type of building, space heating with solar is more difficult and expensive than simply heating domestic water. Space heating based on solar hot water may be more appropriate for new buildings than for existing buildings, where the system can be carefully integrated into the initial building design.

Solar air heating can be used wherever there is a south facing wall and a high ventilation load. This could include recreation facilities or offices with separate ventilation fans.

Wastewater treatment plants are good candidates for solar air heating as they have large air exchange requirements and walls without windows. Again, solar air heating is most cost-effective when incorporated into the design of new facilities.

## 6 Local Government Mechanisms & Getting Started

### 6.1 Bylaws, Policies & Other Mechanisms

The use of renewable energy to create heat, at an individual or district scale, may be encouraged through the use of regulatory or policy instruments and non-financial incentives. While the following are explored in greater detail in the *Governance, Utilities and Financing* Module, consider the bullets listed on this page as part of your local government renewables implementation toolkit:

- **Review governing and policy documents**, including (where applicable) Regional Growth Strategy documents, Official Community Plans and Neighbourhood Plans. Consider how energy-related issues are — or are not — reflected.
- **Update these documents** to clearly and directly include your community's support for energy efficiency, conservation and renewable energy. Where appropriate, include reference to specific technologies, for example ground-source heat pumps or a biomass system, in particular neighbourhoods.
- **Create guidelines** to ensure quality and consistency in the installation and use of renewably fuelled infrastructure.
- **Look at current and future land use patterns**. Are there areas in which densification could be encouraged or energy synergies (between heat producer and consumer) could be fostered? Where is district heating an opportunity?
- **Consider whether you have the capacity and interest to pursue the creation of a heating utility** where there is district heating potential. Who are the potential partners? What are the options for establishing a utility? How might the local government want to be involved?
- **Review rezoning requirements** to determine how rezoning portions of a neighbourhood, for example, might

encourage the use of renewable sources of energy or connection to a district heating system.

- **Include restrictive covenants requiring the use of renewable energy** in all parcels sold by local governments. Build these provisions into any subsequent Master Development Agreements.
- **Revise the building permit system** by expediting and charging a more favourable fee for developments that are connected to a district heating system or that incorporate renewable heating technologies.
- **Consider density bonus zoning** in exchange for the creation of, or connection to, renewably-fired heating systems (including a district heating system).
- **Update municipal procurement policies** to include greenhouse gas reduction targets and renewable energy requirements so that you are walking the talk.
- **Consider a comprehensive educational campaign**. Information dissemination for developers, builders and the public, relating to renewables and the importance of its inclusion in the energy mix of your community is an invaluable component of local government action. Various provincial Ministries have produced fact sheets and backgrounders to help you with this.

### 6.2 Getting Started

#### 6.2.1 Choosing Appropriate Sources of Renewable Energy

Whether for district heating, one-off building applications, for neighbourhoods or the community-at-large, various renewable energies have different applications. Some of the renewable energy technologies described in this Module, including heat pumps and ground-source energy as well as many forms of heat recovery and solar heating, will work in any jurisdiction. Biomass, biogas and water-source heat pumps may be less viable,

depending on whether or not the resource is actually available in or near the community.

To help determine potential for using various renewable energy sources for heating in your community, conduct an assessment of which renewable sources of fuel are potentially relevant.

1. Is there a source of free or low-cost biomass or biogas nearby, and on a sustainable basis?
  - Biomass (woodwaste)
  - Biogas (agricultural waste)
  - Municipal solid waste (landfill)
  - Landfill gas (landfill)
  - Digester gas (wastewater treatment plant)
2. Is there land available for a heat producing facility?
  - Biomass (woodwaste)
  - Biogas (agricultural waste)
  - Municipal solid waste
  - Landfill gas
  - Digester gas
3. Is the air temperature most often above -10°C?
  - Air-source heat pump
4. Are there opportunities for a district heating system to transfer heat to nearby buildings?
  - Ground-source heat pump
  - Municipal solid waste
  - Landfill gas
  - Digester gas
5. Are there new large-footprint facilities (such as a recreation facility, a school, mall or hospital) slated for development?
  - Ground-source heat pump
  - Heat recovery opportunities
  - Passive solar design
6. Are there existing large-footprint facilities (such as a recreation facility, a school, mall or hospital) that can be retrofit?
  - Ground-source heat-pump (if hydronic heating is currently used)
  - Wastewater heat recovery
  - Solar hot water
  - Solar air heating
7. Is there unobstructed access to the sun and if so, can it be preserved?
  - Solar hot water
  - Solar air heating
  - Passive solar design
8. Is there a sewage treatment plant nearby?
  - Heat recovery
  - Digester gas
9. Is there a landfill site nearby?
  - Municipal solid waste
  - Landfill gas
10. Is there a public swimming pool or recreational facility?
  - Solar hot water
  - Heat recovery opportunities
11. Is there an ice rink in close proximity to other heat-using infrastructure?
  - Heat recovery opportunities

### 6.2.2 District Heating

To look further into the potential for a district heating system in your community, consider taking the following first steps:

1. Consider whether a district heating system is appropriate for your community:
  - Is there a source of free or low-cost fuel nearby, such as waste wood or landfill gas?
  - Is there a new development being proposed with a number of buildings that could be connected to a system?
  - Are there any buildings or facilities with a relatively large year-round need for heat?

- Are there a number of buildings within close proximity to each other?
  - Is there a major load (i.e. hospital, shopping mall, recreation centre, industrial facility) that can serve as a primary customer to anchor the project?
  - Are key buildings on the system easily converted to district heating? (Buildings with boilers and hot water heating are easiest to convert.)
2. Contact critical partners to determine whether there is any interest in developing a district heating system. This could include the local mill, if woodwaste is the fuel source; a stockyard for manure and the landfill if biogas is being considered; private partners to provide specialized technical assistance; and key potential customers.
  3. Establish a working group to collaborate on the project. This group should include local government staff and at least one elected official, as well as key partners, utilities and potential customers.
  4. Investigate sources of funding for the preliminary scoping study. CEA's guide, *Funding Your Community Energy and Climate Change Initiatives*, provides an up-to-date reference for available funding and may be downloaded free-of-charge, from [www.communityenergy.bc.ca](http://www.communityenergy.bc.ca).
  5. Contact the relevant regulatory authorities (such as the BC Safety Authority, Ministry of Environment, etc.) and other partners, such as the Ministry of Economic Development, to involve them from the earliest stage possible.
  6. Launch a scoping study to determine whether it is worthwhile doing a further feasibility study. Determine how much of this can be done by local government staff, instead of a consultant. Some of the items that can be done in-house include:
    - Determining the availability of waste heat/fuel;
    - Contacting local building owners to assess their interest, their existing heating systems and their annual heating bills;
    - Plotting potential customers and piping routes on municipal plans, and determining the distance between potential customers for heat.
  7. Contact the Community Energy Association. CEA can provide information on district heating systems including case studies, contact names and funding sources. CEA can also help with the initial assessment, making a proposal to Council or hiring the right consultant. Natural Resources Canada and the Canadian District Energy Association are other useful sources of information.

# Annex I: Canadian Examples of District Heating Systems & Other Neighbourhood Heating Systems

## A. Existing District Heating Systems in Canada

The following are examples of district heating systems in use across Canada. A number of conventionally fuelled systems are included here, as the heat distribution infrastructure used by a natural gas fuelled boiler is comparable to that of a renewably fuelled system. Further, in many cases a natural gas fired boiler can either be converted to a renewably-fuelled boiler or, when the boiler reaches the end of its useable life, swapped for a renewably fuelled system.

Location	Type of System	Notes
City of Revelstoke Revelstoke Community Energy Corporation	District heat — Biomass (woodwaste)	British Columbia's first renewably-based district heating system, using waste wood to heat the city center. Community Energy Association 2004 Energy Aware Award winner. <a href="http://www.cityofrevelstoke.com/edc/energyproject-announcement.htm">www.cityofrevelstoke.com/edc/energyproject-announcement.htm</a>
City of Okotoks Drakes Landing Solar Community	District heat — Solar hot water	Solar heated hot water super charges the ground. This energy is extracted for space heating in the winter. <a href="http://www.dlsc.ca/about.htm">www.dlsc.ca/about.htm</a>
City of Vancouver Central Heat Distribution Ltd.	District heat — Natural gas	Central Heat Distribution Ltd. provides steam heat to buildings in downtown Vancouver.
City of North Vancouver Lonsdale Energy Corp.	District heat — Natural gas	Mini-plants located in parking garages throughout the precinct heat water which is circulated through the downtown energy district. <a href="http://www.cnv.org/server.aspx?c=2&amp;i=98">www.cnv.org/server.aspx?c=2&amp;i=98</a>
Sherwood Park, AB Centre in the Park Community Energy System	District heat — Natural gas	Hot water district heating system that can be converted to use alternative fuels (including biomass) once/if economical. <a href="http://www.strathcona.ab.ca/Strathcona/Whats+New/News+releases/2005/March+2005/Community+energy+system+to+be+developed.htm">www.strathcona.ab.ca/Strathcona/Whats+New/News+releases/2005/March+2005/Community+energy+system+to+be+developed.htm</a>
City of Markham Markham District Energy Inc.	District heat & electricity — Natural gas	Cogeneration system which operates with high efficiency boilers and chillers. <a href="http://www.markham.ca/markham/channels/newscentre/newsreleases/040603_gmifund.htm">www.markham.ca/markham/channels/newscentre/newsreleases/040603_gmifund.htm</a>
City of Windsor District Energy Windsor	District heat and cooling — Natural gas	This system was the first in North America to supply both district heating and cooling. <a href="http://www.wuc.on.ca/index.asp?scn=65000&amp;sub=65100">www.wuc.on.ca/index.asp?scn=65000&amp;sub=65100</a>
City of Greater Sudbury Sudbury District Energy Corporation (SDEC)	District heat & electricity — Natural gas	A 5MW natural gas fired cogeneration plant, which produces 4.4 MW of heat in the form of steam for seven different steam hosts in downtown Sudbury. <a href="http://www.summitconnects.com/Articles_Columns/Summit_Articles/2001/special_focus/PPP/Sudbury_energy.htm">www.summitconnects.com/Articles_Columns/Summit_Articles/2001/special_focus/PPP/Sudbury_energy.htm</a>
City of Toronto West Don Lands / East Bayfront	District heat — Natural gas	The Toronto Waterfront Revitalization Corporation (TWRC), a corporation of the City of Toronto, is pursuing the development of a district energy system to serve the West Don Lands and East Bayfront. Large urban infill projects will be comprehensively serviced with new infrastructure. The district energy system will be comprised of a central energy plant, a piped distribution system and energy transfer stations at individual buildings. A single central energy plant is proposed to serve both the West Don Lands and East Bayfront. The plant would be designed in a way that would enable its capacity to be expanded incrementally to coincide with the development of the precincts. <a href="http://www.toronto.ca/legdocs/2006/agendas/committees/pof/pof060918/it044.pdf">www.toronto.ca/legdocs/2006/agendas/committees/pof/pof060918/it044.pdf</a>
City of Toronto Downsview Park (PDP)	District heat — Natural gas (diesel fuel backup)	PDP owns steam plant, which includes 4 gas fired water tube boilers and the distribution system. <a href="http://www.pdp.ca/The_Plan.408.0.html">www.pdp.ca/The_Plan.408.0.html</a>
City of Cornwall Cornwall Electric	District heat & electricity — Natural gas	This is the first municipally owned hot water district heating/cogeneration system in Canada. It was created in 1995 and currently heats approximately 14 buildings including hospitals, schools, a library and senior citizens' residence. <a href="http://www.greenlearning.ca/climate-change/policy/index.php?section=6&amp;sub=1">www.greenlearning.ca/climate-change/policy/index.php?section=6&amp;sub=1</a>

## B. Existing Ground-Source Neighbourhood Heating

The following are British Columbia examples of developer-driven initiatives to use ground-source heat pumps to heat and cool planned neighbourhoods, *using either* individual or district ground-source fields.

Location	Type of System	Notes
City of Kelowna Wilden Estates	Individual heat & cooling — Ground-source heat pumps	All homeowners in this planned community are encouraged to use individual ground-source heat pumps to heat and cool their houses. <a href="http://www.wilden.ca/geothermal.htm">www.wilden.ca/geothermal.htm</a>
City of Chilliwack Halcyon Meadows	Neighbourhood heat & cooling — Ground-source heat pumps	An open-loop ground water main runs through the complex, and connects to individual heat pumps used by residents to heat and cool their homes. <a href="http://www.halcyonmeadows.com/geothermal.htm">www.halcyonmeadows.com/geothermal.htm</a>
Kamloops First Nation Reserve Sun Rivers Development	Individual heat & cooling — Ground-source heat pump	Multi-utility concept including individual heating and cooling services from individual units in each residence. Provided by developer-owned utility. <a href="http://www.sunrivers.com/geothermal/golf-geothermal-heating.shtml">www.sunrivers.com/geothermal/golf-geothermal-heating.shtml</a>

## C. District Heating Systems in the Planning Stage

The following is a selected list of planned district heating systems across Canada, organized geographically from West to East.

Location	Type of System	Notes
City of Richmond	Planned district heat — Ground-source heat pump and heat recovery	The City is planning a new 2,500-unit mixed-use development to be built on municipally owned land next to the new Olympic speed-skating oval. Heat for the system may come from ground-source heat pumps and heat recovered from wastewater and the Olympic speed skating oval.
Grande Prairie Aqatera Utilities Inc	Planned district heating and electricity – Biomass cogeneration Preliminary feasibility study completed. Implementation plan under development.	Aqatera is undertaking the business development work required to establish a district heating system in Grande Prairie. The system is expected to distribute heat to approximately 30 buildings (including public municipal and provincial facilities, schools and the hospital), with the first customer connection scheduled for fall 2008. A recently completed biomass-fuelled Combined Heat and Power (CHP) plant owned by Canadian Gas & Electric will provide steam, which will be purchased by Aqatera to provide heat for the system. <a href="http://www.fcm.ca/english/media/press/aug92006.html">www.fcm.ca/english/media/press/aug92006.html</a>
City of Toronto Regent Park District Energy	Planned district heating — Natural gas (with potential to convert to renewable)	Toronto Community Housing Corporation (TCHC) is designing a district heating system for Regent Park, located near the West Don Lands (see above). It is expected to be similar to or form part of the West Don Lands Project.
City of Halifax	Planned district heat — Natural gas	It is expected that a district heating project, planned for the City of Halifax, will involve construction of a natural gas-fired combined heat and electrical power plant on Halifax's peninsula. Waste energy from the plant will be utilized to provide heat to the universities and hospitals through an underground distribution system. <a href="http://www.halifax.ca/mediaroom/pressrelease/pr2005/050817CommunityEnergyProject.html">www.halifax.ca/mediaroom/pressrelease/pr2005/050817CommunityEnergyProject.html</a>

## Resources

### Community Energy Association (CEA)

CEA provides assistance with all kinds of issues relating to energy planning, energy efficiency and renewable energy for local governments in British Columbia. See [www.communityenergy.bc.ca](http://www.communityenergy.bc.ca), for access to resources such as:

- *Renewable Energy Guide Modules: Governance, Utilities and Financing and Electricity*
- *Funding Your Community Energy and Climate Change Initiatives*
- A Tool Kit for Community Energy Planning in British Columbia

### Other Helpful Resources

#### BC Sustainable Energy Association

[www.bcsea.org](http://www.bcsea.org) and [www.solarbc.org](http://www.solarbc.org)

In addition to detailed information on sustainable sources of energy and their applications (available at [www.bcsea.org](http://www.bcsea.org)), BCSEA runs the 100,000 Solar Roofs program in BC, providing information to help communities integrate residential solar water heating on a broad basis.

#### Canadian District Energy Association (CDEA)

[www.cdea.ca](http://www.cdea.ca)

CDEA is an industry association representing member utilities, government agencies, building owners, consulting engineers, suppliers, developers, bankers and investors who share a common interest in promoting the growth of district energy in Canada.

#### Canadian Bioenergy Association (CANBIO)

[www.canbio.ca](http://www.canbio.ca)

CANBIO is a national, industry-driven, non-profit organization of individuals, businesses and non-governmental organizations interested in the development, promotion and use of bioenergy.

#### Canadian GeoExchange Coalition (CGEC)

[www.geo-exchange.ca](http://www.geo-exchange.ca)

CGEC is an industry body representing the interests of the ground-source heat pump industry in Canada.

#### Canadian Solar Industries Association (CANSIA)

[www.cansia.ca](http://www.cansia.ca)

CanSIA is a federally registered not-for-profit association whose membership is comprised of individuals, companies and governments sharing an interest in solar technology.

#### Centre for Sustainable Community Development (CSCD)

[www.sustainablecommunities.fcm.ca/home](http://www.sustainablecommunities.fcm.ca/home)

The Federation of Canadian Municipalities CSCD offers financial services and resources to Canadian municipal governments to improve environmental performance and reduce greenhouse gas emissions.

#### GeoExchange BC

[www.geoexchangebc.ca](http://www.geoexchangebc.ca)

GeoExchange BC is a provincially-based organization that represents the interests of the ground-source heat pump industry in BC. It provides information, case studies and a service directory for the geo-exchange industry in BC.

#### Light House Sustainable Building Centre

[www.sustainablebuildingcentre.com](http://www.sustainablebuildingcentre.com)

Light House is an enterprising non-profit society dedicated to advancing and catalyzing sustainability in British Columbia's built environment. It is a resource and display centre and offers a range of free and fee-based programs and services out of its Vancouver-based office.

#### ManureNet

<http://res2.agr.ca/initiatives/manurenet>

Agriculture Canada hosts a useful website which provides information on anaerobic digestion of animal waste.

## **Natural Resources Canada (NRCan)**

[www.nrcan.gc.ca](http://www.nrcan.gc.ca)

NRCan provides a variety of information on renewable energy heating technologies as well as downloadable, technical guides. RETScreen is a free software tool to help you evaluate possible renewable energy projects:

[www.retscreen.net](http://www.retscreen.net). NRCan also operates the Refrigeration Action Program for Buildings, which can provide advice and pilot programs for energy efficiency in ice rinks, including heat recovery. Particularly useful websites include the renewable energy network ([www.canren.gc.ca](http://www.canren.gc.ca)) and sustainable buildings and communities ([www.sbc.nrcan.gc.ca](http://www.sbc.nrcan.gc.ca)).

## **Pembina Institute**

[www.pembina.org/index.php](http://www.pembina.org/index.php)

The Pembina Institute is an independent, not-for-profit environmental policy research and education organization. Its major policy research and education programs are in the areas of sustainable energy, climate change, environmental governance, ecological fiscal reform, sustainability indicators, and environmental impacts of the energy industry.

## **SmartGrowth BC**

[www.smartgrowth.bc.ca/index.cfm](http://www.smartgrowth.bc.ca/index.cfm)

SmartGrowth BC is a provincial, non-governmental organization devoted to fiscally, socially and environmentally responsible land use and development. It works with community groups, businesses, municipalities and the public, and advocates for the creation of more livable communities in British Columbia.

## References and Further Reading

### **Advancing Geexchange Energy Systems: Is There a Role for BC's Municipalities?**

Zeeg, T., UBC School of Community & Regional Planning (2006)

### **Finnie Distributing (1997) Inc. (Case Study)**

Canadian Renewable Energy Network (2003)

[www.canren.gc.ca/renew\\_ene/index.asp?CaId=47&PgId=1121](http://www.canren.gc.ca/renew_ene/index.asp?CaId=47&PgId=1121)

### **Case Study: Vancouver Aquatic Centre**

Natural Resources Canada (2005)

<http://oee.nrcan.gc.ca/publications/infosource/pub/ici/eii/m92-242-2002-8e.cfm?attr=20>

### **Community Energy Planning (Vol 1)**

Natural Resources Canada (2005)

[www.sbc.nrcan.gc.ca/documentation/communities/volume\\_1.pdf](http://www.sbc.nrcan.gc.ca/documentation/communities/volume_1.pdf)

### **Conservation Potential Review**

BC Hydro (2002).

[www.bchydro.com/info/reports/reports856.html](http://www.bchydro.com/info/reports/reports856.html)

### **GeoExchange: A Climate Control System From the Ground Up**

Piechowski, M., (2000)

[www.geoconnections.com.au](http://www.geoconnections.com.au)

### **Heating and Cooling with a Heat Pump**

Natural Resources Canada, (2005)

<http://oee.nrcan.gc.ca/publications/infosource/pub/home/heating-heat-pump/booklet.pdf>

### **Heating Communities with Renewable Fuels: The Municipal Guide to Biomass District Energy**

Maher, T. and Penny, J., prepared for Natural Resources Canada and United States Department of Energy (1999)

### **Price of Solar Water Heating in Canada**

CanSIA Issue Report (2006)

[www.cansia.ca/downloads/report2006/C20.pdf](http://www.cansia.ca/downloads/report2006/C20.pdf)

### **Renewable Energy Technologies in the Lower Mainland: Planning for Passive Survivability**

Brown, C. UBC School of Community & Regional Planning (2006)

### **RETScreen Clean Energy Project Analysis Software**

This free software is available for analysis of a wide variety of energy systems powered by renewable sources.

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

### **Whistler 2020: Moving Towards A Sustainable Future**

Resort Municipality of Whistler (2005)

[www.whistler.ca/content/view/full/154/203/](http://www.whistler.ca/content/view/full/154/203/)

### **Whistler Legacy Development District Earth Energy Feasibility Study**

Cobalt Engineering (undated)

[www.cobaltengineering.com/projects/sustainable-design/whistler-athletes-village-des-feasibility-study/](http://www.cobaltengineering.com/projects/sustainable-design/whistler-athletes-village-des-feasibility-study/)

