COMMUNITY ENERGY:

PLANNING, DEVELOPMENT & DELIVERY – STRATEGIES FOR THERMAL NETWORKS

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

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Brad Bradford is the Community Energy Planner at IDEA, and supports the Association's initiatives in the Canadian market. Brad is working with Canadian communities, government agencies, and project proponents interested in deploying district energy systems to support more resilient city-building, increase economic competitiveness, and drive urban intensification. His research and project work focuses on the intersection of land-use planning, urban form, and density as catalysts for efficient thermal energy solutions. Brad holds a Master of Arts in Planning from the University of Waterloo.

The International District Energy Association (IDEA) is a nonprofit trade association founded in 1909 to promote energy efficiency and environmental quality through the advancement of district heating, district cooling, and combined heat and power (CHP). IDEA works to foster the success of over 1700 association members who are DE executives, managers, engineers, consultants, and equipment suppliers from 25 countries.

IDEA strives to advance community energy planning principles and support the development of thermal networks across Canada, recognising that many organisations are working towards these common goals. This publication is intended to augment an expanding body of resources. IDEA also seeks to promote thought leadership on the development of district energy, support the international transfer of knowledge and industry expertise, connect district energy practitioners with each other and with progressive stakeholders, and increase the thermal energy marketplace across Canada.

Please visit www.districtenergy.org for more information.

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EXECUTIVE SUMMARY

District energy (DE) – what the future holds:
– more efficient use of resources;
– community-based economic engine;
– safe, secure, and reliable energy;
– affordable, high-quality thermal services;
– attractive local environments;
– livable towns and cities.

District energy is the local production and distribution of thermal energy. It is a highly efficient means of providing locally generated thermal energy for heating and cooling residential, commercial and institutional buildings, and industrial processes. District energy systems comprise three main elements:

- A connection into the building or industrial process.
- A network of insulated pipes to distribute the thermal energy from the central plant to the buildings.
- A central energy plant containing equipment that produces thermal energy in the form of steam or hot water for heating, or chilled water for cooling. The central plant may also incorporate combined heat and power (**CHP**) units which produce electricity and useful thermal energy.

These three elements work together as an integrated system. The steam, hot water, and/or chilled water that is distributed can provide a range of services to building owners, including space heating, domestic hot-water services, and cooling. The nature of the service required and other local conditions will determine the most appropriate medium (hot water or steam) to carry the thermal energy.

District energy is a proven means of meeting demand for these services. It is well established in many Canadian cities, including Toronto, Montreal, Vancouver, Ottawa, London, and Calgary, and is widespread in countries across Europe and Asia. It delivers a range of social, sustainability, environmental, and economic benefits by providing reliable, efficient, affordable, and clean thermal energy from locally controlled and highly efficient central plants. In Canada, most systems are fired by natural gas but, due to scale, have the flexibility to utilize multiple fuel sources and to harness waste heat from industry as well as local renewable resources, such as geothermal, large-scale solar thermal, and biomass. Many technologies using these fuels may not be technically or economically feasible for individual buildings. However, a **district energy network** provides the means to combine the energy demands of many buildings to achieve the economies of scale needed to make these fuels practicable.

Rising to the challenge

Municipal leaders across the country are facing growing economic, social, and sustainability challenges and are increasingly interested in local energy production as a means of addressing them. The resilience of energy infrastructure in the face of extreme weather events is a particular concern. Community leaders responsible for framing strategic approaches to energy are looking to develop and champion local energy projects, but may feel they lack the knowledge and expertise to do so. Drawing on the experience of communities in Canada and abroad, this *Community Energy Development Guide* has been developed to help and guide them.

Figure 1: Plant room stacks.
Photo credit: ENMAX Corporation

PREFACE

> District energy provides a wide range of benefits for communities. These can be broader than simply matters of energy generation, distribution, and supply.

Energy can be a significant driver for the health and welfare of residents, and the growth and development of business, as well as energy stability for cities and communities of all sizes. Until recently, for a majority of property owners, businesses, and local governments, energy has been little more than a utility and a bill to pay. Similarly, land-use planners and property developers have not needed to be concerned about the energy requirements of tenants, residents, and building owners. But the growing cost of traditional energy arrangements; concern about national and local energy security; and the possible threat of climate change are increasingly focusing attention onto local energy opportunities.

In a number of provinces and territories, access to low-cost, long-term capital, and other energy and environmental policies, have opened up unprecedented opportunities to make money, replace cut budgets, and put assets to more productive use, while meeting wider social and environmental objectives. To take advantage of these benefits, many communities, municipalities, and other public sector organizations, as well as businesses and landowners, are actively considering becoming energy producers as well as consumers by developing energy projects themselves, or forming partnerships with the private sector to develop more sustainable properties and communities.

Assessing the potential value and impacts of local energy in order to become a project champion, sponsor, or developer requires a general understanding of the opportunities. A perceived lack of skills, money, or understanding of the project development process can seem daunting obstacles. Crucially, public project managers will need to adopt the commercial approach of a private developer. Land-use planning has a role to play in supporting project proponents (PPs) in the early stages by mapping energy opportunities and making data available. This guide is intended to help project proponents through the entire development process.

Global and local considerations

The world is in a period of growing energy insecurity, and municipal and business leaders are focusing attention on improving the energy resiliency of their towns and cities. Systemic high prices per barrel of oil, geopolitical pressures and supply uncertainty, coupled with political instability in parts of the world with a high proportion of available reserves, are keeping oil prices high and increasing the volatility of the global energy market. Environmental regulations are reducing the viability of coal for power generation and, while exploitation of **shale gas** reserves has softened natural gas prices recently, concerns over extraction techniques and the impact on clean water supplies may affect future supplies and prices. The March 2011 tsunami tragedy and nuclear plant meltdown in Fukushima, Japan, has slowed a nuclear resurgence and even led countries like Germany to reduce dependency on nuclear for electricity. Developing local infrastructure with high-efficiency generation, exploiting locally available energy resources, enhances the energy security of local communities, and shields them from the negative impacts of rising and volatile global energy markets.

Preparing for such instability also increases economic competitiveness. Cities and communities that take steps to improve their energy security and resilience are more attractive to businesses, which provide employment for residents who will, in turn, be attracted by a lower-cost, less polluting, and more secure energy supply. This economic vibrancy is enhanced through an economic multiplier effect, as cash that would otherwise leave the area to pay for outside energy supplies is kept within the local economy to be spent on local goods and services. This strengthens the local tax base, enabling the municipality to provide high-quality services to residents and businesses.

Ultimately, the consideration given by elected officials and community leaders to maintaining the economic attractiveness of their areas will be reflected in other aspects of the public realm. Compact communities that integrate a diversity of uses and density of buildings enhance the opportunity for district energy, and provide the densification that reduces sprawl and supports good public transit systems. A diverse and compact community provides residential, civic, retail, cultural, and entertainment facilities, all within easy, “walkable” distances. This, together with district energy, adds up to a high-quality and attractive place to live and work. The community of Hammerby Stoljad, Sweden, provides an excellent example of an integrated approach to addressing the energy, water, and waste requirements of the city. Economic competitiveness is increasingly about the ability to attract and retain intellectual capital. Highly skilled, talented people seek out attractive local environments in which to live and work and raise their families.

District energy

District energy is a long-term investment to improve the physical infrastructure of the community it serves. It consists of a network of underground pipes carrying hot water, steam, or chilled water from a central plant to the buildings using the service. Many established **district heating (DH)** projects in Canada use steam as the carrying medium, while new developments tend to use hot water. There are pros and cons to each approach, which are typically determined by local conditions. The heat supplied to buildings can be employed for space heating or domestic hot water, or be converted to chilled water for cooling.

District energy networks offer a complementary infrastructure to other energy networks. They can exploit a variety of fuel sources, both fossil and renewable, such as natural gas, oil, coal, biomass, geothermal, large-scale solar thermal, and waste to energy. They are also able to capture and distribute surplus heat from industrial processes and power generation that would otherwise be wasted. Heat networks aggregate the thermal demand of multiple buildings to a scale that enables the use of technologies with higher efficiencies, or ones that may not be economical to deploy at the individual building level, such as biomass, waste to energy, or CHP, also known as **cogeneration**. While natural gas has been, and is likely to remain, the preferred fuel choice in urban areas of Canada due to increased availability and favourable emissions profiles, many CHP plants can operate on a variety of renewable fuels, such as municipal waste, landfill gas, and digester gas. For rural communities, the local availability of bio-derived fuels has made these fuels the principal choice.

Electrical generation in Canada is primarily produced in large power and hydro plants remote from the towns and cities where the electricity is required. The efficiency of electricity production from all fossil fuels in Canadian public electricity plants is 38%[1]. Shifting the generation of electricity from very large power plants many miles from most customers, to community-scale plants (5–50 megawatts) closer to populated areas allows the heat that is normally wasted by dumping in oceans, lakes, and rivers to be captured and distributed to buildings through district energy systems. This means there is no longer any need to burn fuel in individual buildings for heating and, as the electricity is generated closer to where it is used, less electricity is lost during transmission and distribution – such losses in the U.S. were estimated at 6.6% in 1997 and 6.5% in 2007[2]. If this shift is well managed, it can also help ensure energy is more affordable to consumers.

Instead of building large power stations at great distances from our towns and cities, establishing a smaller CHP plant within, or adjacent to, urban areas can offer significant benefits. CHP refers to a plant that generates both electrical and thermal energy in a process that can achieve efficiencies of 80% or even higher. These CHP plants offer the flexibility of using different fuel types. Integrating thermal storage with CHP allows electricity and heat production to be decoupled so that chilled water or heat produced by the CHP unit during periods of peak demand for electricity can be stored and used later during peak thermal demand periods. This avoids the need to burn extra fuel to meet these peaks.

Additionally, if electric boilers are included, they can be used to balance periods of over- and underproduction of electricity from generators and intermittent resources like solar and wind turbines, reducing stress on the grid. Over- and underproduction periods are reflected in the volatile wholesale price of electricity, which can fluctuate wildly between negative and positive. Plant rooms incorporating CHP units with back-up boilers, electric boilers, and thermal storage can respond to the wholesale price signal and play the market and, thus, provide balance in the grid, while simultaneously providing secure thermal energy and power services to the local area. This reduces stress caused by congestion on the grid and also reduces transmission and distribution losses, improving overall efficiency and providing better energy security.

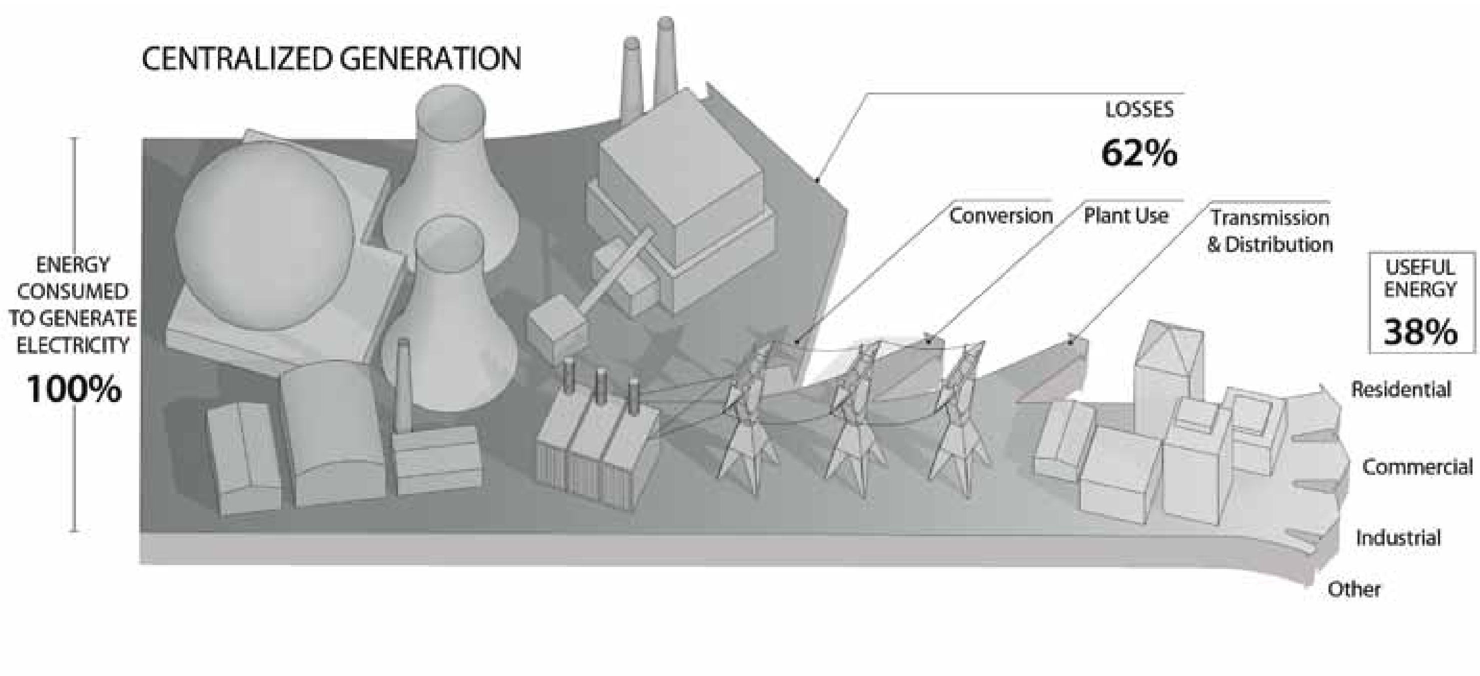


Figure 2: The typical centralized power generation process wastes approximately two-thirds of primary energy in the form of heat rejected into the atmosphere. District energy captures this heat and is 80–90% efficient.

Local opportunities and resources

Thermal energy can be transported over long distances. Major district energy networks in Europe (Paris, Berlin, Copenhagen, Stockholm, and Helsinki) extend over 50km in length. Established district energy networks are found in the central business districts of larger cities such as Montreal, Ottawa, and Vancouver, and are growing in cities and communities such as Markham and Calgary. In Toronto, the district energy system has a grid network of over 42km of underground piping supplying 522 megawatts thermal equivalent of heating capacity from three gas-fired steam plants, and 72,000 tons of cooling capacity, sourced primarily from a deep lake water system. Toronto's district heating system services over 150 buildings in the downtown core and the cooling network serves over 60 buildings[3].

However, district energy systems can be deployed in smaller towns, campuses, and planned developments, where the density of thermal energy demand is sufficient to support the commercial development of the infrastructure. As the central production and distribution of thermal energy are inherently local activities, district energy helps communities identify opportunities to deploy local resources, such as biomass from forestry (particularly in rural communities), tree clippings, or waste wood from construction or demolition; or local sources of heat, including geothermal, wasted industrial heat, and municipal waste to energy.

Incorporating district energy encourages land-use planners to shape building development in a way that supports its use by, for example, locating producers of excess heat next to users of heat, or developing buildings with a high heat density in a linear fashion to facilitate the building of a shared heat "spine" main. Likewise, district cooling systems can be built to provide chilled water for air conditioning where there is a density of multiple-use buildings.

District energy may not be suitable in all locations. This guide will help proponents identify opportunities where district energy may be feasible, and so avoid inappropriate investment.

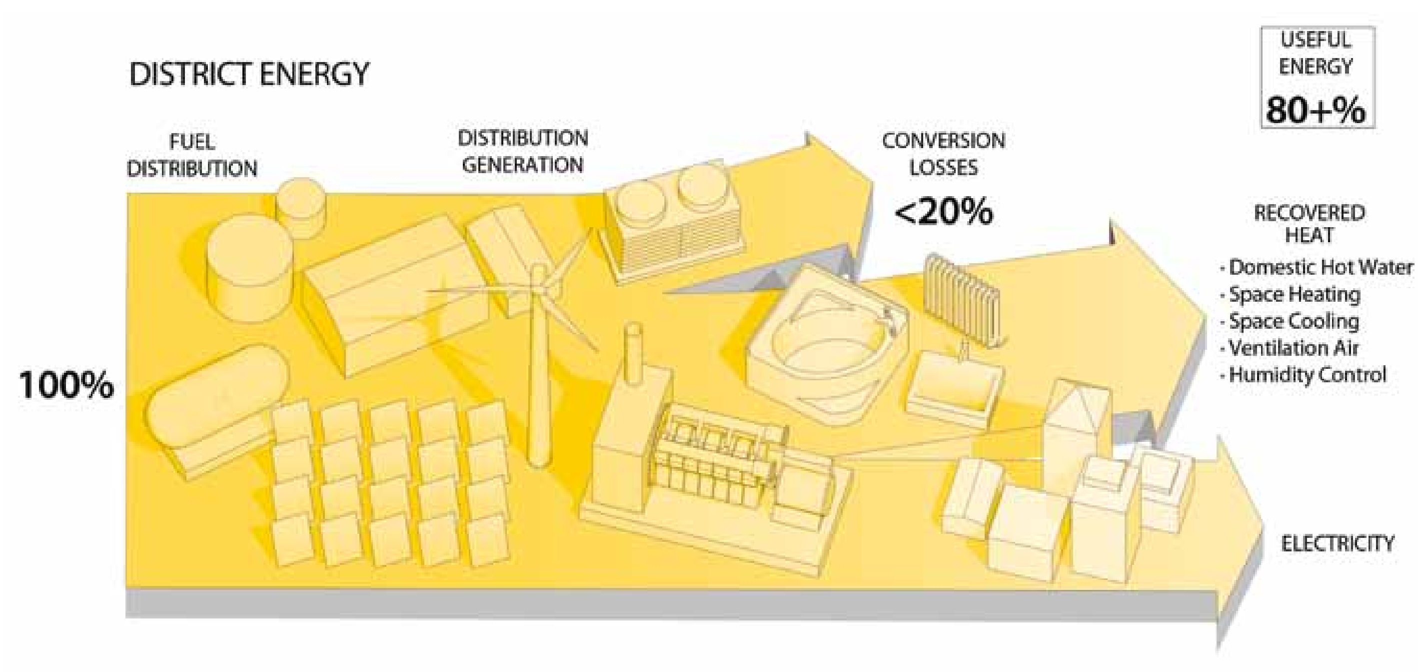
Energy infrastructure for resilient towns and cities

For towns and cities, finding secure, safe, reliable, and resilient sources of energy to support and drive growth in our urban centres will be one of the greatest challenges of this century. The University of Toronto Centre for Resilience and Critical Infrastructure defines resilience as "…that essential ability of an operation to respond to and absorb the effects of shocks and stresses and to recover as rapidly as possible normal capacity and efficiency."[4] Resilience is a response to the future, not the past.

Historically, municipal infrastructure was built on the assumption of 50 to100-year extreme weather events, floods, or other natural disasters. Unfortunately, that paradigm no longer stands. With increasingly frequent and intense weather events, the threat to critical infrastructure service interruption continues to escalate. Going forward, municipalities will need to undertake the critical task of planning and building for such events in a way that provides the capacity to absorb their shocks and stresses.

Worries over the economic disruption caused by increasingly frequent, climate-induced severe weather events and escalating carbon emissions are adding urgency and uncertainty for policymakers seeking to mitigate and adapt to the potential impacts of climate change. A University of Waterloo report[5] (June 2013) prioritizes Canadian city infrastructure as the primary concern and recommends that: "all infrastructures be assessed and addressed at the local community level, where adaptation to a changing climate is most effective", as "the cost of identifying and addressing infrastructure vulnerability to a future climate during construction is much cheaper than the cost of restoring infrastructure after it has been damaged".

In 2013, severe flooding events shut down the major urban centres of Calgary and Toronto, prompting the evacuation of residences and the closing of businesses for several days. Less than a year previously, Hurricane Sandy ravaged the Northeastern United States, destroying houses and disabling



Illustration, copyright AEI / Affiliated Engineers, Inc.

critical infrastructure with an economic loss of more than $50 billion[6]. District energy infrastructure not only ensures that communities can ride out storms like these, but can recover more rapidly afterwards, reducing restitution costs and minimizing the loss of business revenues, which are a growing concern for insurers: “The Insurance Bureau of Canada is warning people of the ‘unequivocal’ evidence of climate change and is urging the public and governments to take the changing weather patterns seriously”. (CBC News, February 23, 2012.)

These issues highlight the need to develop energy infrastructure at a local level, to maximize resource efficiency and exploit indigenous energy opportunities. Concerns over urban resilience in response to the 1998 Québec ice-storm led to the establishment of a district energy network in Markham, Ontario. More recently, the 2003 blackout saw large areas in Ontario and Québec without power.

Co-Op City, located in the Baychester section of the Bronx, is the largest cooperative housing development in the United States, comprised of more than 14,000 apartment units, 35 high-rise buildings, seven clusters of townhouses, eight parking garages, three shopping centres, a high school, two middle schools, and three grade schools for 60,000 residents. These buildings are primarily served by a 40GW CHP on-site district energy system. While much of New York City was without heat and power for weeks after Hurricane Sandy, the Co-Op City community delivered uninterrupted heat and power to residents. Herb Freedman, a principal of Marion Real Estate, Inc. stated, “Hurricane Sandy hit Co-op City about as hard as it hit most anywhere else in New York City, but everybody in Co-op City had (heat and) power before, during, and after the storm.”

Research from the C40 Cities traces the majority of GHG emissions to cities, primarily from three sources: heating and cooling buildings, transportation, and electricity generation[7]. David Miller, former Mayor of the City of Toronto, sees district energy as a means to achieve critical emission reductions while providing an enhanced level of urban resilience: “The general idea is to conserve, manage demand, and create a system of distributed small-scale generation – like neighbourhood-based district energy. Such a system can lower emissions and create a system that’s far more resilient in the face of disasters.” Linking district energy plants as nodes within a strategic energy framework provides a means for diversity in supply, redundancy, and adaptability.

Without a doubt, developing community-based district energy systems is a critical component of the city building process, requiring deliberate action from any municipality serious about increasing their capacity to respond to future shocks and stresses.

Benefits

– ***High efficiency, low cost:*** Producing and distributing thermal energy at a local level is inherently efficient in converting primary energy into usable energy, particularly when combined with power generation through CHP. This higher efficiency leads to lower costs over the long term, especially when using local fuels.

– ***Flexibility and resilience:*** The ability of district energy networks to take heat from multiple sources, fuels, and technologies makes it very flexible. Communities have a more secure energy supply as they are not solely dependent on a single source or imported fuel supplies. Developing district energy networks alongside gas and electricity networks improves their energy resilience. District energy networks allow town and city managers to secure the optimum supply position. Lastly, district energy systems “future proof” communities, since new and emerging technologies like heat pumps, fuel cells, or biofuels can be easily and rapidly retrofitted, without the need to install equipment in each building.

– ***Local control:*** Local operational control also ensures that investment decisions are being made close to the point of impact. Thermal energy services can be delivered through a variety of business vehicles, including local municipal companies. These can later be transferred into the private sector by the sale of shareholding. Large utilities and multi-national companies are also interested in developing such businesses as for-profit entities.

Alternatively, thermal energy services can be delivered through community-owned, not-for-profit **special purpose vehicles (SPVs)**. This allows surpluses to be taken as revenues by local municipalities to help deliver other front-line services. Or, by putting an asset lock on SPVs, it is possible to ensure that surpluses are re-invested in the business to extend the networks into areas with lower returns, or to engage in demand-reduction projects, for example insulating customer buildings or updating control schemes.

– ***Reducing carbon emissions:*** High resource efficiency in using fossil fuels, and the ability to make use of renewable fuels, reduces carbon emissions. This will make a local contribution to the global threat of climate change.

Figure 3: Internal of plant room. **Photo credit: ENMAX Corporation**

WHO IS THIS GUIDE FOR?

Project proponents (PPs) will come from different positions. Each will have their own specific objectives and varying opportunities, resources, and levels of understanding.

This guide is intended for use by elected municipal officials, government energy, economic development and sustainability officials, and land-use planners, who can be project champions or sponsors. Land-use planners and community economic development officials also need to consider energy as part of any area of development as they seek to make communities, towns, and cities more energy efficient. They need to be able to identify energy opportunities and commission projects. This requires a certain level of understanding in order to ask the right questions, understand recommendations, and choose the optimum solution. Public project managers will need to develop the commercial approach of private developers. This guide will help them do so.

About this guide

This guide will help land-use planners and project proponents, both public and private, to:

- understand and create or influence energy maps (see pages 9 and 21) and other information for use in an **official plan** or **secondary plan**.
- gain an understanding of energy use in buildings and developments;
- recognize where there are opportunities for district energy projects, and understand the value of incorporating thermal energy considerations in planning efforts;
- translate energy opportunities into financially sustainable and deliverable projects;
- understand the stages of developing an energy project and who is involved in each stage.

What is in the guide?

Energy must be considered by a wide range of public and private land-use project proponents – for commercial, residential, and industrial developments. Growing interest in developing a community's energy resilience and reducing reliance on sources of energy from outside the region is making local energy more attractive to communities across Canada.

Each project proponent has specific and varying objectives, opportunities, resources, and levels of understanding of the technologies available. This guide contains the information needed to recognize and understand the opportunities that will best meet their objectives. The main focus is on two kinds of energy supply systems: district energy, including district heating and district cooling, and combined heat and power (CHP), but is relevant to low- and zero-carbon energy in general.

Project proponents may prefer to delegate key parts of the process, or even the whole job, to consultants or companies that specialize in energy projects. However, it is important that the customer has a sufficient level of knowledge to understand and assess the recommendations made by the consultant.

Types of project proponents

This guide describes the complete process from project inception to delivery for six broad categories of project proponent.

— ***Local governments:*** Local municipalities can sell thermal energy and electricity and become an energy utility in their own right. This presents a unique opportunity to generate new income and fund wider objectives. It is crucial that public sector proponents understand and adopt a commercial approach to district energy projects, more commonly associated with private sector proponents. Although district energy projects can deliver a number of societal and environmental benefits, they must be financially viable, and economically sustainable over the long term. Therefore, a pragmatic commercial approach should be adopted.

— ***Communities:*** District energy provides the opportunity for communities to come together and reap the benefits of energy generated on their doorstep. A growing number own, manage, and financially benefit from low- and zero-carbon energy, while setting themselves up with secure energy supplies.

— ***Other public sector proponents:*** For example, city or provincial public housing authorities and their private sector partners are major builders and building operators. They, too, can profit from energy projects and play a key role in providing anchor loads (see page 20).

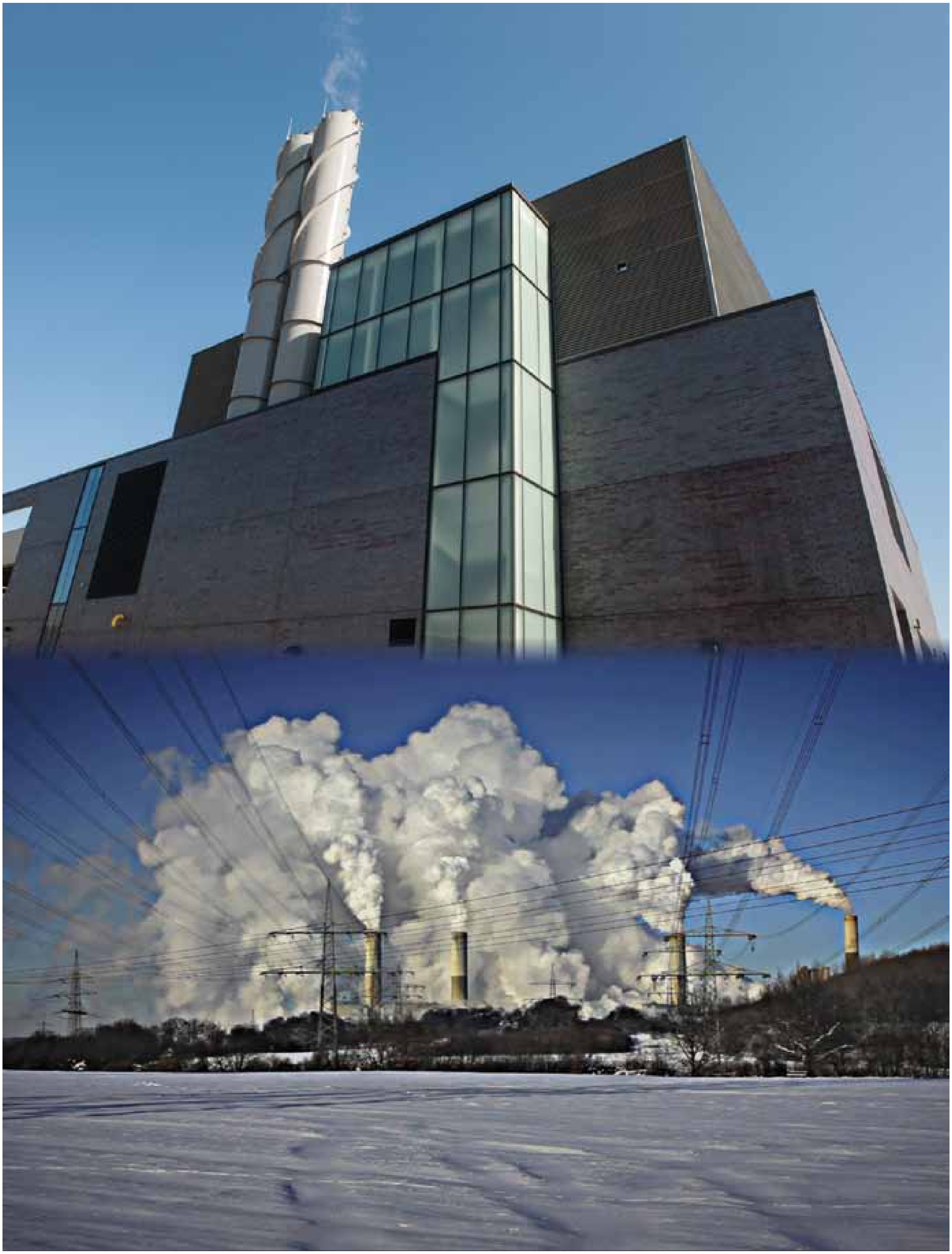


Figure 4: Markham District Energy operates highly efficient district energy and CHP in the Bur Oak Energy Centre at the Cornell Centre, Markham, Ontario (top picture) to capture and use the heat that is wasted by typical central power generation (bottom picture).

Top photograph courtesy of Markham District Energy Inc.

— ***Institutions:*** Universities, colleges, and healthcare providers have historically relied on district energy networks to produce highly reliable, efficient, and lower-carbon energy services to entire campuses, often comprised of 150 to 200 buildings.

— ***Property proponents, landowners and building operators:*** In meeting building code obligations, these types of proponents may need to provide energy solutions for buildings, on-site energy networks, or land for energy centres. They also may need to contribute financially to the expansion of projects via planning obligations and connection charges.

— ***Private sector proponents:*** **IDEA** members include many companies which are able to offer a range of approaches, from contracting to deliver specific elements, to total project development, operation, and ownership.

Each of these proponents may play more than one role in a project, and there can be numerous points of entry into the stages of development. For example, a municipality might set an area-wide energy vision and play the role of champion or project sponsor, so the section on energy maps (page 21) will be of particular relevance. Equally, a municipality that owns land and assets may wish to invest them in developing projects themselves. Municipalities and other public sector proponents may be key to the viability of a project simply by making anchor loads (see page 20) available. A community could decide to take an energy opportunity and cede some or all of the stages of development to third parties. A property proponent might see a project through all ten development stages (see page 10), or only deliver a small part of a larger project, perhaps in partnership with a local municipality, energy company, or cooperative. There are many stages of development in district energy projects, and understanding these stages and their progression underpins the development of a successful project.

Energy as part of livable cities

The potential to reduce emissions and energy costs can play an important role in the wider shaping of livable cities, guided by growth and development decisions that ensure that a city's scale, density, and urban design encourage civic engagement across all sectors of the population. In these settings, communities can describe areas where there are opportunities to locate thermal energy facilities close to potential users and link them. Linking sources and users through a district energy network can improve capital efficiency, conserve space, improve operating efficiency through better load management, and create opportunities for community-scale resource conservation and energy efficiency.

By doing this, the city's inhabitants can experience both health and financial benefits compared to traditional generation and delivery of energy. For example, manufacturing facilities may generate excess heat that can be supplied for the benefit of others in a district energy network. Similarly, large, occasional-use facilities, such as convention centres, stadiums, and arenas may allow the redirection of under-utilized energy capacity to surrounding buildings.

Starting points

How do project proponents go about identifying suitable projects or approaches to energy supply? Many communities already have **Climate Action Plans**, and revisiting those to integrate thermal considerations can open up a range of new opportunities. In cities that have a comprehensive plan, or a plan for new development, or redevelopment of a specific area, municipal leaders may be able to consider that plan in the context of local energy generation potential. Many cities are planning new development areas and revitalizing aged industrial areas by undertaking urban renewal or brownfield projects that would benefit greatly from a district energy system. Ultimately, planners and government leaders can identify their community's priorities and use the steps and tools provided in this guide to see how local energy generation can contribute to sustainability and economic goals.

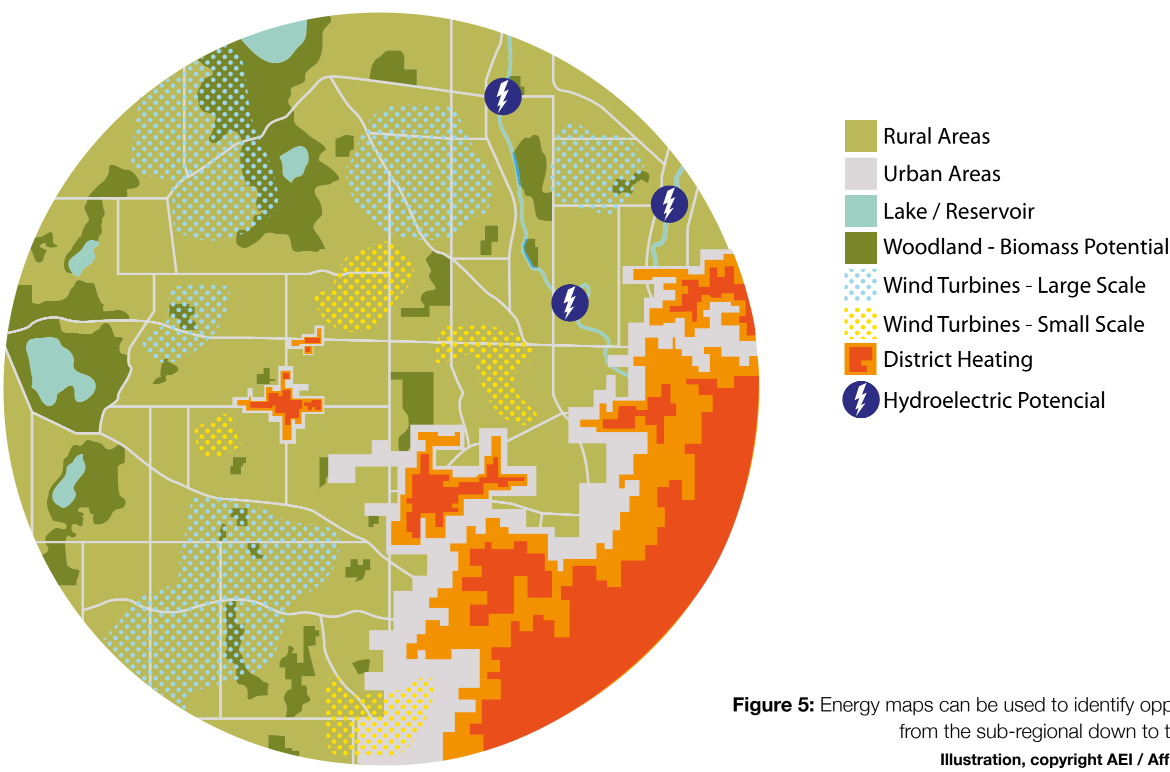


Figure 5: Energy maps can be used to identify opportunities at scales from the sub-regional down to the neighbourhood.

Illustration, copyright AEI / Affiliated Engineers, Inc.

STAGES OF DEVELOPMENT: Introduction

There are ten development stages to follow to bring an energy opportunity to fruition. These are described in detail throughout the rest of this guide.

The stages

The ten stages of development are outlined here. The results of each stage can be used as part of an energy strategy for an area, planning application, or simply as an action plan.

— *Stage 1* considers the objectives frequently adopted by communities and municipalities for district energy projects.

— *Stage 2* covers the types of data that must be gathered, focusing particularly on building density, mix of uses, and anchor loads. It also discusses how this data might be assembled and presented as energy maps to facilitate the planning of thermal networks.

— *Stage 3* looks at how to identify the buildings to be connected to form a district energy project, and what might motivate different types of building owners to commit to the development of the project.

— *Stage 4* then tests what technical option might best meet the energy needs of the buildings comprising the project while meeting the project objectives. This is sometimes referred to as a "high-level feasibility study".

— *Stage 5* subjects the project to a feasibility study. This is a technical exercise to investigate the selected option in detail. It considers the different fuel types and generation options; the configuration of thermal production equipment and storage within the plant facility and its optimum location, network design, and route; and the phasing of development. It will also provide a high-level assessment of the financial viability of the option.

— *Stage 6* develops the financial model for the project. It considers its overall capital cost and operating costs. Potential sources of capital are suggested and revenues listed. Risks to the financial viability of the project are identified with suggestions of how these might be appropriately allocated. The financial model should be subjected to a sensitivity analysis or "stress test" to determine if it is robust.

— *Stage 7* considers different business or commercial models that may be put in place to take the project forward. The relationship with risk and control is discussed, and how these factors can impact the cost of capital.

— *Stages 8, 9 and 10* review the legislative and regulatory environments that affect projects. Consideration is given to procurement routes, commissioning, and delivery.

Figure 6: District energy miniplant seamlessly integrated into the urban fabric of North Vancouver.
Photo credit: B. Bradford, 2011

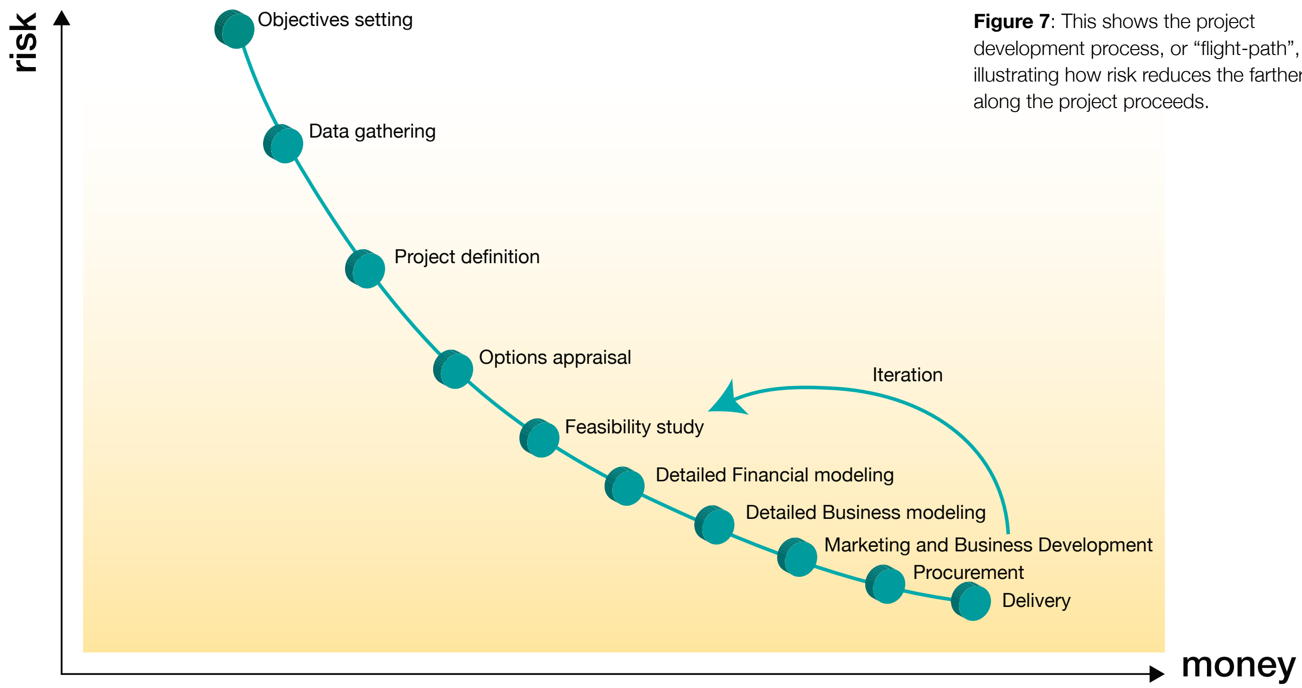


Figure 7: This shows the project development process, or "flight-path", illustrating how risk reduces the farther along the project proceeds.

When to consider energy

In the life of any area, development, or building, there are trigger points when energy should be considered. For example:

- when the heating or cooling system in an existing building is approaching the end of its life and needs replacing;
- when an existing building is being refurbished, or a brownfield environmental cleanup redevelopment is being undertaken, and there is an opportunity to upgrade the building fabric and energy systems;
- when a new building or greenfield development is being planned, particularly transit-oriented developments;
- if a community or building manager has concerns about energy security, price volatility, long-term cost, or simply wants to make a difference;
- if congestion of electricity distribution networks and supply security are issues;
- if a business opportunity to profit from the sale of energy presents itself.

Making the right decision

Generally, an energy system is expected to last between 15 and 40 years, although the underlying infrastructure may last far longer. The choices made at these trigger points can have long-term repercussions. They may lock an owner, occupier, or entire community into one system for a long time, limiting their options in the energy market and tying them in to particular suppliers and equipment. Over time, there will be changes in technology and the supply chain, from which consumers could benefit. This is why flexibility is important and a strategic, long-term perspective on energy supply should be taken as early as possible.

Energy project "flight-path"

People familiar with the development of energy projects, both large and small, follow a well-established approach designed to minimize risk. This approach has a staged trajectory from inception to delivery and forms the basis of the ten stages recommended in this guide (see Figure 7, above).

Overall, the cost of project development can amount to a significant proportion (between 10% and 20% depending on project size) of the total capital cost of delivering the project. Each stage has to be financed, of course, and progressively increases in cost. But the risk of project failure declines as the process progresses. So, while not prescriptive, the ten-stage approach helps avoid spending large amounts of money to no effect, and provides an appropriate sequence of increasing specificity. Much like when landing an aeroplane, as altitude declines as you approach the airport, finer details of the landscape come into view, so the closer a project gets to delivery, the more details come into view, and clarity and scope of the project improve.

Importantly, the stages along the flight-path are likely to be iterative. Although financial and business modelling are carried out in detail later, it is important that they are considered from the start and revisited throughout the process. For example, different investors have different expectations of rates of return, so understanding the business model at the outset is crucial. This is particularly critical in the case where a project proponent has choices of different procurement, financing, and operation models, because technology selections may change slightly or participants may desire comparative scenarios for risk assessment.

CASE STUDY: Achieving a strategic objective in Charlottetown, PEI

Figure 8: District Energy serving Charlottetown, PEI. **Photo credit: Flickr CC Martin Cathrae, 2013**

Charlottetown had three existing district heating systems, built in the 1980s, each with their own plant room containing oil-fired and biomass woodchip boilers and serving the university, the provincial offices and other downtown buildings and a long-term healthcare facility. The province had a long-sought objective to improve its economic resilience by reducing its dependency on oil and electricity from outside the island.

In 1995 the provincial government sold the district heating systems to Trigen Energy Canada Inc. Twenty-eight million dollars was invested in connecting the three systems and constructing a central 72MW capacity energy-from-waste facility, including 1.2MW electricity generating capacity. This is fuelled by municipal waste (41%) and biomass (42%) supplying the base load, with peak load provided by oil (17%) burnt in the boilers retained in the university plant room. The boilers and plant room were also retained at the healthcare facility as reserve capacity. Biomass was originally sawmill residue but, when the sawmill closed, the fuel was switched to woodchip from the local forestry industry. Further system upgrades were made (in 1998) and thermal storage added (in 2004).

The system now provides heating and domestic hot water services to a mix of residential, commercial and institutional customers in 125 buildings via a 17km hot water district heating network. It also supplies steam to a nearby hospital and some cooling to several buildings on the university campus. Revenues derive from heat sales, fees from the municipal waste management company, and the sale of electricity exported to a New Brunswick power utility.

Prince Edward Island has consequently reduced its dependency on imported energy and has boosted its economic performance, calculating that 70 cents of every dollar spent on biomass fuel stays within the local economy compared with only 10 cents for every dollar spent on oil.

In 2007 the system was acquired by Veresen, a Calgary-based energy infrastructure company. It also owns and operates a 100MW district energy system in London, Ontario.

STAGE 1
Objectives setting

STAGE 1 Objectives setting

Defining objectives for the project at the outset will establish a benchmark against which all later decisions can be compared.

1 Defining objectives
All projects must be financially sustainable. Beyond this basic assumption, objectives must be defined from the start. This creates an obligation to address the objectives to be achieved, to align the objectives of different internal departments or external stakeholders, and to deal with any conflicts.

1.1 Main areas
The objectives for an energy project fall into three areas.

1.1.1 Economic considerations
Reducing reliance on imported energy supplies and strengthening local economies through supply diversity and locally available resources is a growing economic consideration for regional and local governments. Energy infrastructure is capital intensive. Developing the infrastructure to exploit locally sustainable energy supplies can involve initial capital investment, where the upfront capital costs of some low- or zero-carbon energy systems can be higher than for traditional energy arrangements in which the infrastructure costs have been paid off. If this cost is passed immediately and directly on to customers (through bills or service charges), the energy may seem non-competitive in the short run. Consequently, innovative financing mechanisms need to be explored to overcome the high capital threshold and spread the costs over a longer term (see Stages 6 and 7). The financial approach will also need to address the lag between investment made during the project's construction and the commencement of revenue flows. This is discussed in more detail on page 40. However, the financial model will need to allow sufficient cash to cover this gap.

In residential settings, lower income households tend to respond to higher bills by reducing consumption, with potentially adverse impacts upon their health and well-being. Prices will probably rise in the medium to long term. Investing in district energy systems will mitigate this impact and help keep the energy rates down and more stable for consumers in the long run. For commercial landlords, it is easier to contract properties with lower energy rates.

At this early stage it is also crucial to understand the project proponent's (PP's) exposure and attitude to risk. This determines the most appropriate business model in respect of the availability of capital (including the assessment of reasonable return) and of the operating risks. This, in turn, will provide the most appropriate method by which affordable energy can be delivered.

During the construction phase, high-quality jobs are generated in infrastructure construction: plant and systems design and construction. During the project's life, it will be valuable to assess the economic multiplier of using local fuels, such as natural gas or renewable fuels, and the impact on the local economy of retaining energy dollars.

1.1.2 Energy security
Energy is vital to modern life, but the fossil fuels society depends on are finite. Growing demand and dwindling supplies mean prices will become more volatile, which could adversely affect supply. Furthermore, most buildings last for 100 years or more. The neighbourhoods in which they sit may last far longer. The tremendous growth experienced in Canada's largest cities over the past decade has placed significant strain on aging electrical infrastructure. Infrastructure upgrades have failed to keep pace with increasing demand, jeopardizing energy security. In some cases, district energy systems have been able to reduce the demand on the electricity infrastructure by providing large portions of the cooling load. A secure energy supply is vital to the occupants and businesses throughout the life, and different uses, of the building or place.

Although discovery of shale gas deposits has softened natural gas pricing in recent years, ongoing growth in demand and environmental concerns will continue to impact our reliance on carbon-based fuels. Global market drivers, including population growth and increased economic growth, as well as urban density in developing nations, will impact market pricing and availability of traditional commodity fuels. However, supply availability and pricing volatility can be mitigated by increased use of locally available fuels, such as wood waste, biomass, geothermal, crop fuels, and certain renewable thermal sources like cold lake water or ocean water for chilling. In addition, for those projects that do

Summary of the strategic options appraisal process

Objectives setting

1. Economic
2. Energy security
3. Environmental

Data collection

1. Understand the energy thumbprint (see page 21).
2. Collect data on the following:
   - existing energy consumption;
   - likely future energy consumption based on rates of new construction, future growth, and improvements to the energy efficiency of existing buildings;
   - the suitability of different low- and zero-carbon technologies;
   - fuel sources and how the energy will be delivered or transported;
   - the pros and cons particular to the location in terms of energy sources, distribution, transport, land use, form, and character.

→ Municipal or project-specific energy map

→ Municipal energy character area (see page 22)

Define project

1. Set out type of project.
2. Identify partners or stakeholders needed to make the project happen.
3. Collect commitments from potential partners and customers.

→ Corporate strategies of municipal, public bodies or private proponents

Appraisal of energy options

For each technology, consider:

1. Scale of the development.
2. Parts of the site served, including connection to surrounding development.
3. Annual energy output.
4. Annual CO_2 emissions reductions.
5. Ability to integrate local or renewable fuel sources.
6. Implications for phasing.
7. Key project delivery requirements.
8. Contribution to regulatory and planning requirements.
9. Indicative benefits, including consideration of revenues.
10. Indicative project costs.

→ Preferred energy strategy

plan on utilizing natural gas, efficiently producing the most energy output from this limited fuel source, through CHP, simply makes good common sense. District energy infrastructure has the flexibility to harness, balance, and maximize the efficient use of all these different available fuel sources.

As standards of living and quality of life increase and consumers are utilizing more electronic equipment, such as computers, home entertainment systems, multiple refrigerators and air conditioning, which increase demand on the regional electricity grid, system reliability is of growing importance. Furthermore, the increased supply percentages of intermittent renewable sources, like wind and solar, are creating balancing and capacity management challenges for independent system operators. By shifting peak electric demand for air conditioning off the electricity grid onto thermal-based chilling, renewable cooling, and thermal storage, the strain on the electricity system can be reduced. In addition, by locating sources of distributed generation, such as CHP, close to load, electric system reliability and national security are enhanced.

For these reasons, public officials are increasingly keen to encourage new and more diverse energy supplies and their efficient use by introducing district energy systems that can use a range of technologies and fuels, and offer greater opportunities for diversity of ownership. They also have the advantage of converting fuel into usable energy more efficiently, thereby reducing CO_2 emissions and saving fossil fuel reserves. Customers benefit from more reliable systems with a higher level of comfort.

1.1.3 Emission reductions

As stated in the Fifth Assessment Report (released September 26, 2013) from the Intergovernmental Panel on Climate Change (**IPCC**), the rise in ocean waters will proceed at a faster rate than we have experienced over the past 40 years. Global mean sea level rise for 2081–2100 is projected to be between 26cm (at the low end) and 82cm (at the high end), depending on the greenhouse emissions path this century.

The scientists say ocean warming dominates the increase in energy stored in the climate system, accounting for 90% of energy accumulated between 1971 and 2010.

For the future, warming is projected to continue under all scenarios. Model simulations indicate that global surface temperature change by the end of the 21st century is likely to exceed 1.5 degrees Celsius, relative to 1850.

The Fifth Assessment Report states that:

"Our assessment of the science finds that the atmosphere and ocean have warmed, the amount of snow and ice has diminished, the global mean sea level has risen and that concentrations of greenhouse gases have increased." [8]

In Canada, there has been no federal legislation enacted into law that defines a cohesive national approach to reducing CO_2 emissions. Although the issue remains relevant at the federal level through ministry activities such as the introduction of gas tax rebates, the majority of activity in the emission-reduction field is taking place at the regional and provincial levels. In particular, the British Columbia carbon tax has driven emission-reduction activities. A recent report[9] found a 17.4% per capita reduction in fuel consumption across all fuels. In addition, the tax shift has resulted in a cut to income and other taxes, resulting in BC having the lowest incomes tax rates in Canada. Similar programs are underway in Québec and Alberta.

Local governments, especially mayors, have agreed that dealing with weather- or climate-related events will largely be their responsibility. Flooding, grid-related power interruptions, water-level rise, and droughts are manifested at the local level. Storm clean-ups and response, depending on the scale and severity, are often managed at a municipal or state level.

The Federation of Canadian Municipalities indicates that:

"Canada's municipal governments are ready to do our part. Not only do we implement policies that generate much of Canada's economic activity and innovation, we play a major role in land-use planning, transportation, water treatment and energy use, making us uniquely placed to drive the shift to a green economy." [10]

Berry Vrbanovic, President, Federation of Canadian Municipalities

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An overwhelming number of mayors with city populations of over 30,000 citizens are committed to using clean energy technologies and energy efficiency solutions to address environmental issues and move forward on energy independence and security objectives. Cutting emissions of greenhouse gases will require substantial infrastructure investment to reduce energy intensity, increase end-use energy efficiency, and move toward lower-carbon solutions. Reaching more sustainable energy and environmental targets will only be achieved if all new and existing buildings and neighbourhoods make a substantial contribution to emission reductions. As climate change objectives increasingly drive municipal policies and decisions, changes to building regulations and standards, such as the Canadian Green Building Council's (see page 58) **Leadership in Energy and Environmental Design (LEED)** or **EcoLogo** certification programs, will be an important influence on the energy decisions of project proponents.

Overall, there appears to be a growing awareness of and desire for lower-carbon energy solutions driven by the acknowledgement that cleaner energy delivers a multitude of long-term economic benefits, particularly at the community level. Energy systems have a major effect on the overall CO_2 emissions of a place or building, so choosing a system with the minimum carbon impact is extremely important.

More efficient district energy and CHP systems, with their lower-carbon footprint, are a sound and practical approach to a more sustainable future, as opposed to larger, central power stations, and individual building heating and cooling systems.

1.2 Prioritizing objectives

District energy projects will benefit from defining the objectives they must achieve from the start. As outlined above, these are likely to be drawn from the three categories discussed. However, district energy is capable of addressing all three areas and so it is necessary to prioritize which is the most important for the stakeholders involved in the project.

STAGE 2
Data gathering

STAGE 2 Data gathering

High-quality and appropriate data is the foundation of a successful strategy or project. For the purposes of options appraisals and evaluating high-level feasibility (Stage 4, page 30), it is not necessary to compile detailed data; that comes later. At this stage it is possible to use "benchmarking" data to get a high-level understanding of the opportunity.

2 Data required

To make rational decisions about a new energy generation and distribution system, it is necessary to:

— collect data on existing and likely future energy consumption of new construction and existing buildings, taking account of improvements to their energy efficiency;
— take account of the rate of construction for new buildings;
— consider fuel and power sources and how the energy will be delivered or transported;
— recognize the pros and cons particular to the location in terms of energy sources, distribution, transport, land use, form, and character;
— consider the sustainability of different low- and zero-carbon energy technologies.

2.1 Development density

A major part of the cost of a district energy system is the distribution system and the pipes needed to carry the thermal energy. The shorter the distance energy has to travel, the lower the cost. The more densely-packed the buildings, and the greater the demand for heating or cooling, the more efficient and viable the network is likely to be.

A number of techniques and measures are available to help reduce costs for heat distribution in areas with low heat demand density. Expressed in terms of heat densities, it is considered that areas with a heat density of 0.93 kWh/ft^2 or with linear heat demand of 9146 kWh/ft can be economically served by district heating (**IEA** DHC/CHP). The United Kingdom (U.K.)-based Energy Saving Trust suggests that around 22 to 23 new buildings per acre (55 per hectare) are necessary for financial viability. Another U.K. study suggests a minimum heat density of 26.5 MM**Btu** per square mile (3,000kWh per square kilometre) per year. In considering market potential for a district energy system, another perspective involves the prospective energy consumption volume of connected buildings per trench foot of distribution piping to be installed. Typical U.S. energy density considerations on a distribution trench foot basis appear in the box above, right.

District Heating System density	Annual delivered energy (MMBtu/trench foot)
Low density	3.1
Medium density	8.5
High density	15.6

Project designers can optimize the network layout to minimize the costs associated with different levels of energy density. In rural or northern communities building density may not be a critical issue. Such communities may have no, or scarce, alternative fuel sources or infrequent fuel deliveries due to the weather. In such circumstances the project economics will be entirely different.

2.2 Demand loads

Demand load is the amount of energy consumed in a given building or development. This varies with weather and the patterns of activity of the building's occupants. For example, residential and hospitality uses tend to have an inverse daily pattern to commercial uses (they typically use energy at different times of the day). Some buildings, such as arenas, convention centres, and stadiums will exhibit **event loads** that occur only on dates when events are scheduled, while buildings like hospitals, universities, and hotels are used 24 hours a day and have fairly steady loads.

Daily **load profiles** are put together to form annual load profiles. These show different profiles in summer and in winter. The **peak load** is the period of highest demand and the **base load** is the period of lowest demand. The base load is never zero as there is demand for domestic hot water, such as for kitchen appliances, at all times.

It is important to create load profiles for any project so an energy system of the right size can be designed to meet demand. Figures 9 and 10 show typical graphs of different load types.

Hourly energy use

Domestic load

6.00 – 7.00am	demand for energy as the household gets up
9.00am	drop in demand as occupants leave for school/work
5.00 – 11.00pm	demand rises as people come home from work

Commercial load

7.30 – 9.00am	demand as people arrive at work
9.00am – 5/6.00pm	demand arches
After – 6.00pm	demand decreases as people leave work

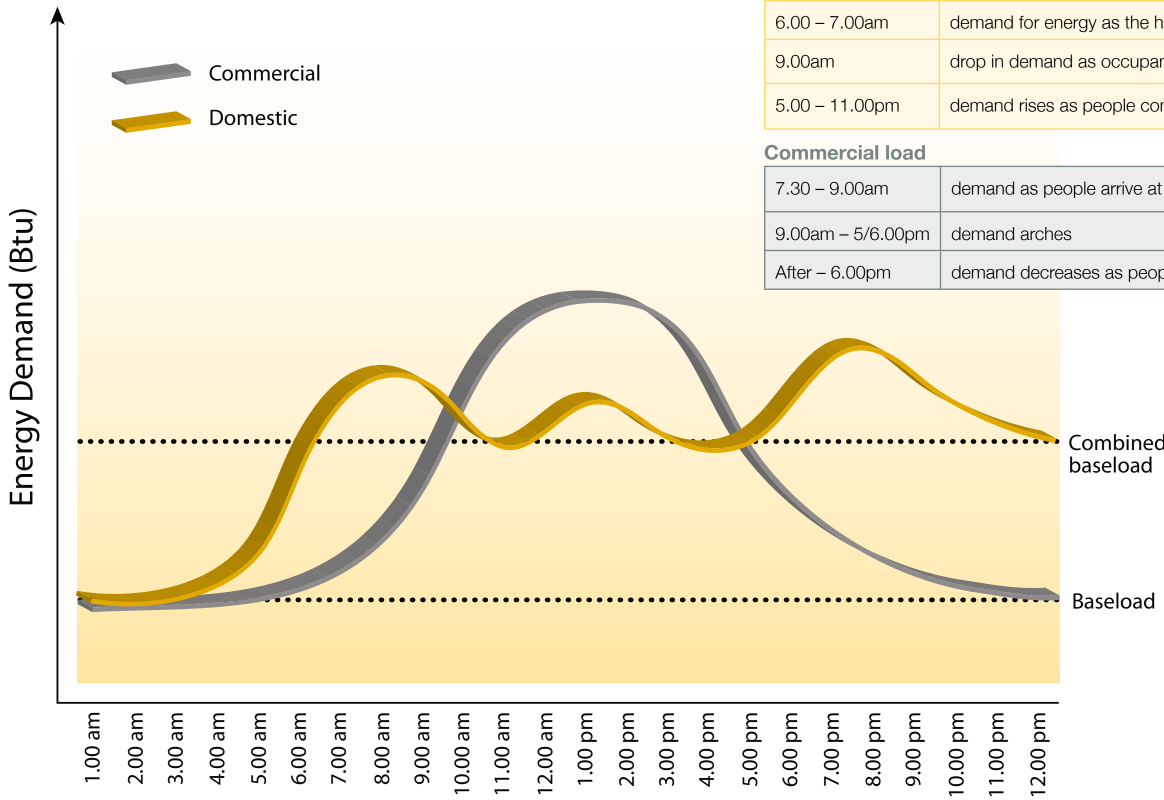


Figure 9: This graph shows a typical domestic and a typical commercial load profile, and how they complement each other.

Yearly heating and cooling

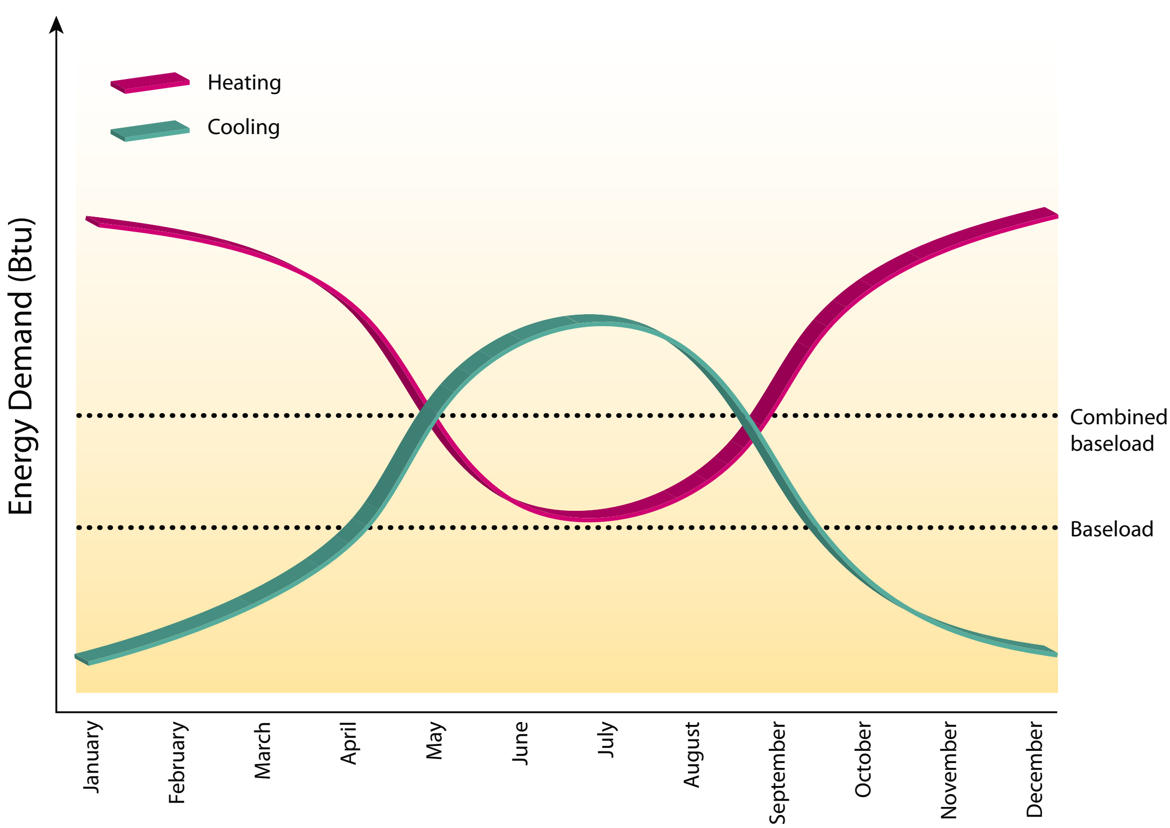


Figure 10: This graph is a typical annual combined heat and cooling load profile. This shows higher heat demand during the winter months and higher cooling demand during summer months when heat demand is low.

2.3 Mix of uses

Having a mix of end uses, reflected in different load profiles, helps in matching demand to supply to get the most out of the central plant. Boilers and generating engines operate most efficiently when there is a steady, smooth load. Most individual loads contain abrupt increases or "spikes" of demand. These spikes can be compared to the inefficient use of fuel in a car in "stop-start" city driving, compared to the greater efficiency of smoother highway driving. Spikiness also affects maintenance requirements and overall equipment longevity.

Boilers for a single building have to be sized to meet peak load, but energy use is only at peak demand for a fraction of the time. As a result, most boilers are oversized and running below their optimum performance, especially condensing boilers, which are most effective after a steady period of demand.

If several residential properties share a boiler or cooling plant, via a district energy network, spikiness gets smoothed out by the overlapping demands of the customer buildings. If commercial buildings are added to the network, they smooth the load out even further, with their complementary energy-use pattern. This gives a smooth load curve over 18 hours. It also raises the level of the base load. In this case, the energy system, when providing heating, can be designed with a **lead boiler**, also called a **prime mover**, to provide the base load, and a back-up or top-up boiler to help with the peak load. In this system, the lead boiler can be a smaller size and run at optimum efficiency a lot of the time, while the back-up boilers meet any additional demand.

When configured in this way, the boiler filling the role of prime mover can be replaced by a CHP engine or turbine. These units produce electricity as well as heat and so increase the efficiency of converting the primary energy of the fuel source into usable energy in the form of power, heat, and cooling. As having a good mix of uses connected to the district energy network improves the efficiency of the central plant, it requires less input fuel for a given output. Additionally, it has a beneficial impact on the need for maintenance and plant longevity. All of these issues contribute to the improvement of the business case for the project.

2.3.1 Cooling

With tighter building envelopes and increases in the use of computers, electronics, and other heat-producing devices, as well as greater density of occupancy, commercial buildings no longer need cooling in just the summer months, but year-round, although the greatest demand, of course, is always during the hottest weather. Air conditioning imposes the greatest strain on the electricity grid and often accounts for 50% to 60% of the electric peak demand in a building with its own cooling equipment.

District cooling systems produce and distribute very cold water to customer buildings in order to provide air conditioning and process cooling for data centres and similar applications. The chilled water is supplied through an underground piping network and flows into the building, either to a heat exchanger, or it circulates directly through the building's heating, ventilation, and air-conditioning system (HVAC). The cold water from the district cooling system absorbs heat from the customer building, increasing the temperature by 10°–12° Celsius. The water then flows back to the central plant through a separate return pipeline. The difference between the temperature of the water flowing towards the building and the water returning to the central plant is known as the **Delta T** and is a critical factor in the design of cooling systems, as the narrow range of difference does not allow room for error. Typically, cooling is generated by electric chillers, although **absorption chillers** can be connected to a heat network to convert heat directly into cooling. Absorption chillers are not as efficient as electric chillers, but in areas with variation between warm summers and cold winters, absorption chillers perfectly complement the drop in demand for heating in the warm months (see Figure 10, page 19). The available thermal energy can be used for cooling instead, keeping overall thermal demand steady all year and avoiding the need to dump heat (see Case study on page 38).

2.3.2 Load diversity

A good mix of uses (or **load diversity**) increases the project's financial viability, and will attract the attention of commercial energy services, investors, and financiers. Mixed-use developments with greater load diversity are more viable than entirely residential developments. In particular, adding residential units to commercial developments will improve load diversity due to the higher demand for domestic hot water in residential properties. Since the mix of uses in any project is usually decided during the development of the **master plan** of a site, it is important to think about the energy system early in the planning process.

2.4 Age of buildings

The age of the building affects load diversity. Changes to building energy codes, which are typically established by the province, mean that newer buildings are more energy efficient and have a relatively low demand for heating, except in very cold weather. However, in Canada's major urban centres, the market propensity for multi-unit residential construction has led to an increase in condominium development, many featuring large portions of window wall facades. The scenic urban vistas often come at the cost of thermal energy efficiency when compared to more traditional punch window designs. The growth in residential construction means there is a high demand for domestic hot water. Additionally, new building designs typically require more "air changes" which decrease the significance of savings achieved through improved building materials.

Some cities, such as Vancouver and Toronto, have established building code specifications for new construction that exceed provincial requirements. This actually presents a challenge for people interested in installing communal heat and power systems, since there may not be sufficient heating demand to justify investment in a CHP system. This can be overcome by having a mix of uses and connecting adjacent existing buildings that have different energy requirements, and therefore different energy demands, via a district heating network. On the other hand, district energy systems are particularly beneficial when retrofitted to serve historical buildings as they can provide lower-cost energy services with lower carbon content without the need for any substantial changes to the buildings' fabric or design.

Therefore, data must be collected on the age and energy demands of the buildings in the surrounding area. This can be measured using benchmarks or actual energy-use data.

2.5 Anchor loads

Certain buildings, such as hospitals, hotels, large housing complexes, prisons, swimming pools, and libraries, as well as military bases and universities, have a large and steady demand for energy over a 24-hour period. Managers of such public sector buildings can take a long-term view on energy provision and, increasingly, have to try to achieve carbon reductions, energy security, and affordable energy supply. Buildings like these also often have space available where energy centres could be placed. Therefore, they make ideal cornerstones for the development

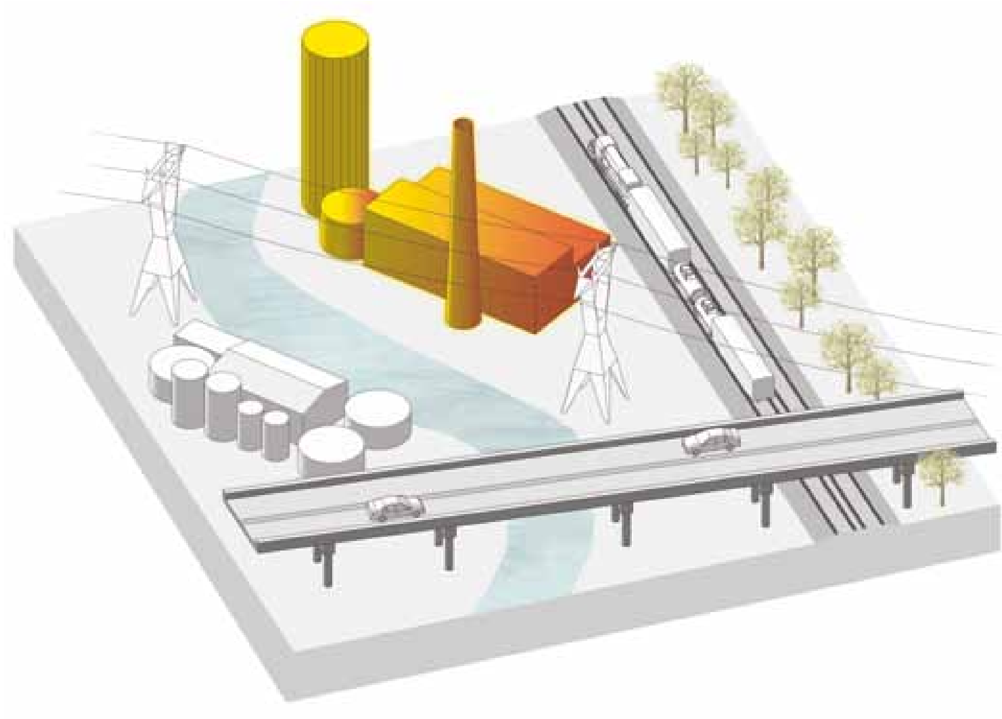


Figure 11: Potential barriers must be identified and taken into consideration. These might be: railway lines/subways, storm water drains, highways, canals, or rivers.

of district energy networks, and are known as **anchor loads**. Similarly, convention centres, arenas, and stadiums have large but infrequent singular demands linked to the number and frequency of full-occupancy events. They can also act as anchor loads.

It is a good idea to note any buildings of this type in the vicinity of a new development, refurbishment, or regeneration project, along with information on their demand loads, ownership, and any plans for refurbishment. Federal, provincial, and municipal governments are the largest owners of property in Canada and therefore warrant particular attention. Identifying anchor loads early in the master planning and project development process is beneficial because the owners of the relevant buildings can champion the project at initiation and as it moves forward.

2.6 Other issues for consideration

Development of an energy system using underground networks may encounter some of the problems shown in Figure 11, above. But they need not be show stoppers and can be overcome, for example, through close liaison with highway authorities. They may also present opportunities. Existing energy systems can also present challenges since they may affect how many buildings will sign up to a new district energy network.

It may be necessary to gather further information and data for consideration on infrastructure, such as:

— gas and heat networks and electricity sub-stations;
— existing power plants, including low- and zero-carbon energy sources, power stations, waste-to-energy plants, and industrial processes that are dumping heat;
— transport infrastructure, such as canals, rivers, wharves, docks, and railways, which could be used to transport bulky fuels, such as biomass;
— the different opportunities and constraints presented by the urban and rural form and character, including topography and significant elevation changes, that might impact pumping requirements and location of thermal storage facilities.

2.7 Organizing the data in a visual representation

The data gathered in Stage 2 creates a location's unique **energy thumbprint**. It is important to organize this data so the project proponent can analyse this thumbprint in order to indicate the most appropriate energy solution, and convey the findings to potential stakeholders, such as public officials, investors, and decision makers. An **energy map** (see Figure 5, page 9) is a tool that can be used to organize/present data as the basis for defining energy character areas (see page 22) as part of energy planning.

Energy maps are commonly used by European land-use planners and district energy proponents and, in conjunction with community energy planning (**CEP**) processes, have recently begun to gain popularity in Canada. While energy maps are not a prerequisite to project development, they can help:

— identify opportunities for new energy projects;
— determine suitable technologies and approaches to energy generation, distribution, and supply;
— highlight opportunities to link to other projects or share energy centres;
— aid decisions about prioritizing projects.

They are particularly useful during options appraisal (Stage 4).

Energy maps provide evidence for district energy implementation and the basis for rational decisions to support planning policies; they also provide information for local infrastructure plans. Project proponents can choose to use one as a starting point for energy strategies for new developments, revitalization projects, and to highlight possible or priority projects.

2.7.1 What can energy maps show?

Energy maps are normally Geographic Information System (GIS)-based, and are often prepared at the local or municipality scale. An energy map might be used in a variety of ways.

— ***Energy strategy:*** a map could form the starting point for the energy strategy for a development by identifying

energy options (to be fully appraised in Stages 1 to 4).
- ***Identifying energy solutions:*** a map can identify likely energy solutions, such as implementation of a district energy network, as part of an urban renewal project.
- ***Priority projects:*** the map might point to possible investment opportunities for a project proponent.
- ***Inform growth options:*** maps provide information that can aid decisions on the allocation of development sites.
- ***Exclude inappropriate areas:*** for example, where nature conservation or landscape character are concerns.

See Case study on page 50.

2.7.2 How to prepare an energy map

There is no single defined process for preparing an energy map. The project proponent will determine the level of detail necessary. For a given area, a map might include:

- an assessment of existing building energy demands and energy installations as a baseline;
- likely locations of new development at different stages in the planning pipeline, and an assessment of how this will affect energy demands over time;
- the availability of potential local and renewable fuels;
- a **heat map**, showing the location of large public buildings and other anchor loads.

When you get down to the neighbourhood or building scale, more detail can be added or a new map created if there is no district level map. It can then be used to define and appraise an energy project (pages 26–27).

2.7.3 Energy character areas

Energy maps can also be used to define **energy character areas,** where the particular characteristics of an area are used to define the appropriate energy solution or planning policy. For example, mature residential suburbs are usually lower-density areas with little mix of use and many owners. These areas may be most suitable for micro-generation technologies (small, often building-integrated technologies, such as solar power). In contrast, city or town centre locations have a higher density of buildings with a mix of uses, including offices, shopping centres, hotels, and public buildings. While there still may be many different building owners, they usually have standardized decision-making processes for procuring energy services. Areas such as these can develop large-scale heating and cooling networks served by CHP plants.

In this way, energy maps can illustrate energy character areas and help project proponents make good investment decisions and plans, whether at the single-building, neighbourhood, or city scale. Energy maps can be an overlay to zoning and use-planning so that appropriate uses are targeted and concentrated.

2.8 Planning policy for district energy

The planning process has significant influence over the ability of a community to develop successful district energy systems. Accounting for the conservation of energy in land use is imperative for achieving local, regional and provincial goals associated with infrastructure, the environment, and energy resource management. Planners have a suite of tools at their disposal to shape and guide nodes of development, urban form, density, and land use as a means to support the development and expansion of district energy systems.

2.8.1 Factors influencing the built form of cities

The built form of many North American cities has been influenced by abundant, low-cost energy. Low-cost energy supply has prompted many middle-class North Americans to move away from the urban core, accepting longer commute times in exchange for lower housing prices. This has left a mark on the built form of many communities, developing regions of scattered single-detached, single-use development. Dispersed, low-density development makes providing frequent transit service difficult, increasing the use of private automobiles.

Another factor influencing the shape of North American cities has been the prevalence of large-scale, centralized energy production. Energy planning in the 20th century was typically the responsibility of government agencies, particularly at the provincial level. Large-scale generation facilities were viewed favourably, on the assumption it would achieve economies of scale through centralization and large capital investments. The result has been a monopolistic procurement model, where decision-making around energy planning is removed from energy end-users and centralized in the hands of a few large-scale producers and government agencies. This energy model has allowed consumers to locate at almost any distance from a generator, with regulation keeping electricity prices low and removing the need to consider proximity from homeowners and businesses. More recently, energy price volatility has alerted producers, consumers, and decision-makers to the implications of energy scarcity in meeting local demand.

2.8.2 Shaping the urban environment for district energy

In contrast, urban environments with their higher density, compact, urban form, and mixed land use represent the greatest potential for the development and expansion of district energy systems. Canada's major urban centres are now encouraging concentrated development and increased density within existing urban boundaries to protect productive agricultural and environmental lands outside towns and cities, while maximizing infrastructure investment. Planners influence the location, form, density, and uses of future development, and can therefore shape the city building process to maximize the potential for district energy. In particular, they should take a proactive position in the early identification of nodes of activity which could support district energy.

Municipalities should try to incorporate the desirability of the development of district energy systems in official plan documents. More detailed direction can be provided within neighbourhood-specific or secondary plans. Local officials, developers, and industry should collectively identify opportunities to concentrate urban form and leverage sources of waste heat. Infill and intensification efforts can be used to support district energy development by requiring new development applications to undertake a study to determine the feasibility of a district energy system connection within a serviced area. In some cases, identifying a single, large thermal user can act as a catalyst for district energy system development. Encouraging compact development will improve the efficiency of district energy systems, while reducing capital costs.

2.9 Planning tools for district energy

Municipalities have a number of tools and resources available to encourage the development of district energy systems. Official plans provide the authority for municipalities to implement specific policies through the review and processing of development applications. **Zoning bylaws** capture potential land uses within a municipality. Planners can zone for, dedicate, and/or assemble lands for district energy facilities. Community improvement plans, zoning activities, and powers of subdivision offer the opportunity to review district energy. Achieving energy planning considerations in the development review process requires the official plan to provide an energy vision based on objectives outlined in supporting provincial legislation, accompanied by a zoning bylaw that specifies targets for development approval.

2.9.1 Bylaws and regulations to encourage district energy
Several Canadian communities have developed "district energy zones" – areas or neighbourhoods with an existing or planned district energy service that require new developments to connect. For example, the City of North Vancouver requires all new development applications in excess of 1000 m^2 to connect to the Lonsdale District Energy Corporation system. In exchange for connection and increased efficiency, developers receive a density bonus to increase saleable floor area. In some cases, mandating connection may not be possible. In these instances, district energy pre-feasibility studies can be required as part of the site-plan approval process. Municipalities can also designate local improvement areas, with a specific levy added to property tax to offset part of the district energy system capital costs.

Any sort of bonus permissions or incentives should be acknowledged upfront in the official plan and/or zoning bylaw. The permissions must be in place and vetted through a public process for acceptance, to avoid creating an unfair development advantage. Engaging stakeholders early on in the development process regarding the opportunity for a district energy system is critical. In order to capitalize on potential opportunities for connection, timing must be considered with respect to the development of the district energy system, age of existing equipment, and connections to new services.

Depending on the province and project objectives, some or all of the following planning policies and tools may be applicable:

- Establish dedicated district energy zones or service areas and consider mandating connection to the system within these zones. At a minimum, require a district energy connection feasibility study as part of the site-plan approval process for all new developments larger than 1000 m^2. Interconnection to district energy and CHP systems should be predictable, consistent and transparent.
- Ensure zoning bylaws, site development/application process, subdivision and new development approval processes support the development of district energy systems. For example:
  - use energy mapping, zoning bylaws, and site-plan approvals requirements to locate heat sources near identified heat sinks, and concentrate density in dedicated district energy service areas;
  - reduce permit fees and expedite approval for projects that meet community energy priorities.
- Incorporate consideration for GHGs and energy demand into the land-use planning and development processes. Provide tools to assist municipal governments with the measurement and evaluation of GHG emissions.
- Targets for energy efficiency or GHG reductions might be measured by achieving an energy density expressed as J/m^2 or MWh/hectare.
- Require total cost assessment of new developments and adjust development charges to account for all new infrastructure expansions (typically intended to recover costs for maintenance of roads, water services etc.).
- In some provinces, additional capital costs for infrastructure can be recovered through supplementary charges on property taxes.
- Provide cohesive integration of land use, energy and transportation into all planning documents, identifying nodes of planned development with density and floor space thresholds that could support district energy.
- Remove policies that compromise the ability to advance district energy systems, such as restrictions on mixed-use developments in urban environments.

2.10 Planning for district energy-ready buildings

Currently housing developers are largely focused on provisions in building design, whereas district energy is more about energy demand and servicing. Heating systems based upon natural gas (forced air) or electricity (baseboard heaters) are well established and installing them in new buildings have become the default options for developers. If district energy infrastructure is not already in place, it requires a greater degree of upfront evaluation.

2.10.1 Ways to encourage district energy-ready buildings
Planners have a number of tools to encourage **district energy-ready (DE-R)** buildings by ensuring proposed building design and systems are compatible with district energy:

- Green building or neighbourhood standards. New buildings in a specific district energy zone could be required to demonstrate at least 25% energy efficiency improvement over the building code. A standard that sets an electricity conservation target will discourage the use of electric heaters. A renewable energy target will discourage the use of natural gas forced air, although such a target alone will not be effective if the source of electricity is hydro (renewable) or if the district energy system is gas fired.
- Where the development of a district energy system is planned or anticipated, all new buildings or retrofits to buildings larger than 1000 m^2 or approximately 10,800 ft^2 (this may vary according to local conditions) should incorporate the following DE-R elements:
  - hydronic HVAC system;
  - centrally located domestic hot water system in lieu of point-of-use heaters;
  - space allocated for an Energy Transfer Station (ETS).

DE-R building design can be negotiated and established through:

- Development agreements, (e.g. Dockside Green, Victoria).
- Standard land-use covenants.
- Prescriptive requirements for the site, such as energy conservation performance targets.
- Development permit area guidelines with process requirements, such as DE feasibility studies or development permit checklists requiring site-level DE infrastructure.

DE-R building design can be encouraged or incentivized through:

- Reductions in development cost charges or community amenity contributions.
- Tax revitalization exemptions.
- Streamlined approval processes.
- Development permit area guidelines encouraging or incentivizing hydronic heating or cooling infrastructure within buildings.

Once a system is operational, a service area bylaw can require buildings to connect. It is recommended that the municipality own a majority portion of the district energy system or heat source when establishing a service area bylaw. Some Canadian municipalities have offered financial assistance to developers to help cover the "premium" associated with installation. This may be reduced substantially if a building also requires cooling.

CASE STUDY: Regeneration in Southeast False Creek, BC

Figure 17: The Southeast False Creek energy centre. **Photograph courtesy of City of Vancouver**

Southeast False Creek was previously the industrial heartland of Vancouver, hosting a range of activities including sawmills, port activities and railway yards, being the western terminus of the Canadian railways. It is separated from downtown Vancouver by a small water inlet, False Creek. In the 1950s, after 120 years of such usage, industry started to migrate away and the area began to deteriorate. After a number of approaches to redevelopment were rebuffed by the planners and the local community, the City Council adopted a set of Blueways policies and guidelines setting a vision of a mixed-use development built to high, environmental and equitable standards that would contribute to the economic and cultural life of the city.

Re-development of the 50-acre site began in 2005. Part was built as the Olympic Village to host athletes at the 2010 Winter Games. The vision was to achieve an energy-efficient neighbourhood based on energy-efficient buildings and a low-carbon district heating network. FVB was commissioned by the City Council to develop a district energy concept and business plan. The resulting study was used to construct a low-temperature hot water network distributing heat captured from untreated urban waste water, the first to do so in North America.

The Southeast False Creek energy centre contains heat pumps which extract heat from the sewage filtered out of the water. The sewage is then re-combined with the water and pumped for final management. This provides the base heat load, representing 70% of the annual thermal demand on the system. Back-up and peak heat are provided by solar thermal collectors and gas heat-only boilers. The resulting system produces 65% fewer greenhouse gases than an equivalent conventional system.

The City Council established a Neighbourhood Energy Utility (NEU), wholly owned by the Council, to operate the system. NEU operates on a commercial basis. It does not rely on tax support, being financially self-sustaining from its revenues, and will provide the Council with a return on its investment. An independent Rate Review Panel advises the Council on heat rates. By 2020 it will serve six million square feet of development and 16,000 new residents.

STAGE 3
Project definition

STAGE 3 Project definition

Securing the support of other stakeholders is vital in order to define the outline of the project well enough to take it to the next stage. In the absence of a heat map, data will still need to be gathered for a project to progress. Other stakeholders are the route to accessing such data.

3 Defining your project

The project objectives, together with the collected data, heat map if available and, in the case of municipalities, energy character areas, enable you to define the project; particularly, the buildings to be connected, the project's scale and extent, the range of partners needed, and their roles.

An approach to defining the buildings to be connected to a project is to use the table below to identify those buildings with features meaning that they are most likely to be interested in connecting to the project. Each building is scored according to a range of features, and marketing effort should be focused on those buildings with the highest scores.

3.1 Collecting commitments

In order to maximize the technical feasibility and financial viability of the project, especially district energy systems, where a critical mass of demand is essential, it is necessary to gain commitment from partners and potential customers to participate in investigating the opportunity further. If enough commitments can be collected, then the outline of the project can be defined well enough to take it to the next stage. A commitment could include a **memorandum of understanding (MOU)** or a **letter of intent (LOI)**.

3.2 Selling the idea

Thought needs to be given to engagement with owners of the buildings identified for connection as well as the wider community. This could start with producing an information sheet setting out the project concept, describing the technology and the benefits of participation, and mapping out the development process. Stakeholders could be invited to attend workshops or forums where the project champion can distribute information material, deliver a presentation, and provide the opportunity for questions and concerns to be raised. A high-level advisory group of external stakeholders could be formed as a channel for communication and to manage the engagement process.

The principal driver for building owners will be a competitive offer for energy services. In part, this includes moving responsibility for the management of complex onsite plant from building managers and caretakers to qualified energy professionals offsite.

Although the benefits of connection to a district energy system may be common to building occupants and owners from all sectors, each will have their own drivers and may accord different priorities and emphasis to the benefits to be derived. These are discussed in the box on page 27, opposite.

Score 1- 10 (10 being most favourable) - Prioritize based on highest total score

	Building 1	Building 2	Building 3	Building 4	Building 5
Hydronic heating and cooling system					
Boilers, chillers or cooling towers reaching end of life					
Property owned or controlled by district energy proponent					
Building owner/Major tenant business relationship with proponent					
Location of in-building plant (basement; rooftop; mid-rise)					
Proximity to DE network					
Planned renovation or re-use					
Building size (GFA)					
TOTAL					

Table1: Example of a building connection assessment.

Principal benefits of community-scale district energy

Economic: reduced operational and capital costs

- Economic development: a vibrant downtown connected to district energy has an economic multiplier effect. The environmental and economic benefits will attract new businesses, creating a thriving district that, in turn, attracts new residents.
- Building owners connected to district energy enjoy cost savings, capital avoidance, and space savings.
- Externalizing management of complex equipment from internal building managers to qualified professional experts.
- District energy can help building owners earn LEED or EcoLogo certification, valuable tools for attracting commercial and residential tenants, enabling them to meet their climate mitigation commitments.
- Building owners are able to offer "green" space on the rental market.

Energy security: increased reliability, greater local control, and fuel flexibility

- Local energy generation gives a community greater control over its energy supply. Moving thermal energy production out of buildings to a district energy plant centralizes the operations and maintenance process and eliminates this burden for building owners.
- The opportunity to generate electricity using CHP reduces a community's reliance upon the potentially vulnerable electrical grid.
- Many new district energy technologies can safely operate on more than one type of fuel, further enhancing the system's autonomy and increasing security of supply, reliability, and cost savings.

Environmental: improved energy efficiency and enhanced environmental protection

- District energy reduces emissions through the efficiency benefits of greater economies of scale, the ability to productively use energy that is typically wasted, and the deployment of energy sources that are not viable at building scale.
- Improved indoor air quality.

3.2.1 Public sector

Public sector organizations, including hospitals, universities, government buildings, and military campuses are now motivated by a range of policies and incentives to improve the energy efficiency of their buildings. These types of bodies are very likely to initiate district energy projects, and may be willing to make a commitment to connect, thereby catalysing the development of a new system and providing an anchor load for the project, by sharing its plant capacity with neighbouring buildings.

Securing the commitment of the key anchor load is similar to a retail development securing an anchor tenancy, which provides the cornerstone around which the project can be built. As public sector organizations can take a long-term view and may be motivated by other non-energy objectives, such as area economic regeneration, they may be willing to provide the anchor load.

Viability of a project generally improves with the project's size and diversity of loads. Therefore, partnerships between different building owners in the private and public bodies are attractive.

3.2.2 Commercial developments

Some commercial building owners have corporate commitments to reduce carbon. However, it is more likely that owners will primarily have other drivers. For new buildings this may be the need to meet site-plan approval in achieving LEED thresholds, add value through increased leasable space, and reduce the cost of heating and cooling their buildings. Owners of existing buildings are also motivated by reduced heating and cooling costs, but are interested in avoiding the cost of replacing existing aging boilers, too. They may be unwilling to make a commitment to connect until they know the probable costs, including:

- the capital cost of connection compared to the cost of installing individual boilers or replacing an existing plant;
- the cost of use over time.

Although developers may need further cost information, they could be interested enough to sign a MOU, agreeing to explore the opportunity further through an Options appraisal (Stage 4) or Feasibility study (Stage 5). As always, obtaining commitments from multiple building owners is more complex than for single buildings. Once there are enough commitments and MOUs, energy ideas can be confirmed and the project can move forward.

3.2.3 Community developments

Local communities may want to benefit from district energy systems. To do so, it is likely that they will need to work with relevant officials in local government and other public sector organizations. Community-owned legal forms can provide the opportunity for local control of the energy infrastructure that allows local communities to determine pricing and service bundling and to aggregate their demand as consumers to drive down infrastructure costs. Net profit can be re-invested in the business or community and/or distributed as dividend to members.

Such opportunities can play a part in a broader approach to the development of livable cities. However, as the interests of consumers and communities may not always be absolutely aligned, it is important to define the principal stakeholders and how the benefits will accrue.

3.2.4 Other utility services

There are parallel drivers increasing the demand for other decentralized and local utility infrastructures, notably cable, non-potable water supply, and waste management. There may be cost benefits in energy projects installing these additional services. While it is unlikely that these services will be contained in the same business, they could cooperate by sharing the same contractor to dig a common trench. Some district energy developers have added a vacant conduit while installing the pipe network. This has later been leased to other service providers, particularly cable or broadband providers, bringing in additional revenue. Consequently, in defining the energy project, the opportunities to include future delivery of one or more of these other infrastructures should be taken into account.

CASE STUDY: Resource efficiency in the Arctic Circle

Fort McPherson is a community of approximately 800 people located 100 kilometres inside the Arctic Circle in the Inuvik Region of the Northwest Territories. Average temperatures range between -30° in winter and +20° in summer.

In 1997 the Gwich'in Development Corporation and NWT Power Corporation established a joint venture company, Aadrii Ltd, to develop, own, and operate the project. Aadrii Ltd engaged FVB Energy to undertake an initial options appraisal and feasibility study and then provide the detailed design of the plant, network and customer connections.

The district energy plant is located within NWT Power Corporation's power plant and recovers waste heat from the diesel generators. A heat network was laid above the ground due to the permafrost, and distributes the heat initially to five buildings including the school, the community office, a commercial retail shop, the water treatment facility, and the swimming pool. Oil-fired peak and back-up boilers are located within each of the buildings. The network was expanded in 1998 to serve more customers.

Customers were not required to contribute to the capital cost of the project through a connection charge, and heating rates are tied to the avoided cost of heating by indexation to the cost of heating oil, factoring in the efficiency of their oil-fired heating system. The project has reduced the community's annual heating fuel consumption by 12% and reduced carbon dioxide and sulphur dioxide emissions.

Aadrii Ltd is now working with the territorial government to identify new customers as well as opportunities for using biomass fuels.

Figure 18: Fort McPherson. **Photo credit: Google Earth Image 2013**

STAGE 4
Options appraisal

STAGE 4 Options appraisal

The next stage is to use all the data to examine energy technology options in order to decide which are the most suitable. Later, the selected option will be subjected to a more detailed feasibility study that assesses with more rigour the technical feasibility and financial viability, while identifying the potential constraints and project risks.

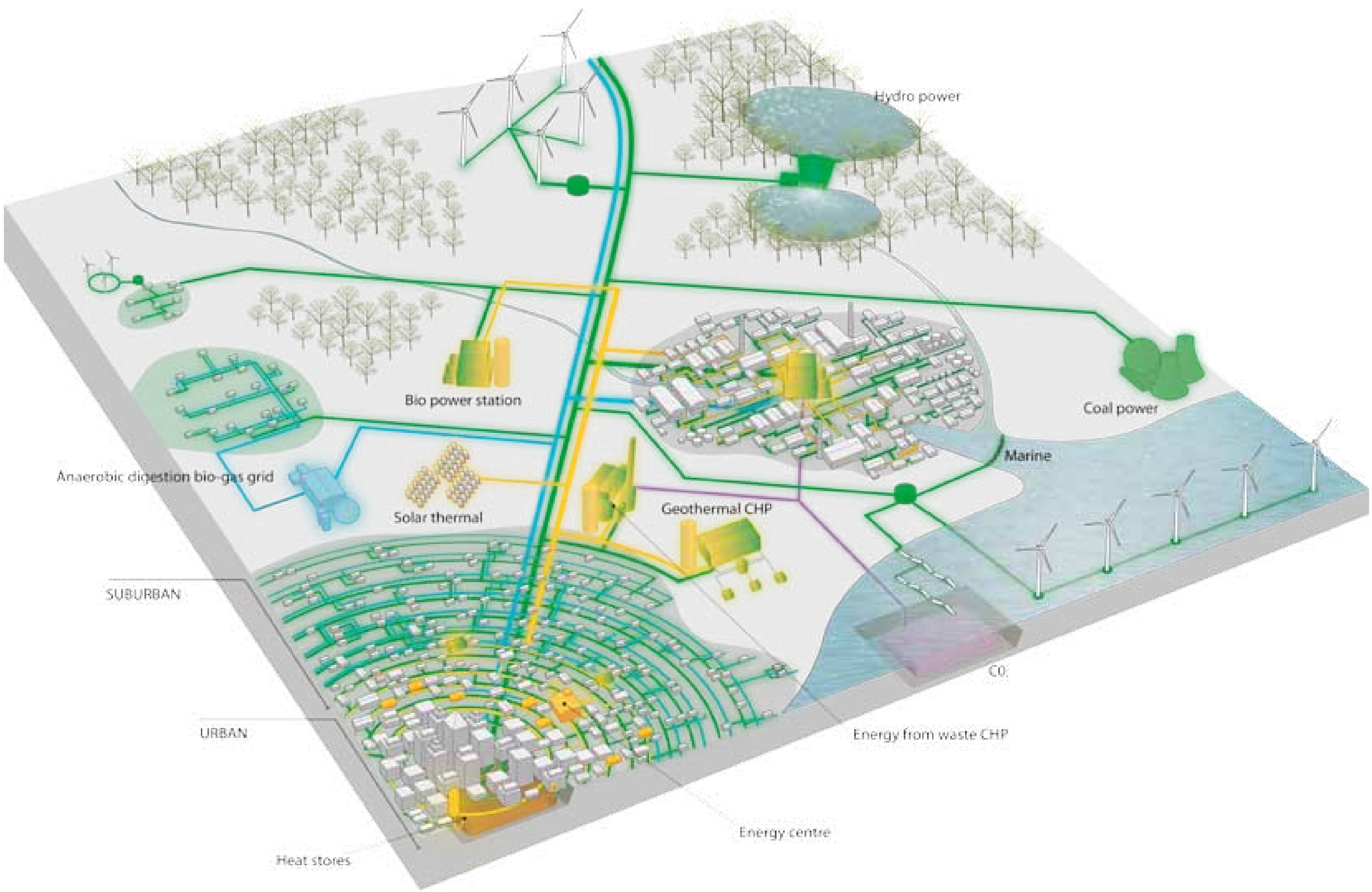


Figure 14: District energy infrastructure allows communities to capture thermal energy from a wide range of sources.

Illustration, with permission of UK CHPA

4 Looking at the options

Based on the data collected for the defined project in Stages 2 and 3, together with the heat map showing adjacent buildings, technical options for meeting the project's energy demands now need to be appraised. This involves comparing a limited number of typical solutions, including the business-as-usual case where a traditional energy system is to be installed or replaced. An options appraisal is not a detailed feasibility study, so estimated capital costs, data on demand loads, and simple payback methodology may be appropriate at this stage. However, it is important to roughly evaluate the technical feasibility and financial viability of the different options. At a later stage it will be necessary to use more sophisticated financial methodologies. These are described later in the guide.

Natural Resources Canada[11] (**NRCan**) (see page 58) provides a range of information packages that aid a planner in not only assessing their readiness to develop district energy but also their design, mapping and technology selection. These scoping tools are not full-blown economic or life-cycle analysis, but will help a planner determine whether to invest time and resources in further evaluation of district energy.

These enable the decision maker to assess the optimal location for the system and then the effectiveness of the possible technologies. The RETScreen software package allows the designer to compare supply technologies and to develop a preliminary financial assessment. The DEEM (District Energy Economic Model) – available spring 2014 – will determine the economic benefit to the community of its investment in terms of jobs created and the impact on the local GDP. This information will be key to selecting the most beneficial technology. The software is available through Natural Resources Canada on the RETScreen website: www.retscreen.net/. (See page 58.)

Simulation of community needs can be undertaken using a variety of NRCan-developed modelling techniques such as for new construction, when as-built data is not available or when the number of buildings is large[12]. NRCan is also able to advise on policy and financial incentives, available at local, provincial and federal levels, that may impact upon the technology selection.

IDEA, in collaboration with the **U.S. Department of Energy**'s Clean Energy Application Centers, has developed a District Energy Screening Tool, which is useful in organizing the energy data and development scenarios to perform an early-stage feasibility appraisal. The screening tool analyzes energy load growth, capital and operating cost estimates, building energy needs, various system configurations, and timing sensitivities. The tool will help planners assess the financial viability of a district energy system.

Internal staff may not have the technical expertise to interpret the data in an options appraisal, in which case a technical consultant will need to be engaged. It is important to check the track record of consultants carefully to ensure that they have done similar work before, and to check their references to learn whether previous clients were satisfied. IDEA maintains a database of well qualified consultants.

This process will identify the most cost-effective option. It may be appropriate to consider other services and utilities, such as water, sewage, and cable or fibre-optics at this stage, to assess whether they could add value to the project.

Figure 15: Plant room in Strathcona County, Edmonton, Alberta. **Photograph courtesy of FVB Energy**

CASE STUDY: Funding innovation in East Village, Calgary

Figure 23: Calgary downtown district energy plant room.

Photograph courtesy of ENMAX Corporation

Calgary's East Village lies between the city's downtown core and historic Fort Calgary, where the city was founded in 1875. Previously a bustling area of residential, commercial, and institutional buildings, as well as railway marshalling yards and freight sheds, the area declined as businesses began to migrate closer to the downtown core and residents dispersed to the suburbs. Building and transport infrastructure projects in the 1970s–90s further isolated the area by creating barriers between the East Village and the downtown core.

In 2001, after numerous failed redevelopment initiatives, Calgary City Council adopted the East Village Area Redevelopment Plan. The plan placed economic, social, and environmental sustainability at the heart of its vision, which drove the development of the Calgary Municipal Land Corporation (CMLC). With the CMLC as the redevelopment vehicle and a master plan developed for a new 49-acre urban village, funding provided by federal, provincial and municipal governments, together with a Community Revitalization Levy on property sales, produced $180 million for investment in infrastructure. To help meet environmental standards, the opportunity for district heating was identified and local utility ENMAX invited to submit a proposal.

As ENMAX first began considering district heating as part of its overall strategic vision, it was clear that district energy – with its stable rates and reliability – improves a community's business climate, makes local businesses more competitive, helps to revitalize downtowns and urban core areas, and helps build sustainable infrastructure. The opportunity that came to light was the redevelopment of the East Village and further growth of a densely populated downtown in one of Canada's largest head office locations. In addition to a significant corporate presence, Calgary's downtown and beltline are growing, with increased residential density.

The company's district heating network's first connection was to the City Municipal Building, but grew to serve other downtown buildings as well as the National Music Centre, built as part of the East Village redevelopment. The network is fed by 60MW of natural gas-fired thermal generation located at the Downtown District Energy Centre, operational since 2010, and capable of serving 10 million square feet of floor space. The company is now planning to meet growing demand by adding low-emission combined heat and power generation, where fuel consumption is reduced by improving the energy production process.

District energy can also make local energy supply more reliable and resilient in the face of increasingly frequent severe weather events. The severe flooding in June 2013 caused electricity supply disruptions in Calgary and serious economic losses. Despite sustaining major flood damage at the Downtown District Energy Centre, ENMAX District Energy retained full operating capacity throughout the period and met all system-connected demand without fail.

ENMAX is a wholly-owned subsidiary of the City of Calgary. Aside from its district energy activities, ENMAX generates, distributes and retails electricity. Between 1998 and 2012, ENMAX has contributed over $685 million in dividends to the City of Calgary.

STAGE 5
Feasibility study

STAGE 5 Feasibility study

A feasibility study is a technical exercise to investigate the selected option in detail. It will also provide a high-level assessment of the financial viability of the option.

5 A detailed technical study
Once the most appropriate technology option has been identified, it must be subjected to a detailed technical feasibility study. A study for a CHP/district heating and cooling project is described here.

5.1 Detailed analysis
The data on heating, hot water, and cooling loads that has already been gathered needs to be analyzed in detail. Feasibility is also affected by:
— *Age of buildings and existing energy systems:* These must be taken into account. Each building must be evaluated for connectability and compatibility with the current heating and cooling systems. Buildings may require retrofitting of heating coils, adding costs and impacting competitiveness and project penetration rates. For new buildings, changes to building regulations should be considered.
— *Heat production:* Consideration of the configuration of boilers to meet base and peak loads, as well as opportunities for renewable sources such as solar thermal, or available heat sources from large power plants and energy-from-waste plants.
— *Thermal storage:* The possibility of including thermal storage to provide a buffer in the system and reduce heat dumping.
— *CHP:* Potential opportunities for integrating CHP to produce thermal and electrical energy from a single fuel source. Key requirements for CHP are close proximity to the gas grid, which should have sufficient capacity and pressure to allow supply, and proximity to the power grid to allow for electricity exports.
— *Cooling production:* Compression or absorption chillers, ice or chilled water storage to buffer the system, and potential opportunities for combining heat and cooling on the same network.
— *Phasing:* For new developments, the phasing and timing of construction of new buildings must be considered. It can help reveal the optimum route and size of pipes for the network and good locations for the central plant, which might influence the phasing plan.
— *Routing and network measurements:* Length of the network, height of the buildings, and local topography are needed to calculate the temperatures and pressures for the network.
— *Network heat losses:* How much heat escapes from the pipes between the heat source and the customers.
— *Connections:* The type and scale of connections and pressure breaks between different network elements (for example, transmission and distribution), including the customer interface that transfers the thermal energy to the building's internal system.
— *Land availability:* The appropriate and optimum location for the central plant will need to be determined.

5.1.1 Central plant
The data on loads is used to specify an appropriately sized lead heat or cooling generator, or prime mover, to supply base load, and back-up boilers to meet peak load. At this point in the feasibility study, it is important to determine the quality of the energy required by the loads so as to identify the range of generation technologies that could be used. Buildings that require a high temperature supply (90°C) might look to biomass, natural gas or even CHP. It should be noted that proposing CHP as a primary base load supply increases significantly the complexity of the design and management. If the scope of the project involves CHP, a number of additional factors must be considered in the feasibility study, including:

- thermal profile;
- heat or cooling rate;
- heat or cooling to electric ratio;
- price sensitivity of fuel;
- the potential to sell power to on-site consumers and excesses to the grid/local utility.

The space heating needs of many buildings can be achieved at a lower temperature (60°C) and they can therefore avail themselves of renewable energy sources or low-grade heat-from-waste streams, such as sewage, waste water or other industrial waste heat. Drake Landing Solar Community has demonstrated that the community can be heated entirely from a centralized bank of solar thermal collectors. The 52°C heat is collected and stored in a below-ground seasonal storage facility, levelling the diurnal and seasonal energy demand profile.

A thorough evaluation of the electricity market is required to determine the opportunities to export excess power for sale and the policy drivers affecting the viability of interconnection. This power can be sold on a wholesale basis to the utility grid under federal law and certain provincial laws and, depending on the circumstances, used directly by or sold to end users, displacing their retail electric purchases. Whilst provincial grid operators have previously resisted attempts by independent generators to connect to the grid, these operators and regulators are increasingly recognizing the benefits of embedded generation, particularly in stressed sections of the grid. However, the project finances will be maximized if as much of the generated electricity as possible is used "behind the meter" by on-site consumers. Only after demand has been characterized and power use/sales potential verified can the plant configuration be determined. Common technologies include CHP, natural gas-fired reciprocating engines and turbines. RETScreen can be used to estimate CHP

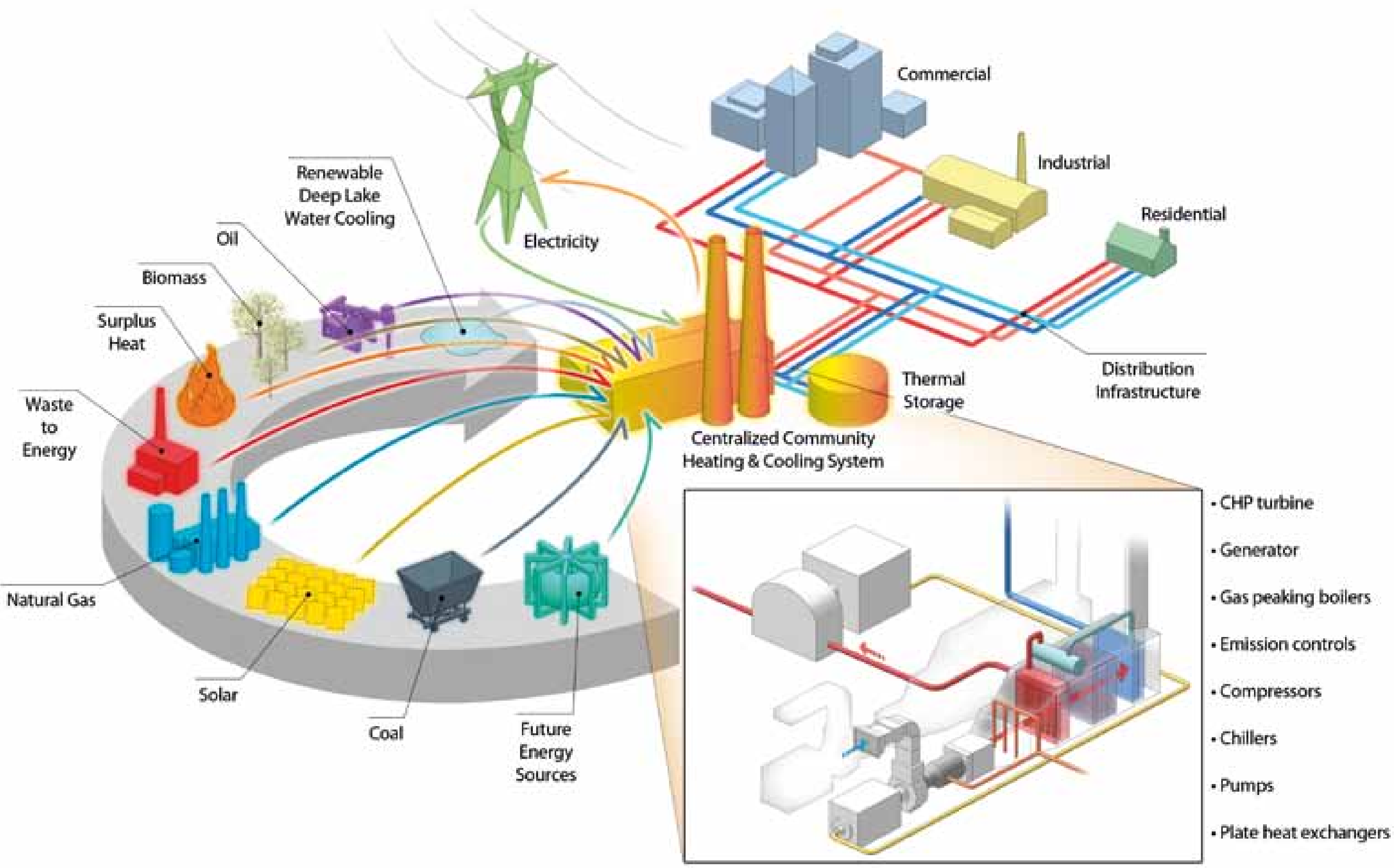


Figure 16: District energy can integrate a variety of fuel sources to take advantage of market conditions and local resources. The central plant houses the prime movers which will vary based on the plant design and configuration.

size requirements. The software is available through Natural Resources Canada on the RETScreen website: www.retscreen.net/. (See page 58.)

The electrical or thermal output of a CHP system can be used to produce chilled water. Hybrid plants integrate electric and steam-driven chillers and often provide valuable balancing benefits to CHP facilities. Direct or steam absorption chillers can also be used to take advantage of excess heat.

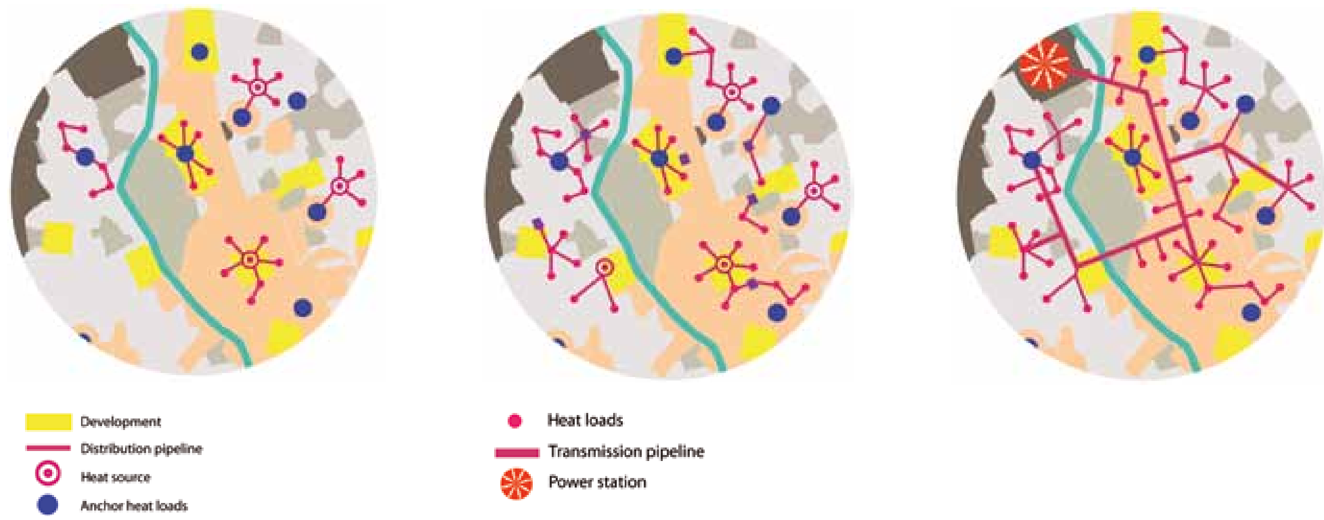
Central plants can accommodate a variety of different heat production equipment. Gas-fired heat-only boilers are very flexible and can be used to provide back-up heat or base load demand, along with further boilers to meet peak demand. When biomass or a solid fuel such as coal is used, it is typically deployed to meet base load, since it has less flexible cycling and ramp times. Gas peaking boilers or thermal stores, which store heat, can respond quickly, and are used to meet peak loads. Electric boilers can also be included, as they provide balancing services to regional grids and microgrids, which require a high level of intermittent, renewable generation capacity.

Planning the siting of a central plant requires detailed consideration to identify the optimum location. Access for transportation can be a factor if bulky fuels such as biomass are being used. Canals and navigable rivers can be used to transport such fuels cheaply and with minimal impact. Plants using natural gas have more flexibility in their location. Many towns and cities may have former industrial sites on the edge of downtown areas, which could be used.

Such former industrial sites are ideal for re-planting thermal networks serving adjacent central business districts. Consideration should also be given to large industrial plants that could be the catalyst for the development of a network to make use of any spare capacity to heat or cool neighbouring buildings.

Lastly, the planning of a new power production plant should identify sites that can co-locate with significant heat demands to facilitate the development of district energy networks. Thermal energy from such plants can be used during the summer in absorption chiller plants to provide air conditioning, and therefore reduce peak demand on power production and ease capacity constraints on power networks. Integrating electrical and thermal output in this way maximizes overall system efficiency.

These decisions require a fairly involved review, which should be conducted by a qualified engineering firm that can help complete an extensive analysis. They will also need to be familiar with regional permitting in respect of air quality requirements. An in-depth evaluation of the economics of the available options will determine the optimum configuration. (See Case study, page 24.)



1. Nodal networks develop around anchor loads, often linked to new development, served by a small heat source.

2. Networks expand and larger heat sources start to emerge to meet growing demand.

3. Networks begin to link to each other to share excess heat capacity. Original heat sources are replaced as they reach the end of their life, potentially with waste heat from a power station. A transition main will carry large volumes of heat over long distances.

Figure 19: These diagrams show network development.

5.1.2 Fuel

Some thought must be given to types of fuel and their supply chains, as well as space for the delivery, storage, and handling of bulky fuels, such as biomass. These issues will help determine the feasibility of the heat or cooling production systems.

5.1.3 Future proofing

This includes:

- planning space for additional capacity within the plant utility to cover future expansion of the network;
- a building design that will allow plant replacement and the later fitting of new technologies, such as fuel cells or biomass CHP;
- sizing pipe work to allow future expansion of the network.

Ideally, these factors should be considered as an integral part of the master planning process in new building developments.

5.2 Gradual development

Many projects develop as heat- or cooling-only projects until the network, and therefore the load, is large enough to justify full CHP. This is a useful approach in the phasing of new-build projects. Other opportunities for heat production that could augment the project, such as solar thermal, heat pumps, and geothermal, as well as sources of waste heat near the project, need to be considered at the same time because:

- technologies may not be compatible with CHP. Solar thermal, for example, might result in excess heat in summer;
- different technologies may produce temperatures that are too low for district heating.

Another approach is to build a **nodal network** that involves development of smaller, localized district energy systems sized to meet the needs of the immediate area. Ultimately, these smaller systems would be linked together as market penetration allows and system interconnection merits.

This gradual approach is in line with energy strategies adopted by a growing number of cities for the emergence of extensive district heating networks over the long term. Meanwhile, developments need to be designed to be ready to connect when they are able to do so. Planning policy, informed by energy maps, is central to supporting this process and ensuring future customer connections (see page 21). A number of Canadian municipalities have undertaken energy mapping studies as part of broader community energy planning initiatives, including Vancouver, Calgary, Barrie, Guelph, Burlington, Hamilton, London, and Toronto. By identifying areas of existing thermal demand, future growth and density, municipalities can strategically direct thermal energy infrastructure investments, for example:

Amendments to the City of Guelph's Downtown Secondary Plan:

"The City shall work with Guelph Hydro and landowners to develop district energy systems, combining heat and power, for large-scale developments or areas within downtown, where the feasibility of such facilities has been demonstrated. Should the City and Guelph Hydro identify parts of downtown as potential district energy areas, new development shall be district energy-ready subject to the City establishing District Energy-Ready Guidelines. (Section 11.1.6.2.2).

Where a district energy system has been established or is planned, new City-owned buildings shall use the system and private development will be encouraged to connect to it. (Section 11.1.6.2.3)."

In other cases, it may be heat available from large industrial boilers, a CHP plant with spare heat capacity, or a local water

feature that serves as a catalyst for developing a district energy network. Enwave's deep lake water cooling system leverages its proximity to Lake Ontario to provide cooling services to more than 150 buildings in downtown Toronto.
(See the Case study on page 38.)

5.3 Finance

The capital, operational, and maintenance costs, along with likely revenues from heat, cooling, and electricity sales, should be roughly estimated at this stage, too. It should be noted that financial models for district energy projects are particularly sensitive to revenues and therefore care should be taken in getting them well defined. Here, it is appropriate to use a more sophisticated financial appraisal methodology than in Stage 4. For example, discounted cash flow, that takes into account future cash flows and discounts them to present-day values; and life-cycle costing that identifies avoided future costs such as boiler replacement. This will help to establish whether the proposed project is economically viable and affordable for customers.

Rates of return can be calculated and reviewed based on a variety of sensitivity analyses, including debt-to-equity ratios, weighted average cost of capital, and various forms of capital resources. Capital resources include bonds, loan guaranteed debt, and potential government program funding from grants, loans, or tax policy. Some projects may be eligible for funding from the Infrastructure Canada Gas Tax Fund (see page 58) and/or the Federation of Canadian Municipalities Green Municipal Fund (see page 58). In some cases, **Tax Increment Financing (TIF)** districts can be established to help fund long-term infrastructure investments. It is important to fully evaluate the range of financial resources available to project development. For more information, see Stages 8, 9 and 10.

5.4 The optimum solution

The feasibility study may produce a range of scenarios, using different permutations of technologies and design arrangements, in order to identify the optimum technical solution. It is important to conservatively project revenue and the timing of sales revenue from customer connections, and to include reasonable capital costs and contingencies to capture the project capital risk. Some time should be allotted for running iterations of a sensitivity analysis to evaluate the impact on rates of return for various scenarios. Depending on whether the project principals are private investors, public entities, or partnerships, this may alter the rate of interest targets and financial viability of the project.

Figure 20: Hamilton Community Energy, Ontario. **Photograph courtesy of FVB Energy**

CASE STUDY: District cooling in Toronto fed by deep lake water

Figure 12: Enwave's Deep Lake Water Cooling uses the icy water of Lake Ontario to provide renewable cooling for the city of Toronto.

Image and text courtesy of Enwave

An innovative renewable district cooling system and upgrades to Toronto's district heating system have brought efficiency and environmental benefits to a reliable system with a long history of serving the city's commercial and residential inhabitants.

A unique partnership between Enwave and the City of Toronto enabled the city's downtown core to use an alternative to conventional, energy-intensive air conditioning, and to implement the largest lake-source cooling system in the world.

Commissioned in 2004, Enwave's 75,000 ton (TR) Deep Lake Water Cooling (DLWC) system uses Lake Ontario's icy water as a renewable energy source. In winter, the surface of the lake cools to about 39°F (a little less than 4°C). This cold water's density increases, causing it to sink. In summer, the surface water heats up, staying at the surface as it is not dense enough to sink. No matter how hot the summer, the deep water remains very cold. Over time, this phenomenon has created a permanent cold water reservoir at the bottom of Lake Ontario.

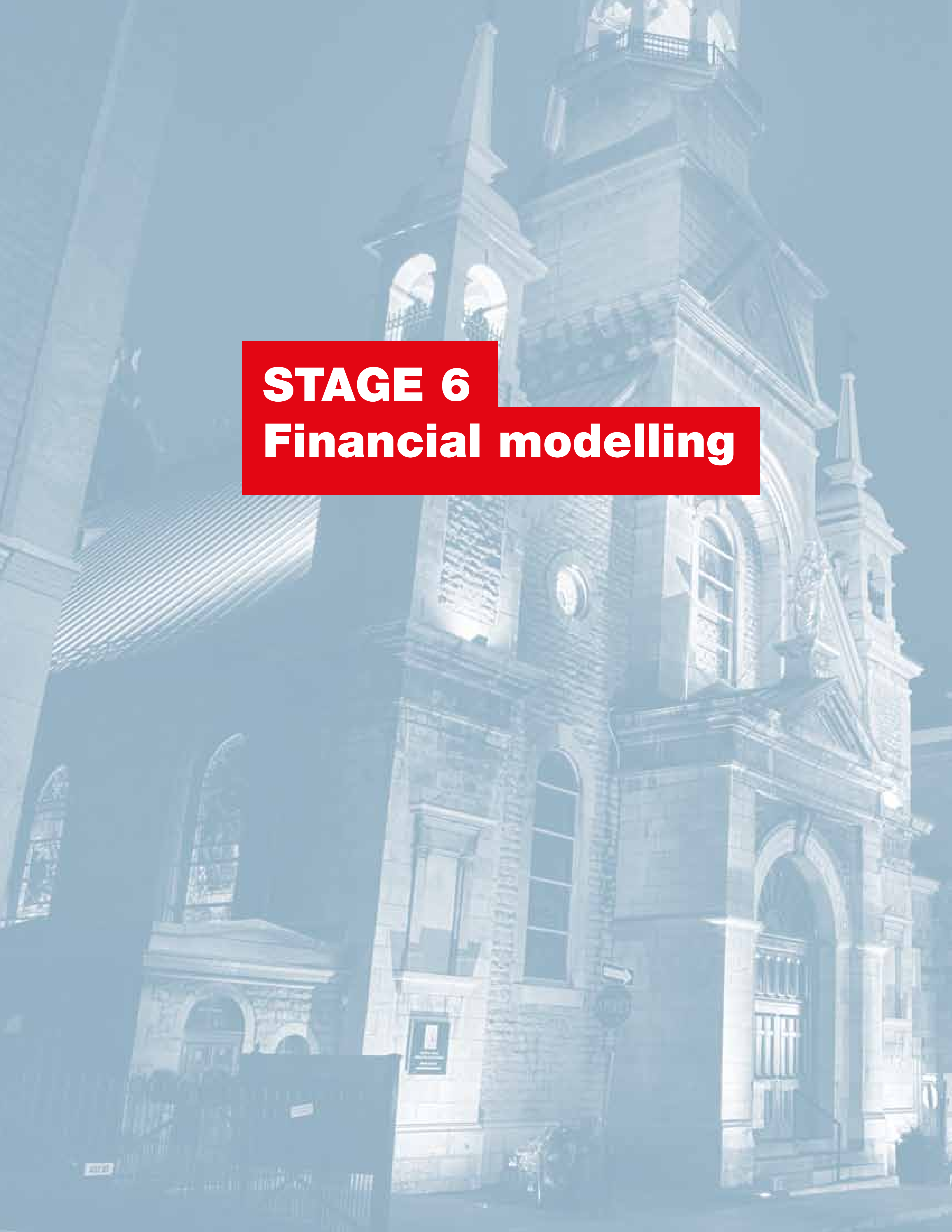
Three pipes that run along the natural slope of the lake bottom pump water from a depth of 83 metres to the Toronto Island Filtration Plant. There, the cold water is processed, then directed to Enwave's Energy Transfer Station, where heat exchangers facilitate an energy transfer between the cold lake water and Enwave's closed chilled water supply loop. The lake water continues on to the city's potable water system. Only the coldness of the lake water is harnessed, not the water itself. As a result, DLWC provides a unique, green alternative to conventional air conditioning.

DLWC reduces electricity use by up to 90% and reduces 61MW of demand on the electrical grid each year, a shift that provides environmental benefits to all customers. The DLWC system eliminates ozone-depleting refrigerants and reduces emissions of harmful pollutants, including NOx, SOx, and CO_2. The environmental benefits are equivalent to removing 15,800 cars from the road.

In 2011, Enwave completed an extensive efficiency upgrade of its Pearl Street Station district heating plant in downtown Toronto. This has reduced natural gas consumption and carbon dioxide emissions, and lowered energy costs. The Pearl Street Station plant now achieves seasonal efficiencies of greater than 92%.

Developers building in areas with district energy are freed from environmental permitting challenges and energy production uncertainty and can focus on designing buildings that take advantage of the increased leasable space created by removing in-building heating and cooling systems. Planners and city officials can attract developers of state-of-the-art buildings to populate a strong, transit-oriented and walkable downtown district that attracts high-quality commercial and residential tenants. These are true economic advantages in a competitive global market.

STAGE 6
Financial modelling



STAGE 6 Financial modelling

The feasibility study and the financial modelling usually need to be undertaken in a reiterative process. They each inform and have consequences upon the other. However, the financial modelling undertaken in the feasibility study is relatively basic and now needs to be investigated in detail.

6 Feasibility and finance

Having determined the technical feasibility and basic financial viability of the project, viability needs to be tested in more detail. In many proposals, factors beyond the project boundary will have a positive impact on the viability of the project. For example, linking the new-build development to existing buildings or communities, particularly anchor loads, achieves a greater economy of scale and makes the scheme more attractive to investors.

The type of business model (see page 46) chosen for the project will affect its financial viability. Particular organizations have different perspectives on capital costs. Public sector organizations generally view investment in infrastructure as a means to an end of achieving broader objectives and are willing to accept a longer-term payback. They can also access capital at a lower cost, whereas capital costs to private sector, profit-making organizations are higher and they require shorter-term paybacks. Therefore, it may be appropriate to undertake the financial modelling using a range of rates of return. This will help determine the appropriate business model to deliver the project.

Once again, for complex projects, expert help will probably be required. Some engineering or multidisciplinary consultancies employ expert staff in this area, but financial advisors with the relevant expertise may also be helpful. Selling heat is relatively simple, but trading in electricity is extremely complex, involving a wide range of policies, regulations, charges, incentives, taxes, and exemptions. It is advisable to choose a consultant who is very familiar with this field.

6.1 Aims and objectives

Financial modelling should begin by re-stating the project's aims and objectives.

— *Financial viability:* The financial model must have a positive value. At first pass it may not, in which case, adjustments to the technical and business model, innovative financing, or further fundraising may be necessary.

— *Affordability to consumers:* For commercial customers, connection to a district energy network must be a competitive proposition in comparison to the business-as-usual case (gas supply and cost, operation, and maintenance of plant). For residential customers, it may be that convenience and quality of service are equally important.

— *Reducing emissions, including SO_2, NOx, CO_2:* This may be considered on a provincial or regional basis. It is important to determine what market mechanisms might exist to monetize emission reductions progress.

— *Supply security:* This has a value to commercial customers and is especially important for mission-critical facilities such as hospitals.

— *Sustainability:* Communities that pursue transit-oriented development to achieve livable communities, centred on lifestyle and convenience, create a valuable local economy that can attract new businesses and residents. Companies want to locate in eco-districts and see a strategic value in investing in such locations.

6.2 Creating a spreadsheet

The next task is to set out all the costs and benefits in a spreadsheet (see Figure 21, page 41). Below are the costs you need to include.

6.2.1 Capital costs

All the capital costs required for the development and delivery of the project, including:

- land for plant utility;
- plant: CHP engine sized to meet base load; back-up and peak boilers to meet peak load; as well as pumps and ancillaries;
- pipes for distribution network;
- consumer hydraulic interface units for bringing heat from the distribution network into the building (not including internal heating system);
- soft costs including engineering permitting, land-use approvals, and rights of way;
- construction and installation costs.

Cash Flow Analysis of 13 MWe Natural Gas Turbine CHP Plant and District Heating and Cooling in Town Centre (In Thousands of Dollars)

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Capital Costs																
District Energy CHP Plant costs (including plant, boilers, chillers, etc.)	(12,766)	(12,766)	-	-	(11,489)	-	-	(11,489)	-	-	(2,553)	-	-	-	-	-
District heating and cooling network costs	(2,924)	(2,193)	(1,462)	(1,462)	(1,462)	(1,462)	(731)	(731)	(731)	(731)	(731)	-	-	-	-	-
Cost of building connections	-	-	(724)	(724)	(483)	(483)	(483)	(241)	(241)	(241)	(241)	(241)	(241)	(241)	(241)	-
Operating Costs																
Natural gas costs	$-	$-	$-	$(755)	$(1,510)	$(2,264)	$(3,019)	$(3,522)	$(4,026)	$(4,277)	$(4,529)	$(4,781)	$(5,032)	$(5,032)	$(5,284)	$(5,535)
Plant O&M costs	$-	$-	$-	$(330)	$(659)	$(989)	$(1,318)	$(1,538)	$(2,483)	$(2,639)	$(2,794)	$(2,949)	$(3,104)	$(3,104)	$(3,259)	$(3,415)
Revenues																
Revenue from sale of heat	-	-	-	913	1,826	2,739	3,653	4,261	4,870	5,174	5,479	5,783	6,088	6,088	6,392	6,696
Revenue from sale of cooling	-	-	-	1,408	2,815	4,223	5,630	6,569	7,507	7,976	8,446	8,915	9,384	9,384	9,853	10,322
Revenue from sale of electricity to grid	-	-	-	527	1,054	1,580	2,107	2,458	2,810	2,985	3,161	3,336	3,512	3,512	3,688	3,863
Total revenue	-	-	-	2,848	5,695	8,543	11,390	13,288	15,187	16,136	17,085	18,034	18,984	18,984	19,933	20,882
Total cost in year	(15,690)	(14,959)	(2,186)	(423)	(9,907)	3,345	5,839	(4,233)	7,705	8,248	6,237	10,063	10,606	10,606	11,148	11,932
Cumulative Costs	(15,690)	(30,649)	(32,835)	(33,258)	(43,165)	(39,820)	(33,981)	(38,214)	(30,509)	(22,261)	(16,024)	(5,961)	4,645	15,251	26,399	38,331
Net present value	(15,690)	(29,936)	(31,919)	(32,285)	(40,435)	(37,815)	(33,457)	(36,466)	(31,250)	(25,934)	(22,105)	(16,221)	(10,315)	(4,691)	940	**6,679**
Discount rate	**5.0%**															

Figure 21: Financial modelling spreadsheet: phased development of public sector project with initial phase operating natural gas boilers and electric chillers. 6.5MWe of CHP capacity added in Year 4 and in Year 7 to meet load growth.

Courtesy of FVB Energy Inc

6.2.2 Operational costs

All costs associated with the operation of the project over a 25-year term. These are:

- — input fuel (natural gas, oil, and/or biomass);
- — electricity for lighting and pumping;
- — maintenance;
- — billing and revenue collection, including bad debt provision;
- — operational management;
- — customer care, including emergency cover;
- — capital interest and repayments;
- — insurance;
- — property and income taxes;
- — contributions to sinking fund for replacement of the system at the end of its life. To ease the financial burden, this may be introduced after senior debt has been discharged;
- — legal and financial advisor fees.

6.2.3 Capital contributions

— Debt: District energy projects can be developed using a mix of debt and equity financing. Loans can be obtained from provincial infrastructure funds, based on robust financial models showing positive cash flows over the full term. Repayments are made from revenues. Long-term contracts can be used as collateral to secure debt at competitive interest rates. Interest payments on debt are tax-deductible for the entity making the payments, whereas equity payments are not. Project proponents should seek expert advice on tax matters. Although Canadian municipalities are able to issue bonds, the actual application of municipal bonds is limited because of the challenges associated with obtaining the necessary provincial backing[13]. Municipalities can, however, form private corporations which allow them to carry debt. For example, Markham District Energy is a private corporation whose sole shareholder is the city of Markham. In Guelph, the city has partnered with the local utility to form a district energy subsidiary.

– Equity: This may come from a variety of stakeholders, ranging from those with a direct interest in the project, to remote investors. It can also come in a variety of forms, including assets and cash. Typically, Canadian projects have used equity for the initial phases of a project before deploying debt finance once the cash flows have stabilized. Different equity sources will have different expectations in terms of return. Viable projects will attract private equity investment in return for an appropriate equity stake. The predictability of positive cash flow associated with a district energy project is the key aspect that attracts such equity. Investments may also include equity from consumers and/or communities, notably pension funds, and land.

— Grants: There have been limited federal grant opportunities through the Federation of Canadian Municipalities Green Fund (see page 58), which has included some provisions for clean energy capital funding as well as low-interest loans. Grant availability will change over time. For current information, check the IDEA website: www.districtenergy.org.

— Connection charges: To help offset the capital cost of installing and building a network, customer connection charges can be used. By connecting to a network, buildings or developments will avoid the expense of installing their own on-site system and may, therefore, be able to contribute towards the cost of a network. This cost might be set at a slightly lower rate than the on-site alternative as an incentive to connect. A hurdle rate analysis is typically used to evaluate the economics of connecting new customers. The developer determines the minimum acceptable rate of return on equity needed to ensure the system remains financially sustainable. If a customer does not meet this minimum or hurdle rate, the developer can ask for a contribution to the cost of connection to compensate.

— Land availability: Public sector landowners may be open to making land available for plant sites for free, or below market values, in return for an equity stake in the project or special purpose vehicle, which is a separate company specifically set up to oversee all aspects of development of the energy system. The identification or provision of land is a key role for municipalities.

Net cash flow

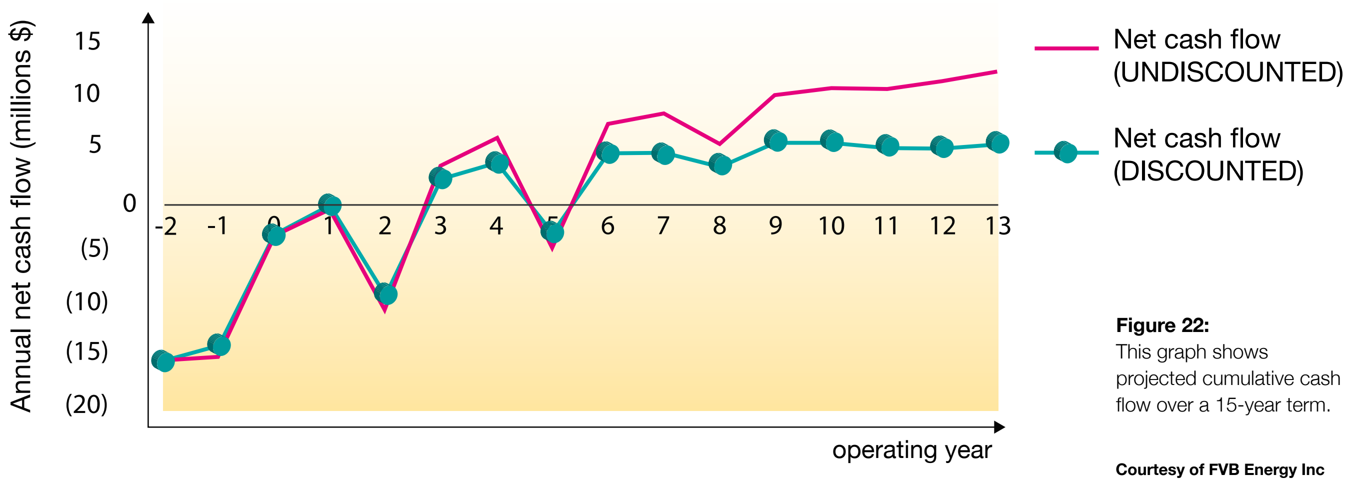


Figure 22:
This graph shows projected cumulative cash flow over a 15-year term.

Courtesy of FVB Energy Inc

6.2.4 Revenues: income

— Thermal energy charges: Payment for the supply of thermal energy to customers. Often tariffs or service agreements include two principal components: a Capacity Charge and a Consumption Charge. The Capacity Charge is based on the fixed-cost recovery of plant, the piping network, and customer interconnection costs, and is allocated based on total capital investment to be recovered over the life of the asset. It is billed monthly and is often determined based on the one-hour peak requirement of the customer. The Consumption Charge is based on recovery of direct variable costs, like fuel and water, and is billed monthly on the recorded metered usage in MWh for heating or cooling.

— Electricity revenues: These will only apply when a power-generating plant is included, such as CHP. The British Columbia Feed-In Tariff (FIT) Standard Offering Program lists CHP as an eligible technology. CHP systems must be at least 80% efficient to qualify[14]. Similar to the sale of thermal energy, there may also be separate revenue streams for the sale of electric energy and capacity, depending on who is buying the power and in which market. Several provinces have established or joined market-based cap and trade systems, such as Alberta's Greenhouse Gas Reduction Program[15].

— Maintenance charges: These cover maintenance to the plant and network, as well as equipment within the customer's property.

— Tax benefits: Credits, exemptions, and accelerated depreciation can reduce tax exposure. For example, Class 43.1 targets CHP with an accelerated depreciation schedule. These may be available at a federal level, or vary by province and type of project.

Once this work is complete, the data must be analyzed using the assessment methodologies discussed on page 31. At this stage, it is most appropriate to use life-cycle costing, including discounted cash flow. This will show if the project is financially sustainable by providing a positive or negative net present value (**NPV**). Simplistically, capital contributions should be offset against capital costs. Income must meet operational costs, support capital servicing (interest charges and payback of loans and investments), and leave a surplus for the project to be financially sustainable. It may be useful to use a range of internal rates of return, to help identify the most appropriate business model to deliver the project.

6.3 Risk assessment

The financial model will be vulnerable to a variety of risks. Therefore, a risk assessment must be developed. Ideally, the risk assessment is drawn up with other stakeholders in the project, as they may identify risks the project developer has overlooked. The risks then need to be evaluated in terms of how likely they are and how significant the consequences. They can next be designated as high, medium, or low risk and allocated to the party best placed to manage them. For risks that remain with the project, strategies must be developed to manage them.

At the end of this exercise, there will be risks outstanding. These will be monetized in the financial model. The model then needs to be subjected to a sensitivity analysis of these risks. The key ones are:

— the absorption rate, that is the build-out, phasing and occupancy of units. Up-front contracts can mitigate this;
— balancing generation and demand, which includes the critical issue of phasing: plant and infrastructure must be installed before demand commences; development phasing must consider the preferred energy strategy at the master planning stage so that potential issues can be identified and addressed;
— permitting and regulatory risks of plant siting;
— cost over-run in construction;
— plant efficiencies failing to reach design specification;
— plant failure;
— fuel price variation;
— non-payment by customers;
— delay in insurance payments for damage to property.

The analysis must look at the likelihood of the risks occurring at various levels and how sensitive the financial model is to them. For example, would the project still be financially sustainable if fuel costs increased by 5%, 10%, 15%, and 20%? If so, then the model is robust. See an example of a risk assessment on page 43.

	Risk Description	Risk Ownership	Impact Description	Impact Severity	Probability	Action Status	Mitigation Strategy	Revised Impact	Revised Probability	Action Status
Engineering design	Poor technical design	Technical Sub-Group	Project fails to achieve objective; project fails to achieve financial viability	High	Possible	Manage	Check track record of engineer; check references; peer review; check Professional Indemnity in place	Low	Low possibility	Review
Planning and permitting	Fail to secure permits	Planning Sub-Group	Project cannot proceed	Extreme	Possible	Actively manage	Early understanding of requirements; early engagement with officials; ongoing engagement, adjustment, and review	Low	Possible	Actively manage until secured
Construction	Poor construction and installation	Technical Sub-Group	Work requires correction and remediation; adverse impacts on project schedule and budget	High	Probable	Actively manage	Monitor and review; set standards in contractor agreements; obtain insurance cover	Off-set	Off-set	Monitor and review
Performance	Plant and equipment fail to achieve performance specification	Technical Sub-Group	Project fails to achieve objective; impact on financial viability	Medium	Possible	Actively manage	Include performance specification in supplier/contractor agreements; obtain insurance	Off-set	Off-set	Monitor and review
Demand	Does not meet expectations; reduces due to customer actions and/or behaviour	Commercial Sub-Group	Impact on technical performance; impact on financial viability	Medium	Possible	Actively manage	Early and ongoing engagement with customers; accurate consumption data monitoring; cooperation agreements on customer equipment; volume or price guarantees in contracts	Low	Low possibility	Actively monitor and review
Input fuel pricing	Prices increase more than anticipated	Commercial Sub-Group	Impact on financial viability	Medium	Possible	Manage	Use market forecasting service; secure long-term or flexible supply contracts; adjust technical design to allow use of alternative fuels	Low	Possible	Review
Output pricing	Revenues fail to cover costs	Commercial Sub-Group	Impact on financial viability	High	Possible	Manage	Active monitoring of costs; liaise with Technical Sub-Group on performance; indexation in customer contracts	Low	Possible	Actively review

Table 2: Example of a risk assessment.

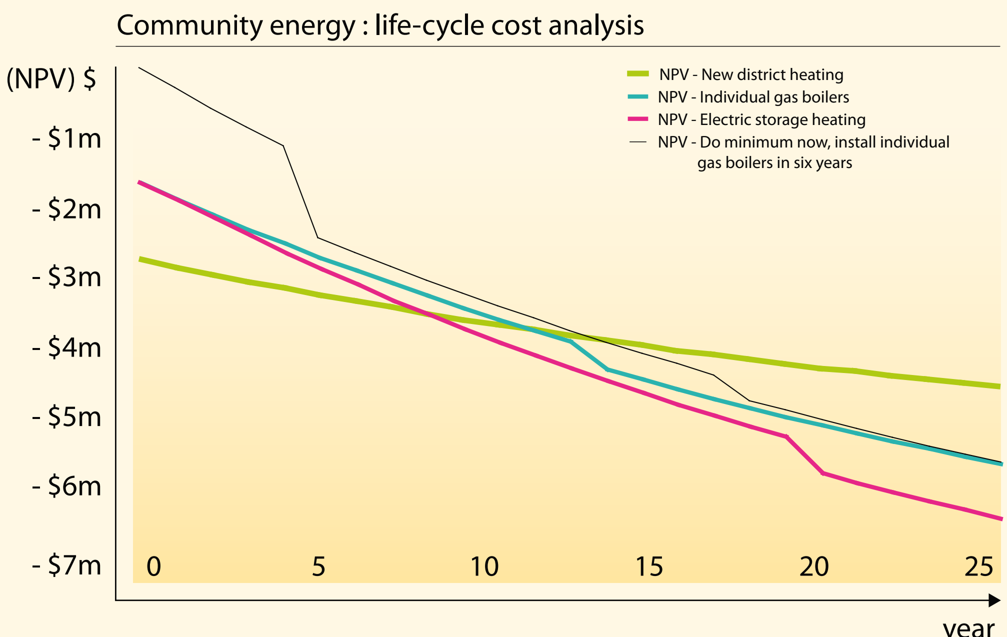
6.4 Project risks

One of the biggest issues in developing district energy systems is determining the absorption rate or the lead/lag on capital investment and revenue return. It is critical to evaluate cost-effective energy efficiency and environmental mitigation strategies, and develop realistic assumptions on the timing of capital deployment, system operations, and market penetration. Capital must be expended before revenues start coming in. This initial investment in plant and distribution piping has to be timed so customer connections follow as soon as possible. Delays in generating revenue from thermal energy sales will negatively impact the rate of return. Sequencing phases of capital deployment to match customer uptake is vital, particularly where new construction is an integral and early portion of the customer mix. This must be considered in the master planning and in the development plan. The overall penetration and timing of completion and occupancy of new buildings can impact the onset of revenue streams and may also affect the type of business model selected to deliver and operate the project. The financial study should consider these issues to ensure there is sufficient capital in reserve to overcome this gap.

Projects that fit connections to pre-existing buildings have the advantage that heating/cooling loads already exist and can provide a revenue stream from the moment of connection. Projects financed with debt have to make capital re-payments from the start of the loan. This may not be a problem, but if there is a lot of capital involved and the break-even point is lengthy, it may create cash flow difficulties for the financial model, or even render it unviable. Equity financing does not present this problem.

The particular constitutional arrangements for the business model may limit the use of equity. Alternatively, the overall capital requirement for the municipality or public utility may be reduced by structuring the business model so it tenders out elements of the project, or its entirety, on a design, build, finance, and operate (**DBFO**) arrangement to a third party. Indeed, contracting out particular functions can be a helpful way of starting a project without having to build an internal department. However, this will transfer the risk to the third party and will increase the overall project cost as the risk will be priced and may result in higher consumer charges.

The business model must be considered in tandem with the financial modelling, as one may need adjusting in light of the other.



Assessing financial viability

Different methodologies can be used to assess financial viability.

—***Payback:*** gives a simple indication of when investment in a particular technology will break even and begin paying back. This gives a very crude indication of viability and does not place a value on future cash flows.

—***Discounted cash flow:*** discounts future costs and revenues at a given rate in order to bring them back to present-day values.

—***Net present value (NPV):*** uses discounted cash flow to give a project an overall **net present value** which is either positive or negative. If it is positive, the project is viable. If it is negative, it will need more capital to bring it to a positive value.

—***Internal rate of return:*** many organizations use a given fixed rate as an internal threshold which projects must meet to be worth further investment.

—***Life-cycle costing:*** Government agencies use a life-cycle cost (LCC) analysis over a 25-year term to determine if a public sector energy project is a sound investment. This approach considers the capital costs of each option as well as other costs over an extended period of time, typically 25 years or more. This adds up the capital costs for each option as well as taking other costs into account (see the graph above).

—***Operational costs:*** these include fuel, maintenance, and replacement costs; the latter must be included because some technologies will need total or partial replacement within a 25-year period.

—***Future costs:*** these are for operations (fuel, maintenance, and replacement costs), brought back to present values using NPV at a discount rate appropriate for the type of organization.

—***Discounting costs:*** including discounting costs avoided, for example, for plant replacement and maintenance.

STAGE 7
Business modelling

STAGE 7 Business modelling

There are four basic business models within the context of district energy projects: **private project development companies** (**PPDs**), public project development companies, hybrid public/private partnerships (P3s), and stakeholder-owned **special purpose vehicles** (**SPVs**). Sources of finance, the roles required to deliver and operate a low-carbon energy project, and the proportion of private and public sector involvement must all be considered.

7.1 Risk and objectives

Throughout this guide, the importance of the project proponent's attitude to risk and their desire for control has been discussed. Most organizations wish to minimize their exposure to risk but, as a general rule, risk should be assigned to the parties that are best able to manage it. However, transferring risk can have financial implications. Risk will be monetized and this could add to the financial burden carried by the stakeholder that accepts it.

Public sector project proponents can generally accept a lower rate of return than private sector ones. They can also access capital at lower rates than private companies, as financiers can be more certain of getting their investment back. Consequently, if a project is transferred from the public sector to a private company, the weighted average cost of capital is likely to increase and this may affect the viability of the project.

Furthermore, if the ownership of a project is transferred to a private company, then the host organization for a project may relinquish operational control over its future direction. This may not be a problem unless the primary objectives are long-term social or environmental benefits. For example, a municipality may want to develop a district energy project as part of the regeneration of a run-down area. Low-cost energy may add to the pace and viability of an urban renewal program and regeneration package. As such, the municipality may be willing to take a long-term view as it knows that if the regeneration is successful, it will stimulate economic activity, building developers will invest in renewal or new construction, property values will rise, and business sales and tax revenues will increase. However, a private company cannot take such a long-term view and it will want a shorter return on its investment.

Alternatively, a private real estate developer may wish to engage a private energy company to design, build, own, and operate a district energy project serving a new development. The primary purpose for the property developer is to comply with planning obligations, build out the property for lease, and prepare it for sale and subsequent exit. It will not want a continuing relationship with the occupants through supplying them with energy. However, if the project provides a sufficient rate of return for the project development energy company, a longer-term operating arrangement may be an attractive business model.

Project champions considering which model to adopt will need to select the one that is going to provide the project with the best chance of success.

7.1.1 Project proponents (PPs)

For the reasons given above, it is important for the host organization to decide on its objectives, what risk it is prepared to accept, and how much control it wishes to have over the project in the long term. These considerations will then help it decide on the most appropriate business model to apply to deliver the project.

Such business models frequently include utilizing PPs of one sort or another. PPs vary in the scope of services that they offer. Some may offer the full spectrum of the **DBOOM** set of roles (**design, build, own, operate, and maintain**), while others may specialize only in offering subsets of those services under contract.

PPs may be public or private organizations, hybrid public/private entities, or third sector organizations, such as residents' cooperatives. The key features of a PP are that it has a separate budget and business plan from the host organization and it provides a focused management of the energy project. The business plan will typically be over a long period and should be sound enough to attract external investment into the project. On the right you can see the strengths and weaknesses of the different PP arrangements.

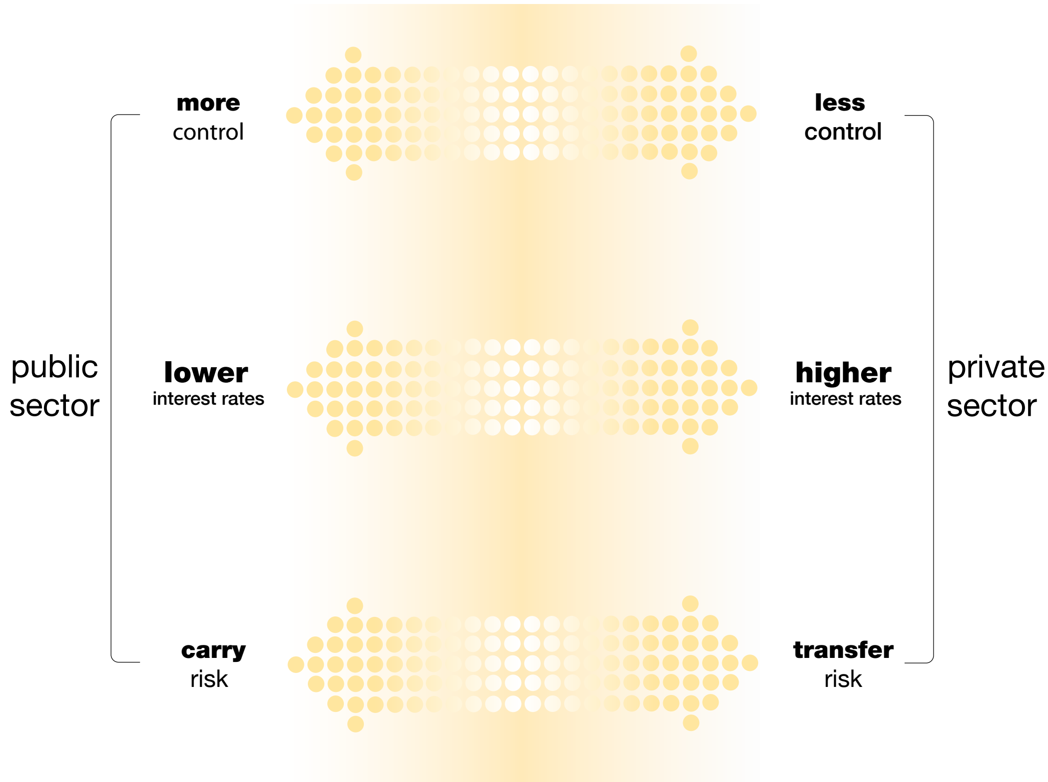


Figure 24: This diagram shows the relationship between risk, control, and the cost of capital for public and private sector projects.

7.2 Private Project Development Companies (PPDs)

There are a number of private companies operating in the energy services market, with specialized expertise in the design, construction, operation, and optimization of central plants and district energy networks. Around the globe, PPDs provide energy management services to municipalities, governments, institutions, and other private sector entities as part of a concession arrangement. Recently, larger utility companies have entered this market, either directly or by buying or taking a stake in a specialist company, thus providing solid financial backing. These are profit-making organizations. To interest them, projects must be sufficiently scaled (approximately 750,000ft^2 of new commercial space or 300–600 multi-unit residential apartment units in the first phase), with appropriate densities and/or an attractive mix of uses and loads. Small (less than 750,000ft^2 or 200 units), wholly residential developments may not interest them. This threshold will drop if there's a mix of loads or a large anchor load nearby.

PPDs may also be interested in extending existing systems to new or existing buildings where the cost of connection will be lower for the building owner than installing or replacing their own plant. These companies can arrange external funding, although the building owners or developers may still need to make a capital contribution for the project to be viable within a reasonable contract length. At a minimum, this is likely to be the cost of providing the business-as-usual case.

The strengths of this approach are:

- the private company invests and carries the financial risk;
- they bring substantial expertise specific to the technology, with extensive project management and operational skills, enabling them to carry the technical risk;
- they continue ownership and operation over the long term.

Weaknesses are:

- higher rates of return are required and energy charges may be higher;
- cannot access low-cost infrastructure funding available through the Federation of Canadian Municipalities;
- public sector sponsors lose control and are unable to direct future development, particularly for projects with a low rate of return;
- customers are tied into a private company with the risk of monopoly abuse.

7.3 Public Project Development Companies

A large number of municipalities own and operate public local distribution companies for purposes of distributing electricity. These public power companies generally serve the buildings and citizens only within the border confines of their city or town. Local governments can form municipal utilities for the purpose of building, owning, and operating district energy companies as well. Indeed, building developers and occupants in Canada are more inclined to sign long-term agreements with municipal owners than the private sector as they have confidence the municipality is there for the long term. For example, in Minnesota, a number of municipal district energy companies are owned and operated as non-profit energy providers, including those in Duluth, New Ulm, and Hibbing.

It is possible to establish a municipal utility or special purpose entity with a defined business plan separate from the municipality, which provides a tightly focused management. Utilizing a project financing strategy, it can also borrow against its assets and revenue streams. However, any debts are likely to be consolidated into the municipality's accounts, meaning it carries the financial risk. Thus, the business case should be soundly based on "invest

Figure 25: A Solar Turbines Titan 130 generator set provides district heating and electricity to London District Energy in London, Ontario, Canada.

Image courtesy of Solar Turbines Incorporated

to save" principles. This also allows it to access capital at close to public sector rates. Publicly owned municipal utilities may be subject to different local taxes, enjoy lower borrowing costs, and, within their charter, have a cost advantage in serving not just other publicly owned buildings, but also nearby privately owned ones.

Although the ownership may be with the municipality, the technical design, build, and operation can be contracted out to specialist professional private companies. Thus, design, construction and operational risk is reduced or passed through.

The strengths of this approach are:

— municipal ownership and control ensures close alignment with municipality social and environmental policies;
— municipal ownership provides covenant strength in obtaining finance, and at a lower cost than private sector borrowing;
— can access low cost infrastructure funding available through the Federation of Canadian Municipalities;
— greater customer confidence and willingness to sign long-term contracts;
— dividends can support the delivery of other services;
— future expansion can be coordinated and controlled by the municipality.

Weaknesses are:

— company is reliant on financial strength of the municipality and it will remain on the municipality's balance sheet;
— municipality must be rated as fair or better;
— municipality carries the financial risk.

7.4 Hybrid public/private partnership arrangements

A hybrid PP company may be established in order to share risk between the public and private sectors and to allow it to access external capital at the lower rates available to the public sector. The Federal Government is keen to encourage public/private partnerships (PPPs) with beneficial funding arrangements, although these are not fully developed. These hybrids could be structured as joint ventures or as special purpose vehicles in which the different parties have a shareholding or membership. It is helpful to think about the different roles necessary for the delivery and operation of a district energy project and to assign these to different parties, or contract them out to specialist professional companies. Possible roles are set out in 7.6, on the right.

There are a number of hybrid models in Canada. For example, in Windsor, Ontario, a private sector company owns the plant whilst the public sector owns the pipes. In Sudbury, a joint venture has been established with a 50/50 ownership model.

Establishing a joint venture or an SPV requires specialized legal assistance. The purposes for the company and its structure will need to be defined in the memorandum of understanding and the **articles of association**. Hybrids must follow the requirements of the legislation that was enacted to bring them into being. Below these, there will be a suite of contracts defining relationships necessary for the provision of the energy services. Although sample contracts are available, they will inevitably require refining to the specific requirements of the host organization.

The strengths of the hybrid approach are:

— close alignment with the socio-environmental aims of the public sector;
— greater flexibility than wholly public or private approaches;
— able to access capital at lower-cost, public sector rates.

Weaknesses are:

— some risk remains with the public sector;
— liabilities are consolidated into public sector accounts;
— has to comply with public sector procurement procedures.

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7.5 Stakeholder-owned special purpose vehicle (SPV)

This is similar to the hybrid approach, above, except ownership is shared amongst a variety of stakeholders. These may be:

— the customers receiving the energy, for example major building owners within a defined location;
— strategic bodies, such as the municipality;
— communities or cooperatives.

An example in the U.S. is District Energy St. Paul, which was formed as a private, not-for-profit organization to take advantage of access to public funding and grants, and to foster a cooperative-like business model. The board of directors comprises representatives of the City of St. Paul, Ramsey County, and various designated, rotating representatives of the customer community. This type of vehicle, common in many parts of the U.S., is best suited to projects where their location, scale, and/or nature challenge traditional financing and ownership models, which will often require a risk premium to accept unconventional terms. This option may be well-suited to delivering long-term solutions to areas requiring regeneration, or to isolated communities in rural areas. It may also offer greater accountability and transparency. In the near to medium term, a district energy network will be connected to a monopoly supplier. Owning the network reduces the risk of monopoly abuse and may also provide a useful way of gaining acceptance and buy-in to a project, by offering residents or communities a stake in the project.

7.6 Potential roles needed for a successful project

— Project champion: identification and definition of a project, achieving stakeholder buy-in, initiating technical feasibility studies and financial investment appraisals, initial fundraising, and driving and promoting the project. The project champion could be the local mayor or the sustainability officer seeking carbon reductions, or the economic development officer seeking to create jobs.

— Regulation: establishing and monitoring standards of performance and/or consumer protection across a wide area, such as a town, city, or region, with which all district energy projects in those areas must comply.

— Governance: this is specific to the particular entity and is concerned with providing strategic guidance, stakeholder accountability, and high-level relationships.

— Contractor*:* a more limited engagement concerned with the physical delivery, including design and construction.

— Asset owner: the party that owns the actual physical assets. This could be a bank or financial investor.

— Operator: responsible for the project's technical operation.

— Retailer: responsible for the retailing of energy across the project, for example, buying it from the central plant operator, arranging its transportation to the end-consumer, and its sale to that consumer.

— Supply chain manager: responsible for the procurement of fuels, equipment, and services necessary for the development and operation of the project.

These roles can be organized in different configurations in order to maximize the benefits and outcomes to the different stakeholders in the most cost-effective fashion. For example, District Energy St. Paul has acted as a project champion in developing district heating in the city. It established the District Heating Development Company initially to construct a new hot-water-based district heating system to serve buildings downtown as an arm's length, not-for-profit company limited by guarantee based on membership. This provided a focused management and a business plan and budget separate from the City and County governments. The City and County are active in guiding the company, with representation on the board, and can therefore influence regulation and governance. It also allows the company to access capital at lower-cost, public sector rates.

However, the company owns the assets and is responsible for development, supply-chain management, and for operation, although many of these activities are contracted out to the private sector. The company retails electricity to a private energy company and variously retails heat to private customers.

7.7 Migrating between different models

It should be noted that the selection of a particular model does not lock the project into that model in perpetuity. There are a myriad long-term ownership models. Municipalities can buy out private companies or take an equity stake in order to increase their strategic control of an energy project within their areas. In reverse, municipalities can develop projects as publicly owned ventures and, once they are well established, and costs and revenues stabilised, sell them on to private sector investors or energy companies. As they will have de-risked the project during its vulnerable development phase it will be worth considerably more than the investment made in it and consequently they can expect a healthy premium. The profit made by the Toronto City Council on the sale of its 43% stake in Enwave for $168 million was the largest windfall the Council had ever received.

CASE STUDY: Heat mapping the city of Fort St. John, BC

Figure 13: Heat map of Fort St John, BC (circle diameter indicates heat intensity).

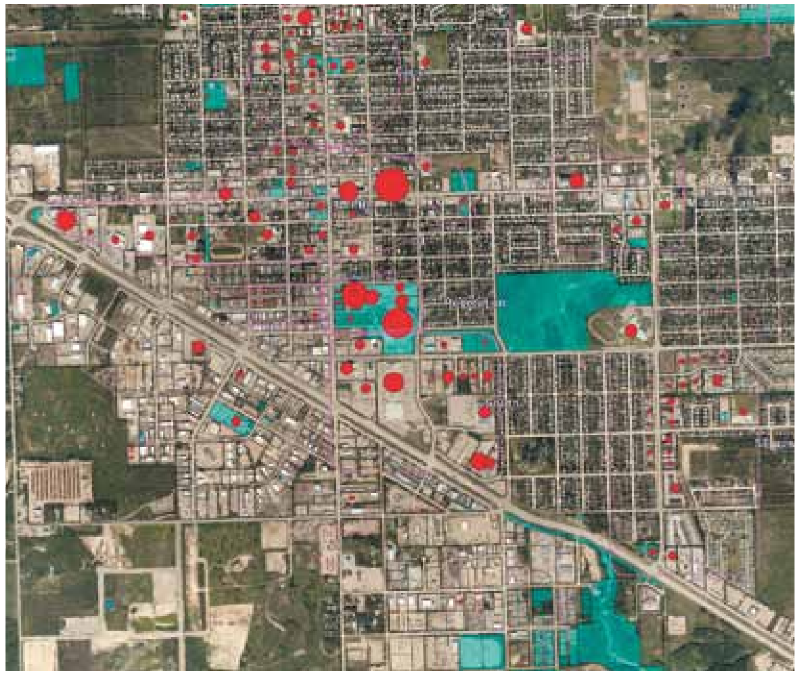

Image and text courtesy of Ramboll

The city officials of Fort St. John, British Columbia, understand the importance of long-term planning for city development that achieves an efficient, sustainable and reliable energy supply to meet future demands, whilst simultaneously achieving desired environmental goals in a financially sound way. One of the means to fulfill the ambitious 2030 GHG reduction target of 12% below 2007 levels is to investigate and identify the potential of a district heating (DH) network through a heat mapping study. Heat mapping is the first step in the planning of this infrastructure essential in achieving environmental targets.

Ramboll Energy (RE) was hired to investigate the potential heat demand for a district heating network in the City through a heat mapping study. This study was broken down into three main stages:

1. Assembly of heat load data for priority buildings using as much actual energy consumption data as possible and presented as a map using Ordnance Survey coordinates.
2. The map was analyzed to identify clusters of buildings and development areas.
3. A main heat network spine was outlined in a high-level implementation plan for the City to further develop, highlighting each individual DH network opportunity.

The main data included:

- building types;
- space to be heated (m^2);
- specific heat demand (individual peak load (kWp) and annual consumption (MWh);
- potential heat sources (CHP, industrial waste heat, waste to energy, etc.);
- existing heat networks;
- future development areas within the city plan.

The methodology for data gathering was to target heat loads by the priority building type, for example:

- central and local government estate;
- hospitals, police and fire stations;
- educational facilities;
- hotels, commercial units and shopping malls;
- private and public residential multi-address units.

This identified 121 buildings or groups of buildings. Eight focus areas (clusters) were identified in the city and its surrounding area (see figure) and prioritized according to size of heat load and the type and mix of buildings (see the table below):

Table – Clusters in prioritized order

High	Medium/high	Medium	Low
Civic	Centre	South	West of Recreation
Recreation	Hospital		South East Residential
			Middle East

Often anchor loads are sought in each cluster as these can provide either a secure and sizeable income stream or be seen as an exemplar building to inspire others in the vicinity. Typically, clusters will be developed around one or more large heat users/producers.

This study is a very early high-level assessment of the potential heat network clusters. The next phase should be to complete a more detailed feasibility study of the preferred scheme(s). A detailed cost analysis and viability calculation based on a whole-life cost approach should be carried out on each network cluster, or the scheme as a whole, to disclose which projects to invest in. Furthermore, a detailed plan with regard to future development and DH potential should be outlined to strengthen and substantiate the city mission of a vibrant as well as an economically and environmentally sustainable community.

STAGES 8, 9 and 10
Marketing and business development; Project procurement; and Delivery

STAGES 8, 9 and 10 Marketing and business development; Project procurement; and Delivery

Stage 8, Marketing and business development;
Stage 9, Procurement of the necessary services, potentially including assigning a project manager and contractors; and Stage 10, Delivery, are the final stages to be completed.

Marketing and business development

8.1 Business development overview

Once the general project has been defined, even with preliminary project schedules and maps, it is important to develop presentation materials and consistent content that describes the physical project, lays out preliminary project phases, and provides an overview of the features and benefits of a local district energy system. Conceptual renderings, development maps, and system interconnection guidelines can be created. Depending on whether the project is a municipal endeavour, a public-private partnership, or a third-party private investment, customers in the marketplace will need to be informed and educated on the merits of the proposed project. Generic materials can be developed from resources provided by membership in the International District Energy Association (IDEA) (www.districtenergy.org), including Power Point presentations and community outreach.

Throughout the project development phase, it is important that potential end-users are identified and that a communications strategy is developed to cultivate buyer interest and identify critical customer locations. Very often, federal, provincial, and municipal buildings serve as anchor loads and their energy requirements need to be fully understood, including timing of major renovations, equipment replacements, or adaptive re-use. From the outset, market intelligence on the potential customer buildings is strategically important and should be a high priority for a professional business development specialist on the team.

8.2 Project Information Memorandum or Request for Qualification

Costs and prices in the financial modelling are, at best, estimates and assumptions. It is therefore a good idea to try to determine if budgets are correct, assess if qualified vendors are present, and verify the project fundamentals. If the project will be tendered to the private sector, testing will reveal if there is an appetite in the market to bid for the project as defined. As this is a specialist area, an experienced consultant is required to do it. The market for energy services is evolving rapidly. It is best to seek advice on the range of services available, and from whom.

Market testing can be done through a **Project Information Memorandum (PIM)** that contains a description of the project, plus key documents, such as the technical feasibility study. This market testing provides a chance to adjust the model to make it more attractive to the market. Potential providers can be identified by issuing a **Request for Qualifications (RFQ)** through an industry clearinghouse to alert regional industry participants of the potential opportunity. This will develop a list of pre-qualified bidders and allow project sponsors to verify projections in the financial model.

Some industry providers are willing to provide turnkey contracts or Design/Build agreements, although these approaches may attract additional price premiums. Private sector partners may have a preferred business model and should be encouraged to identify pros and cons related to risk-sharing and cost recovery mechanisms. Ultimately, the project host must determine the most suitable solution and it would be wise to test any offer against your own project aims and objectives, bearing in mind the different strategic objectives of private and public sector organizations (see page 47). Often, the same companies are willing to provide discrete elements of the project as separate contracts. This could be for installation of the equipment (central plant and equipment, distribution networks, and consumer interface units, including metering), as well as for ongoing operation and maintenance. It is advisable to identify multiple approaches and develop a risk analysis to determine the best scenario for the project.

9 Procurement

9.1 Procurement route

This will depend on the business model selected.

— ***Private sector route:*** public authorities procuring a private sector company to design, build, own, operate, and maintain (DBOOM) a project will need to follow public procurement procedures carefully. They will have to establish an evaluation panel representing a range of skills and expertise, as well as representing appropriate interests within the host organization. Once again, the services of a specialist consultant will be needed in the preparation of tender documentation based on a refined Project information Memorandum or Request for Qualifications. This will then be published in appropriate media as an **Invitation to Participate**. This is a pre-qualification exercise, in which the financial and technical credibility of potential contractors and/or partners and the relevance of their track record can be evaluated. Considerations like relevant experience, bonding capability, etc. can be used to evaluate and compare respondents.

A tender list can then be assembled and companies on it invited to submit initial proposals. Companies responding will need to visit the project locations and meet the host organization to understand the project. In order to ensure impartiality, all visits and meetings should be organized collectively and be open to all pre-qualified companies. Initial proposals can then be evaluated and the tender list focused down to a limited number of companies that are then invited to develop full proposals.

Further meetings and exchanges will then follow. Strict impartiality should always be maintained. Bidders will then submit their best and final offers. After evaluation, a preferred bidder is selected and invited to negotiate. The two parties will identify and agree on key areas for negotiation in a memorandum of understanding or Term Sheet document. Negotiation will then fine-tune the technical, financial, and business model until financial close is achieved and contracts exchanged and signed. Further information can be found at: www.epa.gov/chp/documents/pguide_financing_options.pdf.

— ***In-house provision route:*** public authorities can establish in-house entities to produce plans and specifications for partial bidding and procurement. This route would typically involve the host retaining the services of a qualified consulting engineering firm, architect, legal and permitting specialists, and owner's engineer to oversee quality and project implementation. With qualified technical and project staff, this approach can be useful in mitigating project costs, but the host organization also retains a larger share of project financial risk.

— ***Hybrid/special purpose vehicles route:*** municipalities may have the option to establish a special purpose entity such as a Project Partnership or a Limited Liability Corporation (LLC) that will establish a separate functional organization with a distinct charter, and may include shareholder definitions and financial records. If this route is chosen, the services of a specialist lawyer will be required to draw up the documentation to establish the organization. If the plans include a public authority, it will still have to comply with relevant public bidding and procurement procedures and the process laid out above.

— ***Stakeholder-owned route:*** the procurement route can also depend on who the stakeholders are. Private, non-profit organizations can be formed to act on behalf of the principal customers, as in a cooperative model. Tax implications, ownership and business objectives, market penetration, and capital availability are all important considerations that factor into the final structure.

10 Delivery

10.1 Delivery plan

As part of the negotiations with the preferred bidder, the parties will have set out a project delivery plan, summarized in a Gantt chart. Key milestones will have been set in the final contract. It is advisable to appoint a contracts supervision officer to provide a focus point between the two parties, oversee the delivery of the contract, and deal with any problems that may arise. Additionally, project delivery will involve permits, rights of way, traffic planning, and street construction disruption, and it will be appropriate to appoint a community-relations or resident-relations officer.

For district heating and cooling distribution projects, you will need to open roads in order to lay the pipes. Powers to do this are generally defined in local franchise arrangements with the municipality. Disruption is inevitable and construction coordination and permits and approvals will need to be established with the appropriate local municipal department, such as Facilities, Public Works, and/or Highway Department. Very often, special permits define duration and nature of traffic patterns, safety, and signage. In urban settings, it is important to be mindful of a special events calendar that might cause traffic congestion, such as professional sports events or seasonal festivities that draw crowds.

Commissioning is often used to establish that the project construction has been completed and the equipment and systems operate to design standards. Pressure testing of underground piping can be accomplished through a series of inspections, non-destructive testing, x-ray analysis, and functional burst testing. Most piping components have a standard operating and pressure test in place for acceptance. Major plant equipment should be evaluated through a series of increasing performance standards, from operation confirmation, to delivery performance testing, to confirm that the overall system operates as designed. In a large district cooling system, it may be challenging to simulate a sufficient-size cooling load to evaluate system performance overall. Many large projects now budget a commissioning phase to test the individual components as well as the system performance overall to ensure return on investment and compliance with specifications.

Lastly, all new energy systems will go through a period of teething problems. These could take up to a year to settle down. It is important to be mindful of this fact and endeavour to take a long-term view.

Summary of the project development process

Set overall objectives – see chart on page 15 *(economic, energy security, environmental)*

1. Gather data.
2. Define project – buildings to be served (density levels, load diversity, presence of anchor loads).
3. Options appraisal (consider technical solutions that meet overall objectives for defined project).

→ Other technology.

District energy/CHP

1. Implement detailed feasibility study.

→ Not technically feasible
Consider alternative technical solution.

Technically feasible

1. Build financial model.

Financially viable

1. Build business model that fits risk transfer and control requirements.

Not financially viable
Adjust level of risk transfer and/ or identify other avoided costs and/or further fundraising.

Business model

1. Market test model (check cost and revenue assumptions).
2. Evaluate procurement model.

Private Project Model

1. Prepare documentation *(Project Information Memorandum, Request For Qualifications, Invitation to Participate).*

Public/Private Partnership

1. Decide on business structure *(Joint Venture, Public/Private Partnership, stakeholder-owned cooperative).*
2. Decide role allocation.

Public Project Model

1. Procure separate project elements *(plant room, CHP and ancillaries, distribution infrastructure).*
2. Procure as turnkey contract. Prepare documentation *(Project Information Memorandum, Request For Qualifications, Invitations to Participate)*.

Private Project Model (continued):

1. Decide evaluation criteria Establish evaluation panel.
2. Award preferred bidder.
3. Final negotiation.
4. Financial close.
5. Contracts commence.

Public Project Model (continued):

1. Procure operation, maintenance and billing/ revenue collection services.
2. Franchise turnkey contract.
3. Contracts commence.

POLICY CONSIDERATIONS

Awareness of policy considerations is vital to any energy project development. Communities can benefit from state energy incentive programs and projects must secure necessary permits.

Role of the federal government
The federal government presently plays a limited role in the energy policy arena, particularly with respect to thermal energy. However, it continues to fund valuable district energy development support and research through programs at Natural Resources Canada (NRCan), as well as to provide funds for district energy feasibility studies through the Federation of Canadian Municipalities (FCM) Green Municipal Funds.

Therefore, Canada remains without a national energy strategy and/or carbon pricing. However, the existing programs delivered through NRCan provide a platform and an opportunity for the federal government to develop a suite of supportive policies and financial programs that would facilitate the development of district energy systems. Additionally, such policies and financial programs could deliver not only support, but give direction to the provinces and territories in adopting a consistent approach. This would provide leadership and a signal to the market, as well as ensuring economies of scale in responding to the commercial opportunity.

The federal government could emerge as a leader and champion of high-efficiency, community-based energy systems, by, for example, positioning district energy as essential infrastructure in the face of recent severe weather events, and therefore qualifying for infrastructure improvement funding.

Furthermore, the market could be kickstarted by making a requirement for all federal buildings within reasonable proximity of an existing district energy system to connect to it. This will also promote local jobs and save tax dollars through more competitive energy bills.

Provincial and regional considerations
The ability to develop district energy systems is influenced by a complex matrix of local issues including politics, climate and geography, socioeconomic context, local resources and availability, labour market, utility ownership structure, environmental conditions, and the size and density of the urban areas. For example, electricity procurement can vary by region and province. Although many district energy systems provide thermal services only (heating and cooling), electricity is still required to operate plant and equipment at the heart of the systems. In provinces where electricity is primarily derived from hydro sources (British Columbia, Manitoba, Québec), prices are typically cheaper than in provinces that rely on non-renewable resources (coal in Alberta and nuclear in Ontario account for large portions of the energy supply mix). Therefore, provinces with access to low-cost electricity have less of an incentive to explore more efficient energy systems such as district energy.

British Columbia
District energy operated under private ownership is regulated by the province under the *Utilities Commission Act*. British Columbia (BC) is the only province to regulate district energy services, which provides customers with assurance that the rates charged reflect the accepted cost of service methodologies, using cost allocation practices that account for all appropriate district energy service costs. Additionally, utilities in the province may have access to lower-cost capital for investment in district energy infrastructure. This allows for a longer cost recovery time horizon, translating into more financially sustainable projects, lower rates for customers and the ability to engage in system expansion. If the district energy system is owned by the municipality, regulatory oversight is not required.

British Columbia has a number of energy-related policies that are positioning district energy as a viable option for community-based energy systems. Amongst these provincial policy tools are an internationally-respected carbon tax, Green Communities legislation known as Bill 27 (amending the Local Government Act and Community Charter), and the Climate Action Charter. The Climate Action Charter, in particular, commits all local government

Figure 28: Vancouver at dawn. **Photo credit: Flickr CC Junnn 2013**

voluntary signatories (182 of 190 BC local governments) towards creating more complete, compact, energy-efficient communities across the province. This type of sustainable development provides fertile ground for district energy deployment.

While British Columbia's largest utility, BC Hydro, doesn't own or operate any district energy systems, from 2009–2011,they provided assistance to municipal governments through the Power Smart Sustainable Communities Program (http://www.bchydro.com/powersmart/local_government_district/ps_communities.html) to drive market acceptance of district energy within the province. The program provided access to education, expertise, and financial incentives, including funding for:

— community energy and emissions planning;
— district energy pre-feasibility studies;
— detailed engineering feasibility studies;
— an electricity savings-based capital incentive to offset capital costs for district energy systems.

British Columbia's progressive policy environment has generated significant growth and momentum in the district energy sector, along with the emergence of local expertise. The growth of district energy systems across the province continues to demonstrate their viability, and their potential for netting substantial energy savings. High-profile projects such as the Southeast False Creek Olympic Village, Vancouver's Cambie Corridor, and Dockside Green have helped position district energy systems as part of the public discourse around sustainable community-based energy systems.

Alberta

The province of Alberta is without existing legislation or policy pertaining to district energy. In a similar way to British Columbia, Alberta has set a price for carbon. However, at current levels of $15/tonne, the ability to act as a price stimulant for district energy projects is limited. Construction and operation of CHP facilities utilizing heat extraction require approval from the Alberta Utilities Commission. In contrast, heat generated in a boiler has no specific regulatory framework.

Alberta has made advances on the district energy front with newer systems in Calgary, Edmonton, and smaller scale communities like Okotoks. In Calgary, municipal facilities are serviced by the ENMAX plant (a fully-owned subsidiary of the city) and permit applications are filed with the municipality to install district energy piping similar to the process for fibre-optic cable installation. Okotoks used a small pilot program to study the viability of a solar-based district energy system for supplying thermal energy and domestic hot water within a new subdivision. Today, 52 new homes are connected to the system for heating, cooling, and domestic hot water with year-round solar energy storage. While interest in the oil sands dominates the energy discussion in Alberta, waste heat recovery operations with small-scale district energy networks are already in place for several oil sands industrial applications.

Saskatchewan and Manitoba

Industry data indicates Saskatchewan has only two district energy systems while Manitoba has four. Some of these systems are older, built as early as the 1900s. However, with the discovery of significant fuel resources across the provinces, there is a renewed interest in developing district energy systems.

Saskatchewan is the third largest natural gas-producing province in the country, and is well positioned to support gas-fired district energy and CHP facilities to extend the longevity of its reserves. The province permits electricity produced through CHP applications to be exported to the grid. SaskPower is the largest electric utility in the province, and has a number of partnerships in place to develop more cogeneration facilities. Additionally, the City of Saskatoon is exploring opportunities to capture waste heat from a local power plant to provide thermal energy for the downtown core, and a greenhouse operation through a district energy system.

Figure 26: Winnipeg Bridge downtown at night.
Photo credit: Flickr CC Travel Manitoba 2013

In Manitoba, the two most recent district energy installations utilize geothermal heat. The first system is privately owned, supplying heating and cooling to 18 rental buildings in Winnipeg. The second system is municipally owned and located in Ile-des-Chênes. The system provides heating and cooling for the local arena, fire hall, and community centre. The project received financial support through tax credits from Manitoba's *Geothermal Energy Incentive Program*. District geothermal systems serving multiple buildings are eligible for refundable tax credits of up to 15% and a provincial grant up to a maximum of $150,000.

Ontario

According to industry data, Ontario has the highest number of district energy systems in any province or territory, representing more than 40% of all Canadian systems. Many of the systems were developed through the 1970s and 1980s as a result of the oil crisis and energy pricing volatility. The vast majority of systems are natural gas fired. Ontario's district energy systems include some of Canada's largest, such as Enwave's deep lake water district cooling system, the largest system of its kind in North America.

Ontario is without specific policy or legislation related to district energy and it is regarded as a non-regulated activity. However, the province has set policy for combined heat and power operations. In 2005, the province directed the Ontario Power Authority (OPA) to procure up to 1000 MW of CHP. In 2010, the OPA was directed to negotiate individual CHP contracts for projects over 20 MW and to procure projects of 20 MW or less through a standard offer program.

The 2009 *Green Energy and Economy Act* is often regarded as some of the leading energy legislation in North America. Whilst is does encourage renewable energy by permitting electricity distributors to own and operate renewable energy generation facilities that do not exceed 10 MW, it does not directly support district energy and largely ignores considerations for thermal energy. Further, Ontario's *Municipal Act* restricts the municipality's ability to borrow capital for a variety of projects, including district energy, limiting their scope to initiate such projects.

Québec

District energy is a non-regulated activity in Québec. More recently, the province has become interested in community-based energy systems utilizing biomass. For example, La Cité Verte, is a sustainable community project in Québec City that will develop a district energy system with four biomass (wood pellet) boilers with an installed capacity of 5 MW. The project has received $5m in funding from Hydro Québec in addition to financial support received from Canada's Clean Energy Fund. The emphasis on biomass facilities is, in part, a product of Québec's large forestry industry.

Québec has a number of programs that support efficient energy projects and the incorporation of renewable fuels. Régie de l'Énergie of the Province of Québec will provide financial assistance for feasibility studies for sustainable urban development projects incorporating renewable district energy systems. The program provides proponents with $0.45/kWh saved up to a maximum of $8m per project. Additionally, the Québec Energy Strategy provides energy reduction strategies through sustainable urban development. The program includes an optional component designed to incentivize developing renewable district energy systems. Since 2007, the province has collected a tax on "hydrocarbons" (petroleum, natural gas and coal), making Québec the first North American state or province to charge a carbon tax.

Figure 27: Montreal skyline. **Photo credit: Flickr CC Intiaz Rahim 2013**

Atlantic Canada

Atlantic Canada has district energy systems in New Brunswick, Nova Scotia, and Prince Edward Island. In total, they represent approximately 7% of the country's district energy systems. The majority of the systems are located in Nova Scotia (five).

Newfoundland and Labrador currently have no systems. Much of Atlantic Canada is a net fuel importer. This could be a driver for future growth in the district energy sector.

In 2010, Nova Scotia adopted its *Renewable Electricity Plan*, which aims to increase the province's new renewable energy sources by 25% before 2015 and by 40% before 2020. The plan provides guaranteed feed-in tariffs for renewable energy based on project size and type through its Community Feed-in Tariff (COMFIT) program. Projects must be connected at the distribution level (in most cases, under 6MW) and community owned to be eligible. COMFIT does not include specific provisions for district energy although the program does support the development of CHP facilities.

Figure 29: Yellowknife, Northwest Territories.
Photo credit: Flickr CC ddkkpp 2013

Yukon Territory, Northwest Territories, Nunavut

Due to the remote location of Canada's territories, imported diesel fuel is relied on for space heating and electricity generation. As a result, there are both economic and environmental reasons to support the deployment of district energy systems in the north. Currently, there are three district energy systems in the Yukon, eight in the North West Territories and nine in Nunavut for a total of 20 across the territories.

Canada's north has a number of unique opportunities for district energy system development. The City of Yellowknife is currently studying the feasibility of capturing waste heat from a closed gold mine for a citywide district energy system. Also, the Northwest Territories Power Corporation and Oulliq Energy Corporation in Nunavut have reduced operational costs by recovering heat from diesel generators to heat their own facilities.

Considerable interest has been generated around biomass-fired CHP and district energy systems. New, high-efficiency boilers have made biomass a reliable source for energy in large-scale applications such as institutional, office, or hospital facilities. However, one of the major challenges for biomass systems in the territories is the cost of transporting fuel. Distribution chains for wood pellets are still in their infancy, resulting in increased cost and exposure to supply interruptions.

Building on the interest in using biomass as a clean and efficient source of heat, the Northwest Territories has developed a *Biomass Energy Strategy* to promote greater deployment. The Yukon is developing a similar strategy where local forestry resources could play a role in the development of a regional biomass industry.

Conclusion

It is advisable that at the early phase of project definition, steps are taken to determine eligible funding and policy incentives that might impact technology selections. Municipal, provincial, and federal bodies, such as NRCan, may offer guidance to assist with identifying available financial and technical resources. For more information and a complete list of provincial, local, and federal policy organizations, please visit: www.districtenergy.org. Additionally, readers are encouraged to contact the International District Energy Association (IDEA) for access to industry resources.

Additional resources

For more information on the specific policies in your province that may influence your project, please reference the Natural Resources Canada (NRCan).

NRCan
http://www.nrcan.gc.ca/energy/home
The Energy Sector of Natural Resources Canada is the lead on energy policy for the Government of Canada. NRCan provides information on Acts and Regulations, as well as supporting and publishing research to advance the energy sector.

CanmetENERGY
http://canmetenergy.nrcan.gc.ca/home
Natural Resources Canada's CanmetENERGY is the Canadian leader in clean energy research and technology development. CanmetENERGY manages science and technology programs and services; supports the development of energy policy, codes, and regulations; acts as a window to federal financing; and works with its partners to develop more energy-efficient and cleaner technologies.

RETScreen
http://www.retscreen.net/ang/home.php
RETScreen is an Excel-based, clean-energy project analysis software tool that helps decision makers quickly and inexpensively determine the technical and financial viability of potential renewable energy, energy efficiency and cogeneration projects.

The RETScreen Clean Energy Project Analysis Software is a unique decision-support tool developed with the contribution of numerous experts from government, industry, and academia. The software, provided free of charge, can be used worldwide to evaluate the energy production and savings, costs, emission reductions, financial viability, and risk for various types of renewable-energy and energy-efficient technologies (RETs). The software (available in multiple languages) also includes product, project, hydrology and climate databases, a detailed online user-manual, and a case-study-based college/university-level training course, including an engineering e-textbook.

QUEST
http://questcanada.org/
QUEST – Quality Urban Energy Systems of Tomorrow is a collaborative network of stakeholders who are actively working to make Canada a leader in the design, development, and implementation of integrated community energy solutions (ICES). QUEST provides a variety of publications and resources related to the advancement of integrated community energy systems.

Infrastructure Canada
http://www.infrastructure.gc.ca/index-eng.html
Infrastructure Canada delivers a broad range of infrastructure programs, providing flexible and effective funding support to provincial, territorial, municipal, private sector, and not-for-profit infrastructure projects.

Canada's Gas Tax Fund
http://www.infrastructure.gc.ca/prog/gtf-fte-eng.html
Canada's Gas Tax Fund provides predictable, long-term funding for Canadian municipalities to help them build and revitalize public infrastructure that achieves positive environmental results. More specifically, the fund supports municipal infrastructure projects that contribute to cleaner air and water and reducing greenhouse gas emissions, including community energy systems, wastewater infrastructure, and solid waste management.

Canada's Green Infrastructure Fund
http://www.infrastructure.gc.ca/prog/gif-fiv-eng.html
The Green Infrastructure Fund program specifically targets projects that will improve the quality of the environment and lead to a more sustainable economy over the long term.

Through the Green Infrastructure Fund, Infrastructure Canada supports projects that promote cleaner air, reduced greenhouse gas emissions, and cleaner water. This includes new or rehabilitation infrastructure projects related to green energy generation and transmission, carbon transmission and storage, wastewater infrastructure, and solid waste.

Federation of Canadian Municipalities
http://www.fcm.ca/home.htm
The Government of Canada endowed the Federation of Canadian Municipalities (FCM) with $550 million to create the Green Municipal Fund (GMF). Through the Fund, FCM offers funding and knowledge to municipal governments and their partners for municipal environmental projects, including advancing district energy systems.

Additionally, FCM has developed web-based resources to assist local governments with preparing greenhouse gas (GHG) emission inventories, and monitoring emissions generated at the local level.

Community Energy Association
http://www.communityenergy.bc.ca/
The Community Energy Association (CEA) supports local governments throughout British Columbia in accelerating the application of energy efficiency and renewable energy in all aspects of community design, infrastructure, and community engagement for sustainability. While the association's work is directed toward the British Columbia market, the principles of the research are applicable across the country.

Canadian Institute of Planners
http://www.cip-icu.ca/web/la/en/default.asp
The Canadian Institute of Planners (CIP) is a collaborative national federation that advances professional planning excellence across the country.

Canadian Green Building Council
www.cagbc.org

CaGBC is working to lead and accelerate the transformation to high-performing, healthy green buildings, homes, and communities throughout Canada. CaGBC provides information to assist builders and developers with using district energy to earn additional LEED Certification points for their projects.

CaGBC is developing a multi-year transformative initiative called EcoDistricts, where neighbours, community institutions, and businesses join with city leaders and utility providers to meet ambitious sustainability goals and co-develop innovative district-scale projects.

Stage	Lead	Data needs and considerations	Support
Preliminary planning City/district plan/official plan/secondary plan/Area Redevelopment Plan/ Climate Action Plan	• Planners • Economic development officers • Government officials • Project proponent	• Location and demands of new development • Existing energy demands • Existing energy installations • Resource assessment • Emissions reduction • Objectives	• Engineering, planning, or sustainability consultants • Community members, stakeholders, and interest groups • Other planning bodies or project proponents
1 Objectives setting	• Government officials • Planners • Economic development officers • Project proponent	• Economics and cost-effectiveness • Environmental benefits and emissions reductions • Energy security	• Other planning bodies or project proponents
2 Data gathering	• Project proponent	• Development density • Demand loads • Mix of uses • Age of buildings • Anchor loads • Barriers and opportunities • Energy mapping	• Engineering, planning, or master planning consultants • Building owners and managers • Natural Resources Canada RETScreen
3 Project definition	• Project proponent	• Prioritize clusters with maximum density, diversity, and anchors, and identify key buildings to be connected	• Engineering consultants • Natural Resources Canada RETScreen
4 Options appraisal	• Project proponent	• Detailed analysis of options identified in Stages 1 to 4	• Engineering, planning, or master planning consultants • Natural Resources Canada RETScreen
5 Feasibility study	• Project proponent	• Detailed analysis of data • Technical feasibility • Financial viability • Phasing	• Engineering consultants
6 Financial modelling	• Project proponent	• Detailed financial viability assessment • Capital cost • Operational cost • Revenue	• Consultants • Financial advisors
7 Business modelling	• Project proponent • Government officials	• Project type • Attitude to risk • Desire for long-term control • Regulation • Access to finance and the desired Internal Rate of Return	• Consultants • Legal advisers • Tax and/or bond counsel
8 Marketing and business development	• Project proponent	• Target audience • Likely customer base	• Consultants • Architectural and business community • Other project proponent
9–10 Project procurement and delivery	• Project proponent	• Level of public/private-sector involvement • Overall project viability	• Engineering consultants • Procurement officers • Legal advisers

GLOSSARY

absorption chillers: chillers that use heat to drive the refrigeration cycle and produce chilled water.

anchor load: a large thermal energy load which could connect and potentially provide early income to a **district energy** project.

articles of association: a document that outlines a company's operations and structure.

ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers): a building technology society focused on building systems, energy efficiency, indoor air quality, and sustainability.

base load: see **demand load.**

Btu (British thermal unit): the amount of heat required to raise the temperature of one pound of liquid water by 1° Fahrenheit. **MMBtu** refers to one million Btus.

CEEP (Community Energy and Emissions Plan): evaluates a community's existing energy use and greenhouse gas (GHG) emissions in order to reduce energy consumption and emissions, improve efficiency, and increase the local renewable energy supply. A **CEEP** encompasses land use and transportation, planning, building and site planning, infrastructure, and renewable energy supply.

CEP (Community Energy Plan): A voluntary planning tool for evaluating land use and community design options to support more efficient energy use.

CHP (combined heat and power): the concurrent production of electricity or mechanical power and useful thermal energy (heating and/or cooling) from a single source of fuel. A CHP plant captures heat that is typically exhausted as waste and repurposes it for additional uses.

Climate Action Plan: a document produced by an institution or community that identifies ways to reduce carbon dioxide emissions in accordance with a predetermined timeline for achieving carbon neutrality.

cogeneration: another term for **CHP.**

DBFO (design, build, finance, and operate): a form of project financing in which a private entity finances, designs, constructs, and operates an energy facility for a customer.

DBOOM (design, build, own, operate, and maintain): a procurement method in which a private entity designs, installs, owns, operates, and maintains an energy facility for a customer, who then purchases the energy from the private company. A BOOM (build, own, operate, and maintain) methodology is a similar alternative.

Delta T: the temperature differential between thermal energy supply and return.

demand load: the amount of energy consumers demand in any building or development. **Base load** refers to the pre-existing load for a given area or the load to be met by any system under consideration. The period of highest level and rate of energy consumption over a defined period, usually one hour, is called the **peak load**.

district cooling: the production of chilled water at a central plant for distribution through insulated pipes to multiple buildings for air conditioning.

district energy (DE): the production of thermal energy (heating or cooling) at a central plant or plants and distributing the steam, hot water, and/or chilled water to local buildings through a network of insulated pipes.

district energy network: a system of insulated pipes for distributing heat in the form of steam or hot water, or cooling in the form of chilled water generated in a central plant to supply thermal energy to multiple buildings.

district energy-ready (DE-R): buildings that have been designed and constructed to include equipment and systems that will facilitate later connection to district energy systems developed after the buildings have been completed.

district heating: (DH) the production of steam or hot water at a central plant for distribution through insulated pipes to multiple buildings for space heating, hot water use, or other purposes.

EcoLogo Certification Program: founded by the Canadian federal government, EcoLogo provides customers – public, corporate, and consumer – with assurance that the products and services bearing the logo meet stringent standards of environmental leadership. District energy systems may be candidates for certification under the EcoLogo program.

EID (Energy Improvement District): an area or section of a community designated by a municipality for implementation of clean energy projects including district energy zones. EIDs can utilize municipal bonds for financing and mandate energy performance and use criteria.

energy character area: an area that can be defined by its particular characteristics in order to identify an appropriate energy solution or planning policy.

energy map: a map showing opportunities and constraints for clean and renewable energy projects across a given area. This will incorporate thermal demand data typically presented in a **heat map**.

energy thumbprint: a unique characterization of an area based on a comprehensive set of energy data.

EPA (Environmental Protection Agency): a U.S. federal agency responsible for environmental regulations and compliance.

event load: a temporarily heightened energy demand in a building as a result of a specific event, such as a sporting event in a stadium.

heat map: a map showing locations where heat demand is sufficient to support **district heating**. Often included as part of an **energy mapping** exercise.

HRSG (heat recovery steam generator): a heat exchanger that recovers energy in hot exhaust gases to produce steam that can be used to drive a turbine or in heating applications. By making use of heat energy that is wasted in conventional power cycles, a HRSG increases overall energy utilization and enhances fuel savings.

IDEA (International District Energy Association): a nonprofit trade association formed in 1909 to foster the success of its members in the **district energy** industry (www.districtenergy.org).

IEA (International Energy Agency): an international organization that works to ensure reliable, affordable, and clean energy for its 28 member countries. The International **CHP/**DHC Collaborative is an IEA initiative to support global leaders increasing the use of **CHP** and **district energy** in their countries (www.iea.org).

Invitation to Participate: a pre-qualification process in which the financial and technical credibility of potential contractors can be evaluated.

IPCC (Intergovernmental Panel on Climate Change): the leading international body for the assessment of climate change established by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) and endorsed by the United Nations General Assembly (www.ipcc.ch).

lead boiler: see **prime mover.**

LEED (Leadership in Energy and Environmental Design): an internationally recognized framework for identifying and implementing practical and measurable green building design, construction, operations, and maintenance solutions (www.cagbc.org).

load diversity: different energy consumers use their energy at different times of day. These are **load profile**s. A variety of different **load profile**s will provide load diversity.

load profile: load variation shown on a graph over 24 hours.

LOI (letter of intent): a non-binding document that outlines an agreement between two or more parties before a contract is signed.

master plan: also known as a comprehensive plan, it is a diagram or plan showing how a site or area can be developed or regenerated. Terms such as development plan, **secondary plan**, area re-development plan or design framework are often used. A master plan often establishes a three-dimensional framework of buildings and spaces as well as determining the distribution of uses. Energy would be one element of the master plan.

MOU (memorandum of understanding): a document that describes an agreement between parties and outlines an intended common line of action.

municipal development plan (MDP): see **offical (community) plan**

nodal network: a network that develops gradually as smaller **district energy networks** expand and link together to meet demand growth.

NPV (net present value): the discounted value of an investment's cash inflows minus the discounted value of its cash outflows. To be profitable, an investment should have a net present value greater than zero.

Natural Resources Canada (NRCan): the federal agency responsible for planning energy resources, technical advisory services, and various energy efficiency programs including district heating and cooling.

official (community) plan: an official plan describes an upper, lower or single–tier municipal council's policies on land use. In Alberta, this is referred to as the **municipal development plan (MDP).**

peak load: see **demand load.**

PIM (Project Information Memorandum): a suite of documents describing a **district energy** project for the purposes of procurement. Often included as part of a Request for Proposals (RFP).

PP (project proponent): an individual or organization pursuing the implementation of a **district energy** system in a community or city.

PPD (Private Project Developer): a private **district energy** utility company, which often partners with a public entity using a form of the **DBOOM** model.

prime mover: the machine that provides the **base load** in a **district energy** system, typically an engine or turbine.

RFQ (Request for Qualifications): a business process in which suppliers are invited to participate in a bidding process to bid on specific products or services.

secondary plan: also known as a market plan or area development plan, it refers to a specific area, such as a waterfront or a university campus.

site plan control: requires a developer to submit site plans to the municipality for review and approval. Once the plans are approved, a site plan agreement is generally executed. This contractually binds the owner to develop and maintain a site in accordance with the approved plans and the terms of the agreement. Generally, a building permit will not be issued until site plan approval has been granted.

shale gas: natural gas that is trapped within shale formations. Recent advances in hydraulic fracturing and horizontal drilling technologies have resulted in access to previously inaccessible shale gas deposits.

SPV (special purpose vehicle): a separate entity created to take ownership and responsibility for an energy project's development and ongoing operation.

TES (thermal energy storage): a process in which thermal energy is produced and/or stored for later use. TES shifts thermal energy production to non-peak times.

TIF (Tax Increment Financing): a public financing method that is used as a subsidy for redevelopment, infrastructure, and other community-improvement projects by calculating a grant or loan on the higher property tax that is generated from development (the tax increment).

U.S. DOE (Department of Energy): the federal agency in the U.S. responsible for ensuring U.S. security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions (www.energy.gov).

zoning bylaw: a zoning bylaw controls the use of land in a community and outlines building typology, height, setback and location, lot sizes and dimensions, and parking requirements. The zoning bylaw is the primary tool used to implement the vision described in the **official plan**.

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Ramboll is an international engineering and design consultancy. We have significant experience within energy broadly and within district heating and renewable energy specifically. We are considered to be a world-leading district heating engineering consultancy working internationally with energy planning, combined heat and power (CHP), district heating, heat production for district heating, renewable energy, and district cooling, using the experience gained from numerous Danish and international schemes since 1965.

Ramboll is also an internationally leading consultant within wind energy and waste-to-energy. We advise on every aspect of energy, from the political decisions that are made, to the point when the energy produced is consumed. Our projects include the entire chain, from energy strategies and plans, to production, distribution, and transmission facilities.

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For over 20 years, FVB Energy Inc. Canada (FVB) has been a leader in reducing the strain on Canada's resources. With expertise in District Heating and Cooling, Thermal Energy Storage, Combined Heat and Power, Biomass, and Heat Pumps, FVB offers a unique and comprehensive skill set that helps us meet our clients' environmental and economic objectives. FVB has offices in Edmonton, AB, Toronto (GTA), ON, Ottawa, ON and Vancouver, BC, serving Canada from coast to coast. Globally, the family of FVB companies has operations in Europe and North America working on projects around the world.

In 1990, FVB Sverige AB, was invited to investigate the feasibility of a district heating and cooling system for the city of Edmonton. When the project ended, visionaries at the firm made the bold decision to stay and help foster Canadian expertise in these much-needed energy-saving systems. They dedicated themselves to honing local talent in an effort to reduce the environmental impact of heating and cooling buildings.

FVB is not only the leader in District Energy Systems in Canada, we are recognized world-wide as the leading authority on DE design and best practices. We have been asked to perform studies, peer-reviews, and due diligence for clients in the United States, Middle East, Europe, and Australia.

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