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The New District Energy: Building Blocks for Sustainable Community Development

On-Line Handbook

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Photo courtesy of istockphoto

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Table of Contents

List of Tables

List of Figures

1. Introduction

As world demand for fossil fuels increases and energy supplies become harder to access, the price of energy is expected to rise. Governments and businesses are beginning to pay close attention to the role of energy in the design, development and operation of buildings and whole communities. District energy systems can help communities advance sustainable growth goals and manage the changing nature of risk in the generation and delivery of energy, while contributing to broader community economic development.

Given concerns about the reliability of municipal infrastructure and the effects of greenhouse gases, coupled with opportunities presented by the emergence of alternative fuels and improvements in technology that allows for local scale energy production, businesses, industries and municipalities are taking an interest in the potential of district energy systems.

The handbook is interactive. Readers are encouraged to click on linked text to access additional sources of information on district energy, including detailed case studies and guidelines for energy planning.

Although district energy is a proven technology in use across Canada, successful start-ups of district energy systems still face challenges. *The New District Energy: Building Blocks for Sustainable Community Development* is written for elected officials, policy makers, corporate decision-makers, investors, building owners, planners, environmental managers and all other individuals and organizations interested in district energy. It is intended to encourage information sharing and provide ideas on how to advance district energy development in communities across Canada.

The handbook:

- identifies who can use district energy;
- lists the benefits provided by district energy;
- offers suggestions for overcoming common challenges experienced by communities initiating a district energy system;
- includes a checklist to help accelerate the uptake of district energy systems in a community.

The handbook is part of a series of products and tools prepared for Urban Energy Solutions (UES), a national knowledge-building, outreach and awareness initiative dedicated to showing how district energy can contribute to local community infrastructure and energy conservation in urban regions. Production of the handbook has been made possible through a financial contribution from Infrastructure Canada and the Toronto Atmospheric Fund.

2. What is District Energy?

District energy is a recognized approach to meeting the heating, cooling and domestic hot water needs of buildings, which can also support the process heating requirements of local industry.

District energy serves to manage the thermal needs of energy consumers at a building level and at a community level. As a management system, district energy can help accommodate and meet the different energy demands of buildings and industries that use energy in different amounts and patterns. By linking buildings and industrial activities together through a thermal network, district energy aggregates the varying energy demands into a steady thermal load that can be efficiently managed. [1]

District energy should not be confused with energy generation technologies, since no energy is produced. District energy provides a medium that allows for the transfer of energy. The medium used to transport energy from an energy supplier to energy consumer can be steam, hot water or chilled water.

A district energy system may be designed with a central energy plant, a series of mini plants (a combination of several smaller systems), or multiple plants connected by pipes that provide space heating, hot water,

Figure 1: A District Energy Community Example

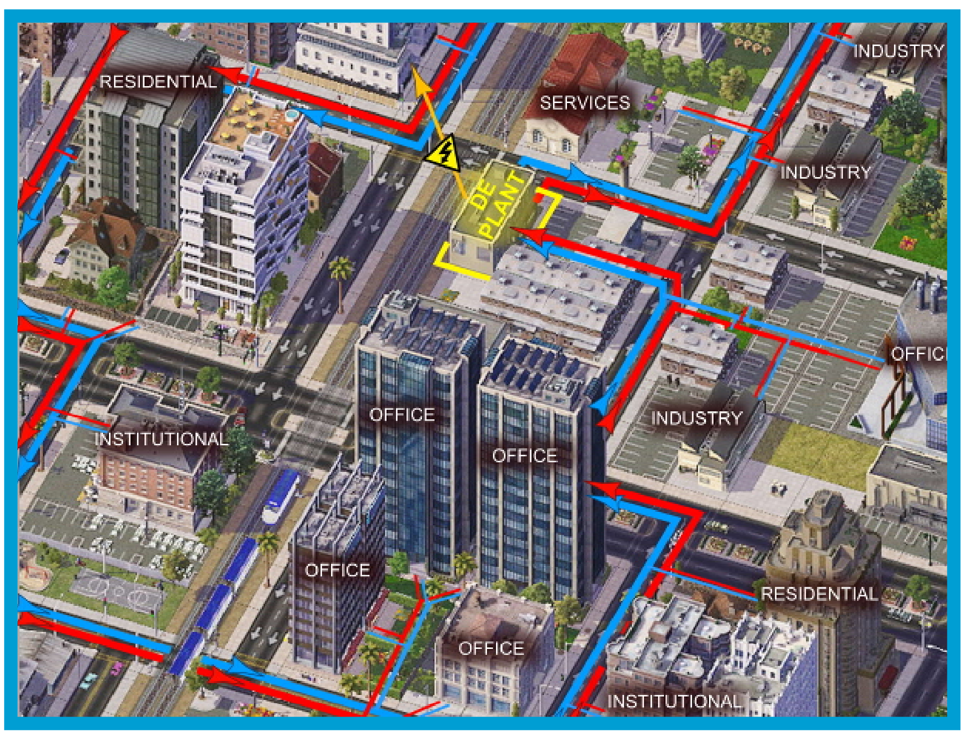
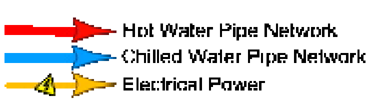


Figure 1 shows the typical layout of a district energy plant that provides thermal energy to several end users, including offices, industries, institutions and residential buildings. **Image source:** Stephen Story (2006)



2. What is District Energy?

steam and chilled water to any group of buildings. Some district energy systems provide electrical power using a process referred to as combined heat and power (CHP).[2]

District energy systems generally consist of three sub-systems:

1. collection and/or generation of thermal energy;
2. distribution of the thermal energy from plant sites to a network of energy consumers;
3. transfer of the thermal energy to the energy consumer.

2.1. How Does it Work?

District energy systems work to produce thermal energy for distribution in the form of steam, hot water or chilled water. The system, which can include an individual heating plant, uses one or more types of fuels and can consist of a combination of different heat sources and technologies. With advances in engineering and technology, new fuel sources have been added to the list of potential fuels for district energy systems. Although traditional sources of fuel – such as natural gas and oil – are most common, alternative and renewable sources (solar power, geothermal energy, biogas, biomass, heat rejected from industrial and municipal operations, and fuel-cell technologies) are now being used in plants across Canada.

Generation

Energy in a district energy system can be generated or recovered using a combination of applications that include conventional heat-only boilers, combined heat and power (CHP), biomass boilers, heat pumps and other technologies that are designed to recover waste heat from municipal, commercial and industrial activities. The types of energy generation technologies and components used in a district energy system are selected and designed to optimize the use of available local fuel sources and rejected heat sources. Table 1 identifies some of the energy generation technologies and fuel sources in use in district energy systems across Canada.

District Energy In Action

Communities across Canada have designed and developed district energy systems using different energy sources to meet specific building and community energy requirements. Case studies of how communities across Canada have used district energy with different energy sources to advance community sustainable community development goals are available for viewing and download at www.cdea.ca.

2. What is District Energy?

Table 1 lists some of the common fuels and technologies used in district energy systems.

Table 1: Common Technologies and Fuels used for District Energy

Plant type	Boiler/ Generator/ Technology	Possible fuel sources	Output
Heat only (hot water and steam) & CHP (Combined Heat & Power)	Combustion turbine	Natural gas, liquid fuels	Steam / electricity 5MW – 25MW
	Reciprocating engine	Natural gas, diesel, landfill gas, digester gas, biogas	Hot water 500kW – 7MW
	Micro turbine	Natural gas, hydrogen, propane, diesel	Hot water 25kW – 500kW
	Fuel cell • Molten carbonate • Phosphoric acid • Proton membrane exchange • Solid oxide	Natural gas, hydrogen	Hot water (steam for molten carbonate & solid oxide fuel cells) 1kw-10MW range
	Stirling engine	Natural gas, landfill gas, propane, etc.	Hot water 1kW – 25kW
Chilled water	Lake/ocean water	Water	Cold water
	Chillers	Steam/hot water/ electricity	Chilled water
Thermal storage	Incorporates one or more large storage tanks of hot or chilled water or ice linked to a district energy system. Mediums for storage can include steel storage tanks, aquifers and boreholes.		

Source: James, Jamie, et al., (2006). *Combined Heat and Power Generation for Highrise Condominiums in Toronto*. Tridel and Toronto and Region Conservation Authority. Edwards G., et al., (2000). *Overcoming Barriers to Implementation of District Energy Projects*, Vol. 2. Calgary: Canadian Energy Research Institute.

2. What is District Energy?

Distribution

Thermal energy is distributed through a network of pipes. Distribution systems may comprise two-, three- or four-pipe systems. Larger district energy systems use a grid system that allows customers to be supplied from two different directions, which improves the reliability of supply.

The simplest of piping configurations for a district energy system consists of two parallel pipe networks (a supply and a return line) where hot water is delivered to users in one pipe. The thermal energy is transferred to a customer's heating, ventilation and air-conditioning system using an energy transfer station that incorporates heat exchangers, instrumentation and controls. These devices allow for the extraction of thermal energy for circulation within a building. A return pipe carries cooler water back to the district energy plant.

In Canada, older steam-based systems generally use a single supply line for high or low pressure steam. Condensate may not be returned, and is often passed through to the local drainage system. While steam remains popular for high-temperature operations, such as industrial applications, newer district energy systems are being designed to provide hot water at low temperatures. Using lower temperatures enables district energy systems to accommodate a variety of new and more energy-efficient built forms, more efficient generating and distribution technologies, and different fuels, such as biomass.

District energy systems can also deliver chilled water to end users for cooling using naturally chilled water (such as deep lake water), absorption chillers, or chillers driven by a steam turbine or electricity. Chilled water is distributed in the same way as hot water, with a heat exchanger located in each building served.

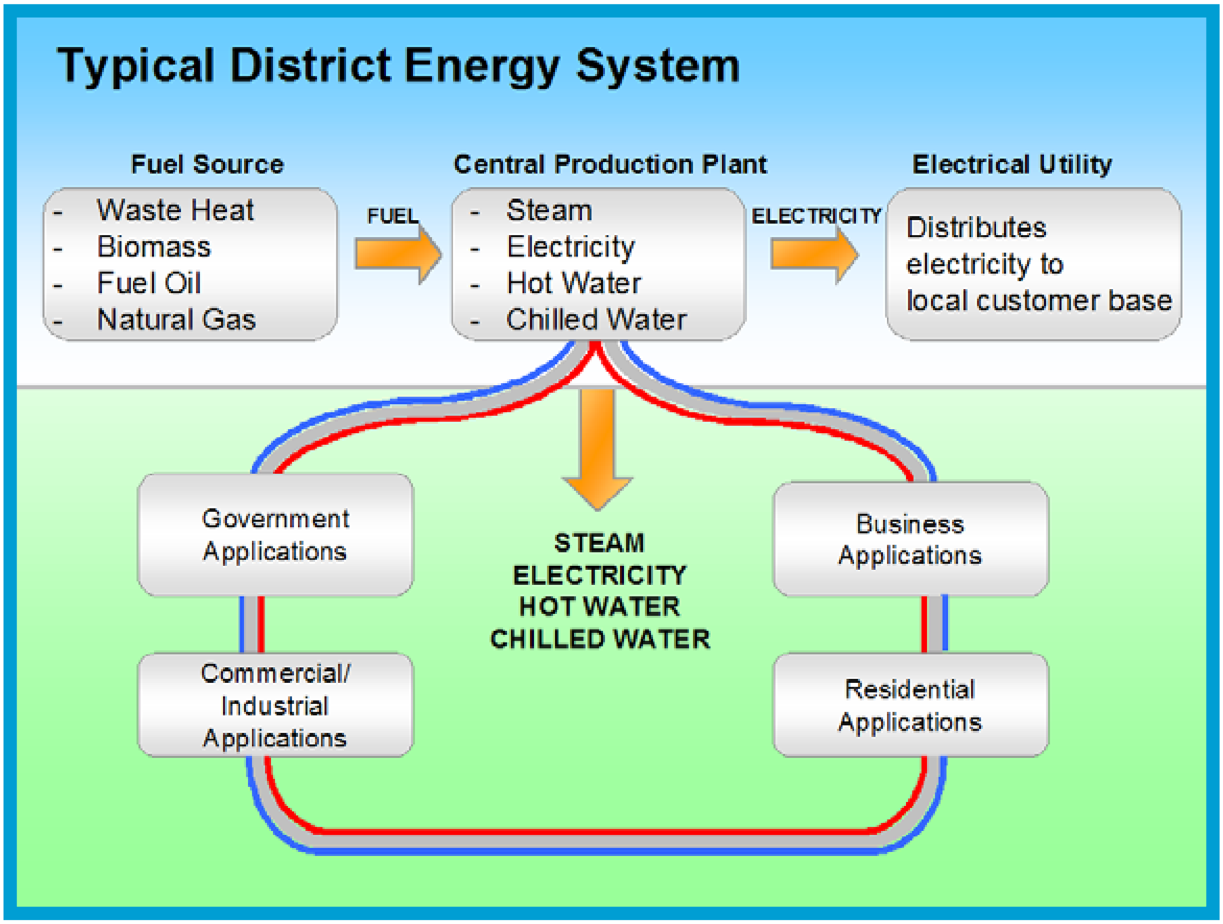
Thermal storage is often used in district energy systems to even out load profiles and provide heating and cooling during peak hours, when demand is high. Thermal storage involves holding large quantities of heat or cooling water in insulated tanks or underground. During off-peak hours, water can be heated or cooled and stored until peak demand occurs.

Figure 2 illustrates the operation of a CHP district energy system.

District energy has the ability to service a variety of users with hot water, chilled water and electricity, including large commercial office buildings, high-density residential development, government services, institutions, and industrial activities.

2. What is District Energy?

Figure 2: Typical District Energy Configuration



Source: Modified diagram. Countryside Power Income Fund. (2007). www.countrysidepowerfund.com

3. Who Can Use District Energy?

District energy can meet the energy needs of a wide range of end users. Table 2 lists some of the facilities that use district energy.

Table 2: Applications of District Energy

Food & Agriculture	Institutional / Government	Medical / Emergency	Commercial / Residential / Transportation	Finance/ IT	Industrial/ Energy/ Defence
• Horticulture • Manure processing facilities • Greenhouses • Food storage facilities (refrigeration facilities)	• Community recreational centres and facilities • University and college campuses • Schools (elementary, high school) • Prisons and detention centres • Exhibitions and fair grounds • Museums • Libraries • Military establishments • Water and waste water treatment facilities · • Transportation networks	• Hospitals and medical treatment centres • Emergency management facilities • Search and Rescue • Law Enforcement • Fire and Hazardous Materials • Laboratories • Nursing homes • Blood-supply facilities • Mortuaries • Medical and pharmaceutical stockpiles	• Sports facilities and complexes • Shopping centres • Office buildings • Supermarkets • Convention centres • Stadiums • Airports • High-rise residential (varying in size) • Low-rise residential (town-homes, apartments, single detached housing, row housing, and duplexes)	• Tele-communication facilities (cellphone operators) • Data storage and transfer facilities	• Pharmaceuticals and fine chemicals • Paper and board manufacturing • Brewing, distilling and malting • Ceramics • Brick and cement plants • Food processing • Mineral processing • Oil refineries • Iron and steel • Timber processing and lumber mills • Ethanol plants • Utilities

3.1. Applications

In Canada, more than 112 district energy systems serve mid-sized communities as well as Canada's largest cities, including Montréal, Toronto and Vancouver. Market sectors using district energy include farming, institutions, medical facilities, municipal critical infrastructure and emergency services, commercial and residential facilities, information technology centres and industry.[3]

3. Who Can Use District Energy?

Food and Agriculture

The food and agriculture sector accounts for nearly 10% of Canada's national economic activity. The farms and facilities involved in agricultural production use large amounts of heat and electricity to produce, harvest and process products. In agriculture, the loss of thermal services and electricity for a prolonged period threatens the timely supply of food, so reliability is essential. District energy is successfully used in aquaculture operations, industrial greenhouses, food and beverage processing plants, refrigerated warehouses, distribution facilities and grocery stores.

Supporting Local Farmers

In Vegreville, Alberta, a small biogas plant mitigates the environmental effects of manure generated by feedlots and cuts the associated life-cycle of greenhouse gas emissions by 70 to 80% compared with the current practice of land spreading. Using an Integrated Manure Utilization System (IMUS), the plant produces about 1 megawatt of electricity and 898 kW of thermal energy for facility operations. Nearly 700 homes are powered by the IMUS system in the farming communities of Vegreville and Two Hills. The system also has the capacity to supply heat for nearby homes and farms. The plant is fuelled with manure from feed farms, so it provides local farmers with an additional source of income.

Institutional and Government Services

Across Canada, government services and institutional campuses require electricity, air conditioning, heated and chilled water, advanced humidity control and ventilation in the buildings they occupy. Some services, such as research and laboratory facilities, require reliable thermal service to ensure valuable research processes are not disrupted, while critical municipal infrastructure, including wastewater purification and drinking water treatment facilities, use thermal energy and electricity to ensure safe, potable water continues to flow.

Keeping Science Cooled

The University of Toronto, St. George Campus, is one of the largest consumers of energy in the City of Toronto, using 235,500 megawatt-hours of electricity and 1.7 million British Thermal Units (MBTUs) of steam. In addition to space heating, the campus district energy system supplies 30 % of the electricity requirements for laboratories, computer rooms, and greenhouses. The system services nearly 1 million square metres of space and provides essential cooling services to major research facilities. During the August 2003 blackout that affected eastern Canada and the United States, the district energy system came back on stream shortly after power was restored, allowing for the supply of electricity to keep refrigerated research materials safe and parts of the University cooled using centrifugal chillers. With its district energy system, the University can meet some of the basic thermal and electricity needs of the campus, while complying with province-wide calls to reduce power consumption.

3. Who Can Use District Energy?

Emergency and Medical Services

District energy systems can assist medical facilities, particularly hospitals, with meeting requirements for ensuring a continuous supply of energy and maintaining a sanitary environment. Hospital facilities often include a combination of buildings or are located on a campus that requires a high level of resiliency in heating and cooling to ensure comfortable and constant temperatures for laboratories, operating theatres and patient care facilities. District energy systems can meet the operating goals of institutions by providing space heating and cooling, domestic hot water, humidification and sterilization services. Emergency services, including management facilities, shelters and search-and-rescue centres, also require a dependable source of thermal energy throughout natural and human-caused disasters.

Emergency Rooms Stay Open

Although the 2003 blackout shut down some of the essential services of hospitals, depleted drinking water reservoirs, and knocked out 911 dispatch centres in the City of Toronto, the City of Greater Sudbury municipal services and the Hôpital régional de Sudbury Regional Hospital (HRSRH) were minimally affected by the power outage. In 2000, the City of Greater Sudbury, with support from Sudbury Hydro and Toromont Energy Ltd., developed a 5-megawatt CHP facility that services seven major buildings in the downtown core, including two office towers and a federal government building, with hot water for heating and chilled water for cooling, and provides power to the Ontario grid. In 2001, the Sudbury Hospital constructed a 6.7-megawatt natural gas CHP plant to provide the hospital with heating, cooling and electricity. During the blackout, commercial buildings in downtown Sudbury remained cool, and hospital operations were not interrupted.

Commercial and Residential Facilities

Commercial and residential facilities range from hotels and casinos to office buildings and high-rise apartment buildings. District energy can provide heating, cooling and domestic hot water for large arenas, airports, convention centres and condominiums. District energy can also meet the heating needs of low-density housing, such as single-detached houses and townhouses.

Keeping the Lights On

During the 2003 blackout, the Air Canada operations centre at Pearson International Airport placed an emergency call to the Department of National Defence for a generator to keep the airlines operations centre open. As part of the efforts of the Greater Toronto Airport Authority (GTAA) to reduce energy costs, ensure a secure supply of emergency power, and address growing thermal energy demands, Pearson Airport became the first airport in Canada to establish a district energy system with CHP capacity. In 2001, the GTAA built a Central Utility Plant for the airport that supplied steam for heating and chilled water for cooling the airport terminals. To improve the resiliency of the Airport and accommodate planned future expansion, the district energy system was expanded to include a 117-megawatt, natural gas–fired, combined-cycle cogeneration (CHP) facility. To ensure optimal performance and economic viability, the thermal capacity of the plant was designed to supply steam needs for the system including the operation of a steam driven generator, but also allow for the optional operation of the plant's steam boilers in standby mode while using steam from the cogeneration system. The economics of the system were further improved with the ability to sell excess electricity to the Ontario power grid.

3. Who Can Use District Energy?

Financial and Information Technology

District energy systems can also meet high thermal cooling demands and requirements for an uninterrupted power supply for electronic transactions and telecommunications. The Information Technology (IT) sector requires a stable source of thermal energy and electricity to protect large volumes of business and industry data stored in data centres and the operation of servers that support Internet service. Interruptions that disrupt cooling systems and electricity, even those that last for a fraction of a second, can create havoc, particularly for the banking and financial industry. IT equipment generates significant heat, so air-conditioning is essential to ensure reliable service.

The telecommunications industry, which includes satellite communications, cable networks, wireless communications and 911 services, has a similar need for reliable thermal energy and electricity. Cellular telephone towers, radio services and terrestrial satellite components need dependable thermal energy and electricity to maintain operations and keep electronics cooled for optimal performance.

Integrating Reliable Cooling

In downtown Toronto, the new RBC Centre, a 400,000-square-foot office building providing state-of-the-art commercial space for tenants at Bay and Adelaide, will be kept cool with Canada's cleanest and coldest naturally cooled water provided through Enwave's Deep Lake Water Cooling system. Enwave provides cooling, heating and energy management services to more than 150 buildings in downtown Toronto. Tenants benefit from reliable cooling to meet the demands of server rooms, as well as humidity control, while enjoying lower electrical utility costs.

Industry and Defence

Heat rejected from industrial and energy refinement operations is among the largest unused sources of fuel in Canada. In oil production, district energy systems can provide the steam that is pumped into wells and use the excess heat for electricity generation needed for pumping oil out of the ground. For many energy-intensive industries, district energy provides a reliable, affordable and competitive way to meet high processing heat load needs, while reducing operating costs. National Defence and federal facilities also require reliable supplies of heating, cooling and electricity to maintain defence and emergency readiness, and to improve resiliency against natural and human-induced hazards and disasters.

Keeping Separate From the Grid

During the 2003 blackout, National Defence facilities were kept operational through backup diesel systems and CHP. At Canadian Forces Base Valcartier in Quebec, a district energy CHP system was installed in 1999 to provide thermal energy in the form of steam and electricity for base facilities. CFB Valcartier is a small city, providing infrastructure and a full range of services to a resident population of 5,000 to 10,000 people. The base has 400 buildings with over 400,000 m^2 of interior floor space. During the blackout, Valcartier continued to supply base residents with heat and electricity to maintain a state of preparedness.

4. Why District Energy Now?

District energy has a well-established history of helping communities meet local heating and cooling demands, while contributing to sustainable community development.

4.1. A Short History

The origins of district energy can be traced to Roman times, when warm water was circulated through open trenches to provide heat for buildings and baths. The first documented district energy system was created in the 14th century A.D. in Chaudes Aigues Cantal, a village in France. The system, which distributed warm water through wooden pipes, remains in use today.

The first commercial application of district energy in North America was established in Lockport, New York, in 1877 by an inventor named Birdsill Holly. Holly used boilers as a central heat source and built a network of pipes capable of carrying steam. The system began with 14 customers, but within three years, operations had doubled to serve the needs of local factories and residential customers.

In Canada, district energy was introduced in the early 1880s in London, Ontario, to meet the heating needs of university, hospital and government complexes. The first commercial district energy system in Canada was established in 1924 in Winnipeg. District energy systems have advanced considerably over the last decade and now contribute to community and environmental planning.

"How we design, build and rebuild our communities can have a large impact on our collective energy use. Energy use in communities depends on how individual component services in a community are designed and how the components and systems work together...In Canadian communities, the most promising methods of reducing energy use are known, such as district energy and combined heat and power systems."

Source: National Advisory Panel on Sustainable Energy Science and Technology. 2006. *Powerful Connections - Priorities and Directions in Energy Science and Technology in Canada.*

4.2. Current Market Drivers

Today, municipalities and businesses turn to district energy to conserve energy, address climate change, provide incentives for community-based energy production and meet growing demands for a secure supply of energy.

Sustainable Energy Planning

Planning for energy can contribute to the sustainability of a community by reducing energy costs and lowering environmental impacts. Energy use, supply and demand not only depend on but also can help shape the design and development of a community, and the activities of citizens, businesses, institutions, government agencies and industry. District energy

4. Why District Energy Now?

Making District Energy the Norm

Across Europe, district energy systems are widely used to provide heating and cooling services. In Nordic countries, which include Denmark, Finland, Iceland, Norway and Sweden, district heating represents over 35% of the market for heat and domestic hot water use. For each country, district heating has developed into an important source of heat supply for homes, offices and industry and as a strategy for achieving energy supply self-sufficiency. Countries such as Denmark made a commitment to energy planning in the early 1980s through legislation and tax measures to improve energy efficiency and expand the use of district energy systems. As a result, nearly 60% of all Danish homes are heated by district energy, less than 2% of Denmark's oil is now imported and 25% of district energy fuel is provided by renewable energy sources. Similar investments by Sweden have led to a steady uptake of district heating as the preferred heating service for buildings in the residential and service sector.

systems promote efficiency in the use of land, transportation, building design, infrastructure, and waste management. Communities' efforts to improve energy efficiency, reduce reliance on imported fuels and make better use of local, renewable and alternative fuel have involved guidelines and legislation to encourage decentralized energy production, including district energy.

Climate Change

Greenhouse gases trap heat from the sun in the Earth's atmosphere. Elevated levels of greenhouse gases, including carbon dioxide, methane and nitrous oxide, can lead to changes in the climate. There is now broad consensus among scientists and politicians that to avoid the full effects of climate change, including floods, droughts, extreme heat and other problems, greenhouse gas emissions need to be reduced.

Canada has set a goal of a 31% reduction in overall greenhouse gas emissions relative to 2006 emission intensities by 2020.[4] Meeting the goal will require the reduction of overall energy use through improvements in building energy efficiency and community design, as well as the deployment of technologies associated with lower levels of greenhouse gas emissions, such as district energy, which can use renewable and alternative fuel sources.

As a result of climate change, communities across Canada are experiencing warmer summers. This has expanded the market for district energy, especially for cooling services.

Regulations and Incentives

Government policies and research, including work undertaken by Natural Resources Canada, are starting to address the links among energy, the environment and the economy. Incentives are now in place to encourage municipalities and the private sector to install district energy systems to meet national priorities, while addressing local growth management and economic development goals. The incentives available include federal tax advantages, regulatory flexibility for municipalities to encourage distributed and decentralized energy production, and grants and loans by agencies, such as the Federation of Canadian Municipalities, for feasibility studies and capital costs related to the development of district energy systems.

4. Why District Energy Now?

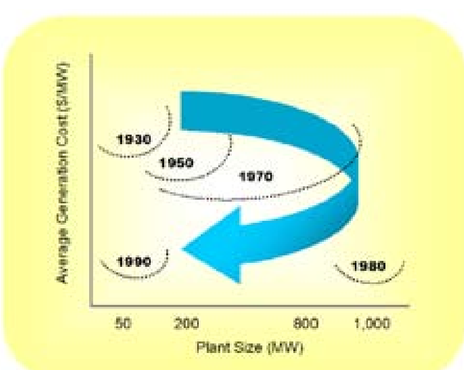
Energy Growth and Security

Demand for energy continues to grow. Canada's power consumption has risen by nearly 10% since 1990. This is related to the widespread use of electronic equipment for business and residential applications, and the growth of energy-intensive industries, such as the oil and gas sectors. Total Canadian demand for electricity is projected to growth to 593 terawatt-hours (TWh) by 2020.[5] Similar demands for space heating are also estimated to grow by an annual rate of 1to 2% over the next 20 years to accommodate new residential, institutional and commercial developments.[6]

While demand for energy is increasing, the creation of new centralized generation and transmission networks has slowed. Since the early 1980s, advancements in generating and rejected heat capture technologies have reduced costs through the use of smaller-scale plants, including district energy systems with CHP capacity that can be located close to communities (see Figure 3). Generally, large-scale power production plants, such as coal-fired systems, achieve low levels of energy efficiency. That is, much of the heat energy produced during the burning of a fuel is lost to the atmosphere and not converted into a useful source of energy.

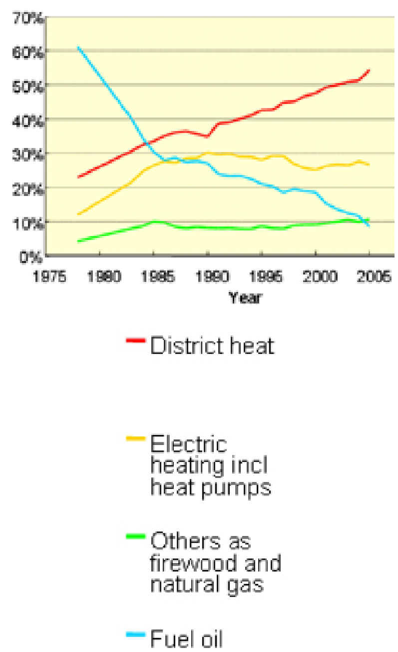
Utilities, businesses and municipalities are responding to the changing nature of risk in the delivery of energy. A dependable supply of energy is now seen as critical for the safe operation of our cities, businesses and residences. Meeting Canada's future energy demands will require the use of efficient systems, such as district energy, to manage heat energy effectively and economically to meet heating, cooling, and domestic hot water demands.

Figure 3: Optimal Size of Generating Plants



Source: Bayless, Charles E. (1994). "Less Is More: Why Gas Turbines Will Transform Electric Utilities," *Public Utilities Fortnightly*, Vol. 12(1). (Figure has been modified.)

Market Share of District Energy in Sweden



Source: Modified figure. Breitholtz, Leif. (2007). *The Swedish heat market for buildings in the residential and service sectors*. Presentation, 2007 CDEA Conference, Toronto

5. What are the Benefits of District Energy?

District energy systems can meet demand for energy while minimizing energy waste, reducing energy costs, increasing the security of the energy supply, reducing the need for large-scale central generation and reliance on grid transmission infrastructure, and contributing to sustainable community development.

5.1. Community Benefits

District energy systems can enhance local economies and help revitalize urban centres through infrastructure investment and by creating an attractive development opportunity.

In the past, the decision to invest in a district energy project was based on one primary concern – cost. However, district energy systems of all kinds require substantial capital investment, but the returns may be spread over many years. Although an economic assessment is an important part of any decision to install a district energy system, a broader review of the economic, environmental and social benefits will better demonstrate the advantages that district energy can bring to a community. Table 3 provides an overview of the many benefits provided by district energy.

Municipalities, like businesses, face many challenges in trying to maintain a high quality of life for residents and an attractive investment environment for business. Municipalities need to capitalize on advantages and strengthen their ability to compete in a global economy. District energy systems can enhance local economies and help revitalize urban centres through infrastructure investment and by creating an attractive development opportunity.

District energy contributes to employment and supports local training

District energy systems can contribute directly to job creation, increase opportunities to use human resources, and create new training and education programs. Nearly 60% of the costs associated with the development of a district energy system can be attributed to labour, and, in urban areas, about half of the necessary equipment can be purchased from local suppliers.[7] As a result, the majority of the capital investment, labour and equipment costs, is retained in the community. For example, in the construction of Toronto's Deep Lake Water Cooling plant, nearly 1,000 person-years of local labour in construction were generated. In Bécancour, Quebec, the equivalent of 25 jobs were added to the local community when an industrial district energy plant was built.

5. What are the Benefits of District Energy?

Table 3: Community Benefits of District Energy

See References for sources.

Benefits	Energy utilization & efficiency	Environmental enhancement	Economic development	Community design & growth management	Resiliency & adaptability	Infrastructure advancement
Regional level	Contributes to reducing utility infrasctructure needs by load profile reshaping.	Improves regional air quality by reducing the need to rely on central plants fuelled by coal.	Achieves distribution savings. Capacity development and reductions can be made in small increments, closely matched with demand.	Encourages local utilities to invest in distribution network.	Delays or eliminates need to build large central generating plants, transmission corridors and distribution lines.	Improves overall system reliability by reducing peak loads.
	Reduces distribution losses by managing the demand for thermal load.	Reduces the consumption of fossil fuels and associated impacts of extraction.	Strengthens local markets by encouraging production of services and technologies for district energy.	Allows for the integration of thermal and electrical power growth into a community energy plan.	Increases diversity of fuel supply, thereby improving energy security and use of existing grid assets.	Decreases vulnerability to catastrophic disruptions of central supply and generation stations.
	Improves overall supply reliability.	Reduces the amount or requirement for heat discharge from large central generation stations into freshwater bodies.	Encourages liberalization and competition in energy markets.	Reduces the impact on land area required for rights-of-way and land required for central generation stations.	Improves resiliency of critical infrastructure sectors.	Ensures better system stability due to multiple inputs and reduced consequences of system failure.
Local level	Contributes to meeting established community energy-reduction goals.	Reduces harmful air emissions (NO_x, SO_x, CO_2 and PM).	Promotes local job creation (e.g., construction, manufacturing, technicians, installers/ operators).	Reduces the size of ecological (energy) footprints.	Ensures more reliable local energy delivery and ancillary benefits (voltage support, contingency reserves – for peaking).	Offers "hot swap" capability – opportunity to easily switch between various forms of energy production services.
	Improves the performance of district energy system and building energy efficiency when land use development is planned around a district energy system.	Uses waste-to-energy technologies to offset solid waste management challenges.	Achieves long-term reduction of energy costs (capital and operating).	Aids with brownfield remediation by attracting investors and contribute to urban revitalization, particularly for downtown environments.	Reduces reliance on single sources of energy production/ fuel disruption risk.	Can support or use municipal infrastructure services – such as sewers – for heat capture and provides fresh potable water from deep lakewater cooling.
	Encourages the use of local fuel sources – biomass, solid waste, biogas (landfills), and naturally cold water.	Contributes to direct and indirect education of public regarding issues of sustainability, energy, and the environment.	Increases energy dollars reinvested into the local economy.	Creates minimal impact on aesthetics through screening, soundproofing, and urban design.	Replaces grid-based generation.	Allows for faster permitting than traditional upgrades.

5. What are the Benefits of District Energy?

Advancing Local Energy Training

Canada's first interactive training plant was established in the City of Hamilton, Ontario. With the Hamilton Community Energy district energy system, the developers considered how the facility could be designed to help educate the public and encourage future generations to consider training in specialized trades and professions related to district energy. Interpretive features were incorporated into the landscaping, such as red and blue paving stones to show the route of the hot and cool water supply. Large windows were added to allow the public to see plant operations, and a classroom was incorporated into the plant to allow training courses to be held at the facility.

Developing a district energy system calls for experienced labour, such as welders, heavy equipment operators, and energy-efficiency specialists. Colleges across Canada, such as Mohawk College in Ontario and Douglas College in British Columbia, are working with local district energy system operators to train students who then have access to real-world experience through tours of system networks and customer connections.

Successful local training programs can also be established during the installation of a district energy system. For instance, in Grassy Narrows, Ontario, a training program was established to provide local workers in the Aboriginal community with experience in installing plumbing systems and maintaining the system. Local workers were retained to operate the community's district energy systems.[8]

District energy promotes community intensification and revitalization

District energy systems are an investment in a city's infrastructure and can help shape land use development. Today, most new housing or office development tends to be located on large tracts of land on the outskirts of cities. This pattern of growth places additional stresses on the community and the resources of local government by consuming more land than compact development does, using more energy and increasing community costs for infrastructure and the provision of services such as public transit.

District energy systems can help communities promote compact, mixed-use development by matching the energy needs of neighbouring facilities to minimize energy waste and reduce infrastructure and utility costs. At the same time, district energy can concentrate development through the layout of piped infrastructure, while meeting the heating demands of high-density development, such as offices and residential development.

By providing thermal energy and electricity, district energy can also help reduce the amount of land required to support distribution infrastructure. At the large scale, the average central generating station requires nearly 492.86 hectares (1216.86 acres) of land (see Table 4). By reducing the need for central power generating stations, and locating energy management systems where they are most needed, close to the centres of communities, a district energy system can help conserve open space and agricultural lands around urban areas.

5. What are the Benefits of District Energy?

Table 4: Land Use for Typical Central Power Source Facilities Generation Technology

Generation technology	Typical direct-fired pulverized coal boiler plant (coal)	Integrated gasification combined cycle plant (natural gas)	Pressurized reactor plant (nuclear)	Ridge site wind farm (wind)	Lower pressure indirectly heated gasifier combined cycle plant (biomass)	Combined cycle cogeneration plant (Natural gas)
Area required for utility site operations (in hectares)	129	40.5	1,814	520	121	10
Weighted average acreage (per MW)	165	19	982	40	9	1217

See Endnotes for sources.

District energy systems can also help revitalize downtown areas. Most municipalities have brownfields (former industrial lands) in need of redevelopment, or downtown areas in need of reinvestment. However, many in the private sector are reluctant to develop or invest in these areas and need some incentives to get involved. The challenge for communities is to improve these sites to a point at which investors find them attractive. Traditional strategies have included investment in infrastructure, such as stacked parking facilities or improved sidewalks, and financial incentives, such as façade loans and tax breaks.

District energy can provide an incentive for developers and investors, by reducing the need for capital investments in building heating and cooling systems, and lowering building operation and maintenance costs, while providing access to more profitable and efficient space for revenue generation.

5.2. Environmental Benefits

Producing energy for space heating and cooling as well as electricity requires, in many cases, the combustion of fossil fuels that emit carbon dioxide (CO_2), nitrous oxide (NO_x), sulphur oxide (SO_x) volatile organic compounds (VOC) and particulate matter (PM). These emissions have profound impacts that include climate change, as well as increases in smog, air pollution, acid rain and ground-level ozone. The haze that covers some of Canada's major cities and increasing levels of asthma and other respiratory diseases in urban populations provide evidence of these emissions. District energy systems can help improve environmental conditions by reducing harmful emissions.

5. What are the Benefits of District Energy?

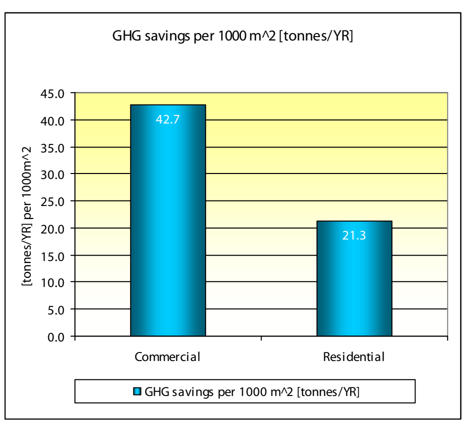
District energy contributes to meeting climate change goals

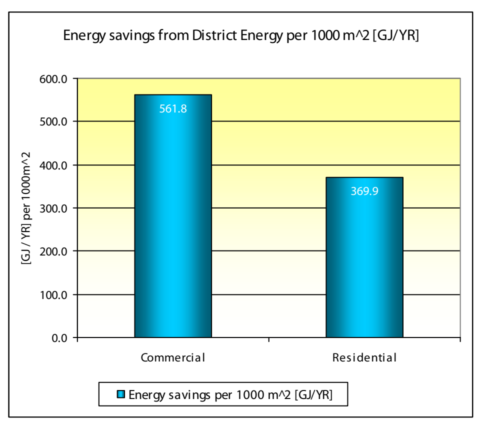
Canada adds over 700 mega-tonnes of carbon dioxide annually to the atmosphere through the consumption of fossil fuels. Communities that incorporate a district energy system can reduce their greenhouse gas emissions, as well as their fossil fuel consumption. Table 5 provides an overview of several district energy systems operating in Canada, showing the average CO_2 emission and energy reductions, compared with conventional systems that can be achieved for commercial and residential buildings.

Recent modelling prepared for Urban Energy Solutions (UES) found that if every residential and commercial building in Canada were connected to a natural gas–fired CHP district energy system, more than 57 million tonnes of CO_2 emissions (9% of Canada's total CO_2 emissions) could be avoided, and nearly 897 million gigajoules of energy (11% of Canada's total energy consumption) saved each year.[9]

Figure 4 illustrates another way of looking at the savings provided by district energy. On average, a district energy CHP system offers significant savings in greenhouse gas emissions and energy use based on floor area for residential and commercial development.

Figure 4: Potential GHG and Energy Savings Based on Floor Space





Source: Modelling prepared on behalf of the Canadian District Energy Association (CDEA) for the Urban Energy Solutions initiative (2007). Modelling based on a high-performance natural gas-supplied CHP district energy system. Contact CDEA at cdea@canurb.com for more information.

Fuelling Sustainable Development

Markham Centre, the planned new downtown for the Town of Markham in Ontario, is intended to be an environmentally sustainable, transit-friendly, attractive suburban downtown that will eventually accommodate 25,000 residents and 17,000 employees. One of the key strategies in its development is the use of district energy. Four energy production plants, operated by Markham District Energy Inc. (MDEI), will supply up to 1.86 million square metres of space with thermal services and electrical services. Markham will also be the first community to have private townhouses connected to a municipal

5. What are the Benefits of District Energy?

Table 5: District Energy Average CO_2 Emission and Energy Reductions for Select Systems

				Commercial		Residential	
Operator/Owner	City	Start	Fuel type	GHG savings (Tonnes/yr)	Energy savings (Tonnes/yr)	GHG savings (Tonnes/yr)	Energy savings (Tonnes/yr)
Lonsdale Energy Corporation / City of North Vancouver	North Vancouver	2004	Gas	3,713	44,797	356	4,300
Markham District Energy Inc. / Town of Markham	Markham	2000	Gas	4,252	76,787	774	14,989
Town of Okotoks	Okotoks	2006	Sunlight	-	-	152	3,044
PEI District Energy Systems	Charlottetown	1998	Biomass	1,749	6,285	-	-

Source: Modelling prepared on behalf of the Canadian District Energy Association (CDEA) for the Urban Energy Solutions initiative (2007). Contact CDEA at cdea@canurb.com for more information.

Addressing climate change requires businesses and municipalities to use technologies that can be easily integrated with existing heating infrastructure. District energy systems can help slow the increases in energy consumption and greenhouse gas emissions associated with new growth, while reducing the environmental impacts of existing homes and businesses.

District energy improves air quality

The last few years have seen many improvements in technology to meet increasingly stringent regulations for air quality. A new generation of engine and turbine designs, sophisticated control systems, and end-of-pipe pollution abatement methods (scrubbers) are now in use that reduce or capture air emissions that can harm human health, including NO_x and SO_x. Table 6 illustrates some of the reductions in air emissions that can be achieved when a natural gas–fired CHP district energy system replaces grid electricity produced from a coal-fired plant.

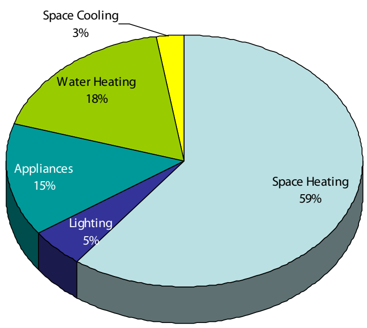
Table 6: Typical District Energy Air Quality Improvements

Typical district energy system	NO_x	SO_x
Reduced air emissions relative to conventional practices	12 tonnes/year	5 tonnes/year
Percentage reduction	28 %	47 %

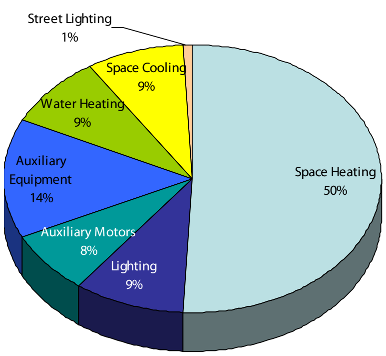
See Endotes for sources.

5. What are the Benefits of District Energy?

Figure 6: Annual Energy Use in Canadian Residential, Institutional and Commercial Buildings



Residential Energy Use



Institutional and Commercial Energy Use

See Endnotes for sources

District energy systems can improve local air quality in several ways. Compared to individual heating and cooling systems for a building, efficient and modern district energy systems with advanced environmental monitoring equipment can run more efficiently and produce fewer emissions than individual building plants. At the same time, emissions from district energy systems are easier to regulate and monitor. If CHP is part of a district energy system, higher efficiencies can be achieved and emissions reduced even further.

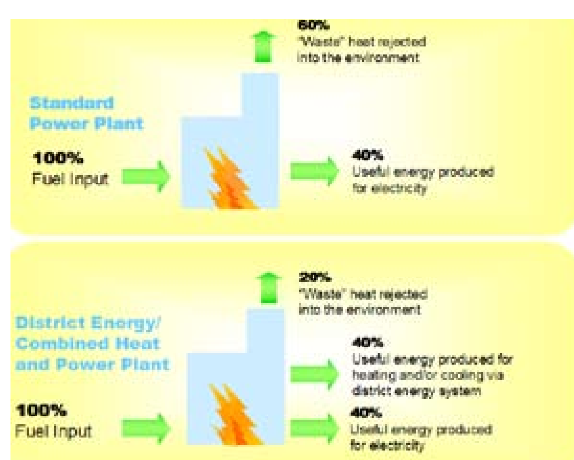
District energy maximizes energy utilization and efficiency

Among the many strengths of district energy is the option to use a diversity of fuel sources, including alternative, renewable, fossil, or waste sources of heat, and improve energy efficiency. The efficiency of a fossil-fuelled power plant is typically between 30 and 45%. This means that nearly two-thirds of the energy produced during the combustion of a fuel is rejected into the atmosphere. District energy systems with CHP capacity can capture energy to achieve system efficiencies of 80% or more by the production of thermal and electrical energy (see Figure 5). Because of the improved efficiencies of district energy systems, less fuel is required than in a conventional system to produce the equivalent amount of energy. The reduced fuel consumption can also result in reduced air emissions.

Other efficiencies associated with district energy systems are related to the system's ability to store thermal energy. Thermal energy can be generated in off-peak periods, and distributed during periods of high demand. This feature lowers the operating cost of the system.

Figure 5: Energy Efficiency of District Energy/Combined Heat and Power Plant

Source:
International District Energy Association (2007).
www.districtenergy.org
(Diagram has been modified)

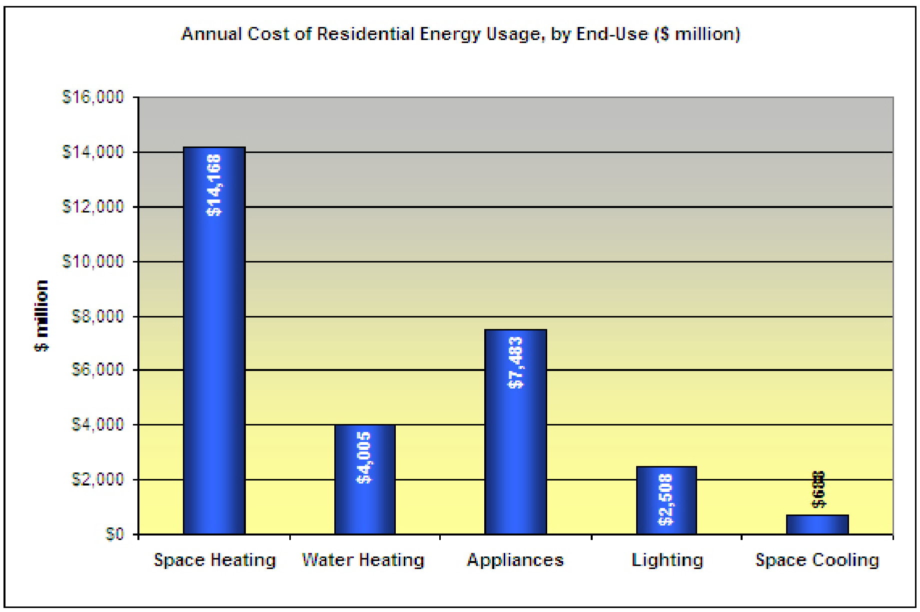


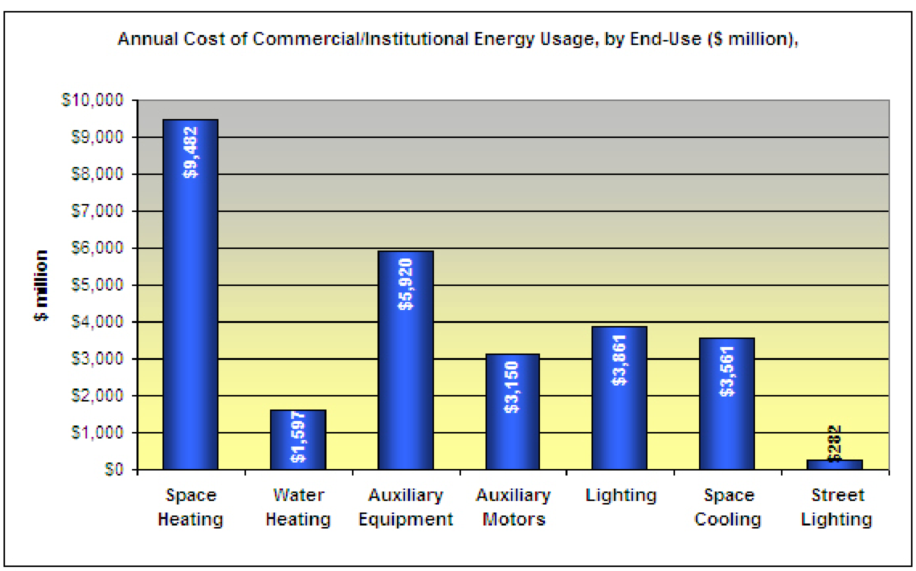
5. What are the Benefits of District Energy?

5.3. Business Benefits

Growing concerns about future energy supply in North America are leading to increased oil and gas exploration, investment in generation from alternative and renewable energy sources, and the application of technologies that can deliver energy within communities both efficiently and in an environmentally responsible manner. Energy is one of the most significant forces driving the North American economy. All commercial, residential, institutional and industrial facilities require energy for space heating, cooling, domestic hot water, and humidity control (see Figure 6). Space heating provides one of the great opportunities for energy cost savings (see Figure 7).

Figure 7: Annual Energy Cost In Canadian Residential, Institutional and Commercial Buildings





Source: Natural Resources Canada, Comprehensive Energy Use Database, 2005.

5. What are the Benefits of District Energy?

Consumers want lower energy costs and more options for supply. At the same time, industial, retail and commercial operators are looking for improved reliability to minimize losses due to energy failures as well as stable energy costs that are insulated from the volatility of the energy marketplace. Investors want predictable returns on investment in energy facilities that are less vulnerable to disruption. Table 7 provides an overview of the business benefits provided by district energy systems.

Table 7: Business Benefits of District Energy

Benefits	Economic attractiveness	Risk mitigation	Energy management/ Commissioning	Design flexibility and space optimization	Improved competitiveness
Building owners and tenants	Increases revenue-generating space (removal of auxiliary systems and building heating and cooling equipment).	Improves safety of operation by removal of on-site fuel storage.	Eliminates commission requirements and maintenance associated with in-building systems.	Provides an opportunity to develop a green roof that can further reduce heat or cooling demands and improve energy efficiency because of removal of building cooling equipment from the roof.	Improves public image – heightens environmental reputation of building owners/developers through demonstrable environmental benefits.
	Eliminates capital costs, interest payments, property taxes, insurance costs and annual maintenance contracts associated with new in-building heating and cooling systems.	Lowers insurance rates because of reduced fire hazard and improves resiliency.	Maintains tenant comfort throughout the year with heat, cooling or electricity through similar process as in-building systems.	Improves indoor air quality by controlling humidity more efficiently (reduces mould, mildew and bacteria build-up).	Ability to receive a high quality thermal and electrical service that minimizes impact on sensitive electrical and operating equipment.
	Lowers ongoing operating, maintenance, and labour costs.	Reduces vibration and noise problems and eliminates stacks going up through a building.	Reduces vibrations and noise that can annoy building occupants through the removal of in-building systems.	Simplifies building design due to reduced mechanical equipment; allows clear design focus on building energy performance.	Tenants receive the benefit of protection for revenue stream through continued supply of thermal and electricity support in the event of a major electrical disruption in the grid.
	Offers better marketability of building space due to lower electricity and power costs, as a result of district energy being less vulnerable to energy price volatility.	Removes requirement to have in-building reserve boilers and electric generators when CHP available.	Reduces the dependency of heating and cooling services on grid, potentially resulting in higher service reliability, particularly for sensitive building use	Reduces space for mechanical equipment and allows designers to incorporate functions of building more effectively and efficiently.	Capital value of building may increase relative to conventional buildings as the costs of conventional energy sources rise above district energy costs.
Investors	Offers long-term stable returns through competitive energy rates.	Expands use of low-cost or renewable fuels.	-	-	Systems can compete with existing utilities at a low-cost in urban regions.
	Represents proven technology and operating performance with a long and useful operating life.	Achieves economies of scale with volume fuel purchasing.	-	-	Systems can meet a variety of user needs from short-term contracts for emergency power to long-term (20+ years) contracts for service and fuel supply that provide predictable cash flow.

See Endnotes for sources

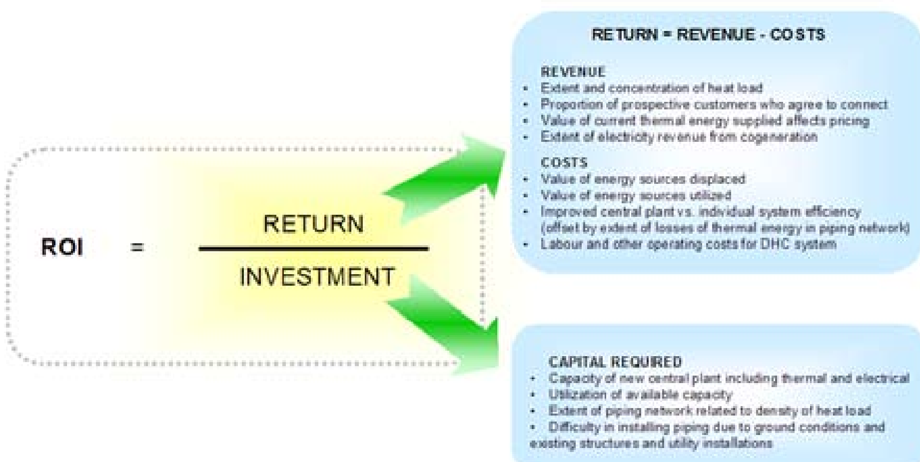
5. What are the Benefits of District Energy?

District energy offers a competitive investment opportunity

Traditionally, district energy systems were developed to maximize economic returns by selling easy-to-access excess thermal energy generated from local industrial operations. The earning potential provided by any district energy system is based on its ability to recapture initial capital cost investments through long-term savings on fuel costs. As the price of energy continues to rise, investors and operators of district energy systems are well placed to earn modest returns from the sale of energy at current prices, while benefiting from reduced fuel consumption compared to conventional systems, savings from bulk purchases of fuels, and the opportunity to blend different fuel sources. Figure 8 illustrates the conditions that determine the return on investment for a district energy system.

Well-established district energy systems in Canada can achieve stable returns of 8 to 12% on investment.

Figure 8: District Energy Return on Investment

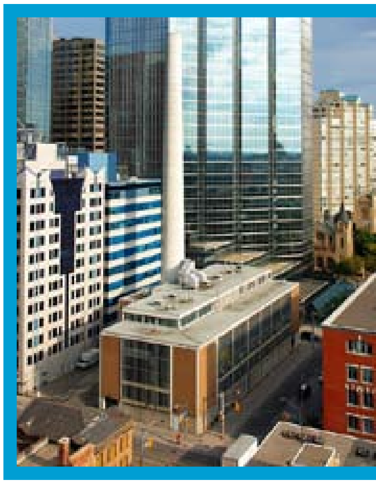


Source: Bond, Gordon. (1993). *Promotional Manual for District Energy Systems*. International Energy Agency, Programme of Research, Development and Demonstration on District Heating and Cooling.

Well-established district energy systems in Canada can achieve stable returns of 8 to 12% on investment. Payback periods range from 5 to 20 years, depending on the size and design of the system, the types of fuels consumed, the type and variety of customers and the partnership structure for the financing and operation of the system.

An example of a small-scale district energy system using CHP to service several new condominium buildings is shown in Table 8.

5. What are the Benefits of District Energy?



True economic benefits of district energy are not captured by the standard methods used to evaluate investments in thermal and electrical services.

The model illustrates that with an average incremental capital cost of $1,317 per kilowatt of capacity, full incremental capital costs would be recovered within nine years, for a return of 11%.

Table 8: Example of District Energy Combined Heat and Power Return on Investment

Sample CHP Project - Operating Assumptions & Project Characteristics	
Operating assumptions	
CHP Electric efficiency (%)	32%
CHP Heat efficiency (%)	48%
CHP Heat to power ratio	1.50
Conventional heating boiler efficiency	80%
Avoided cost of gas delivered to building	$0.45/cubic metre
Thermal utilization	80%
Project characteristics	
Installed CHP system cost ($/kW)	$2,050/kW capacity
Incremental costs ($/kW)	$1,317/kW capacity
Operating hours	2,793 hours per year
Incremental investment	$711,000
Annual savings	$78,000
Return on investment	11.01%
Payback period	9.03 years

Source: James, Jamie, et al., (2006). *Combined Heat and Power Generation for Highrise Condominiums in Toronto*. Tridel and Toronto and Region Conservation Authority.

Many of the true economic benefits of district energy are not captured by the standard methods used to evaluate investments in thermal and electrical services. For instance, the economic benefits of using district energy to improve or displace electric grid bases systems can be estimated by including the additional costs associated with traditional power and transmission systems that may be avoided. By operating, maintaining, coordinating and scheduling district energy systems, communities and industries can benefit from deferred investments in traditional grid-based energy infrastructure, generation, transmission and distribution. District energy can provide energy at a lower risk and cost compared to the expansion or upgrading of central transmission and distribution equipment.

5. What are the Benefits of District Energy?

District energy can help mitigate risk

District energy systems, when properly designed, can provide continuous, reliable thermal services and electricity, leading to improved operational cost savings. These benefits may help communities avoid economic losses from prolonged energy outages, such as the 2003 blackout that affected parts of Ontario, Quebec and the Northeastern United States, which was estimated to have cost Ontario nearly $2 billion.

Figure 9 illustrates the economic impact of energy interruptions and prolonged outages by the minute in billions of U.S. dollars for various market sectors, including government and commercial facilities. While many people think of electricity as being critical for the continued operation of various services, the failure of a heating or cooling supply can also result in significant economic losses in health care, agriculture and many industries. The use of a district energy system can improve thermal energy reliability by reducing or eliminating a facility's dependence on traditional grid sources and provide the facility with alternative sources of energy.

The use of a district energy system can also contribute to improved business operations through the production of reliable thermal energy and electricity and can lower insurance premiums. Organizations that have connected to or converted to the use of a district energy system and eliminated the need to store combustible fuels, have benefited from lower insurance premiums because of the reduced risk of fire. Some insurers provide similar benefits to organizations that receive power directly or have a connection for stand-by power agreement with a district energy system provider. Virtually all district energy systems in North America have a reliability factor of "five nines" (99.999%). To date, there have been no rolling "heat-outs" or major power interruptions reported in North America related to district energy systems.

Economy Keeps Rolling

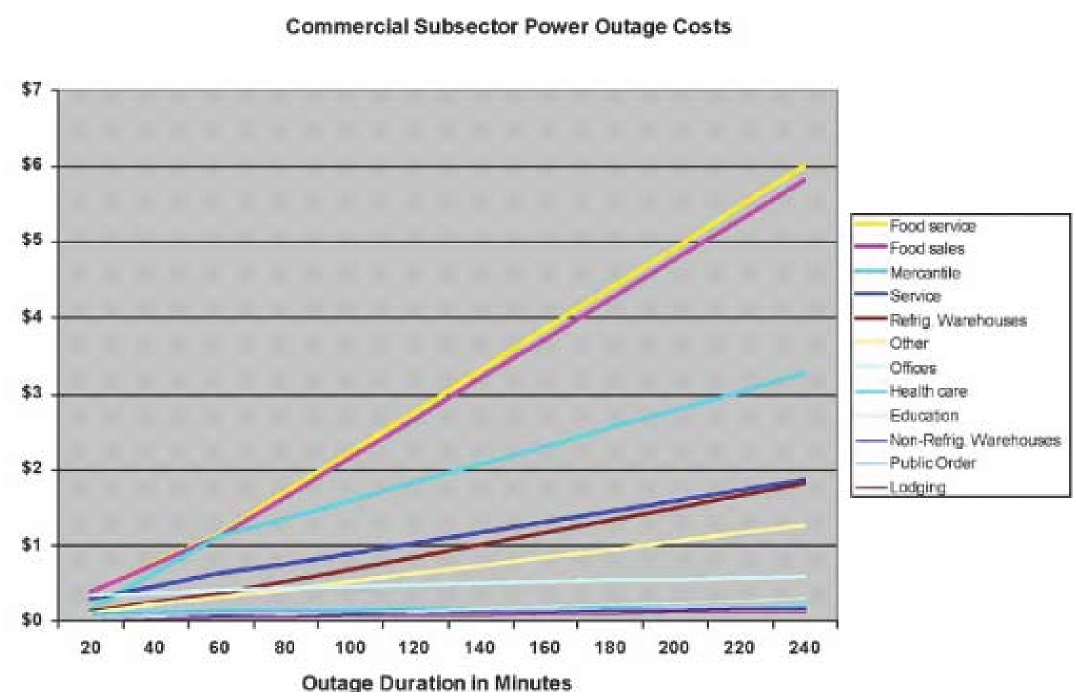
During the ice storm of 1998, many parts of Quebec were without power for several weeks. The Corporation de Chauffage Urbain de Montreal (CCUM) provided 100% of the load for over 20 office buildings, using a 1-megawatt steam turbine, four boilers and two 500-kilowatt diesel engines. CCUM provided all its customers, including the National Bank of Canada and Sun Life Insurance, with a constant source of heat to meet spacing heating requirements during the two-week period when downtown Montreal was without power.

District energy offers economic savings

District energy systems can provide direct savings to building owners and tenants. Many builders and developers of new buildings want to keep start-up costs low and use the criterion of "least-cost" in design and construction, without regard for the building's annual maintenance and operating costs. Tenants and owner-occupiers, on the other hand, have a strong financial interest in how a building performs. Generally, those who live in a building pay more than the developer or initial investor over the lifetime of a building (see Figure 10).

5. What are the Benefits of District Energy?

Figure 9: Commercial Sector Cost of Power Interruptions



Source: Hinrichs, D., L. Markel, and M. Goggin, 2005. *Protecting Critical Energy Infrastructure and Helping Communities Recover from Disaster with Distributed Energy Assets.* prepared by Sentech, Inc. for the U.S. Department of Energy.

Figure 10: Lifetime Costs for Different Decision Makers in a Building

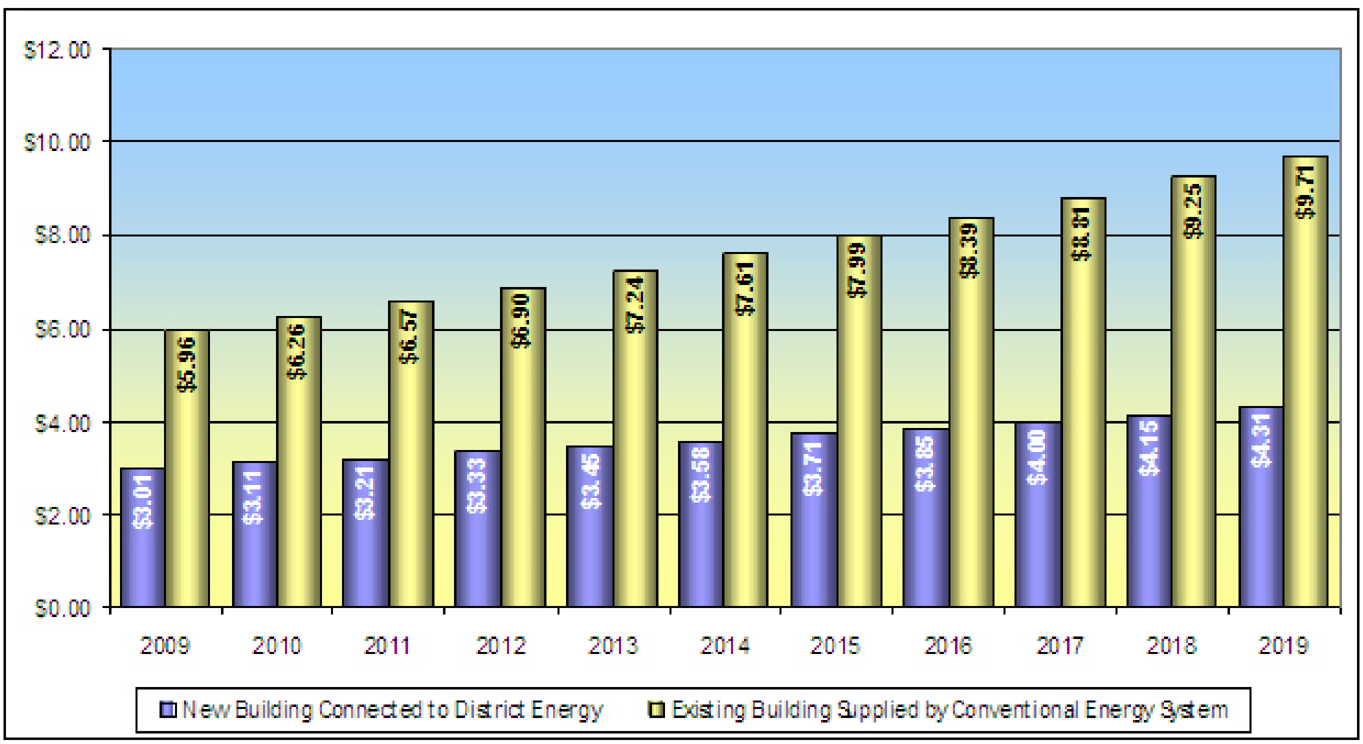
Source: Bartlett, Ed, and Nigel Noward. (2000). "Informing the decision makers on the cost and value of green building." *Building Research and Information. 28(5/6). 315-324.*

5. What are the Benefits of District Energy?

The operating expenses for an owner or tenant can be greatly reduced with the use of a district energy system and long-term economic savings achieved. Some estimates reveal that tenants in a new building that is connected to a district energy cooling network can achieve savings of nearly $3 per square foot a year on utility costs when compared to an existing building with a conventional heating and cooling system (see Figure 11).

Owners and tenants save money because district energy systems generate thermal energy and electricity more efficiently than conventional building heating and cooling systems. Capital costs are lower, because there is no need to install boilers and chillers in a building, and this also means lower operating, maintenance and labour costs. The owners and tenants of a building connected to a district energy system with CHP capacity can also benefit from reduced exposure to fuel cost increases, because they receive power at times when prices for electricity are low.

Figure 11: Utility Expenses New Building vs. Existing Office Tower ($/sq. ft.)



Source: Farris, Kathrine, and Advisum Realty Corp (2007). *Connecting Communities and Buildings Through District Energy*. Presentation at the Canadian District Energy Association Conference.

6. Overcoming Challenges to Implementing District Energy

Despite the existence of many successful district energy systems across Canada, municipalities and businesses continue to face challenges to using district energy to achieve sustainable development and energy efficiency. Utilities and private-sector companies want to invest in district energy systems that have established markets to serve and that can provide a reliable return on investment. Municipalities also want to cut costs and attract investment, but often have restricted budgets. Overcoming challenges to the market penetration of district energy requires innovative approaches to encourage community support, secure funding and reduce capital expenditures.

Incorporating district energy into a municipal planning process and bylaws can stimulate interest in district energy.

6.1. Concentrate Urban Form

District energy systems are most effective, in terms of financial and economic performance, when they are connected and integrated to serve a large number of buildings. The deployment of a district energy system in a community can be limited by:

- the concern that a district energy system will overcomplicate the planning and development process;
- difficulty in coordinating planning among various agencies and interest groups involved in a district energy system;
- permitting, zoning and regulatory constraints.

Incorporating district energy into a municipal planning process and bylaws can stimulate interest in district energy. By integrating district energy options into planning documents and approval processes, a municipality demonstrates its commitment to using district energy to contribute to community growth, economic development and long-term sustainability.

Municipalities can help create the conditions that support the development of a district energy system by encouraging the concentration of urban form, particularly the mixing of high-density residential and commercial buildings. When these land uses are located close together, they generate considerable demand for space heating and cooling. The higher the thermal load in the buildings served by a district energy system, the lower the unit costs related to energy infrastructure per square metre of building.

In the City of North Vancouver, the preparation of an energy plan involved identifying sites within the community with a high demand for thermal services. The City established a policy whereby developers who bought City-owned land were required to connect to the district energy system. The policy follows the precedent set by municipal infrastructure practices relating to provisions for sidewalks, roads, sewer connections and storm water management. The City of Vancouver is using a similar land use planning policy to support a district energy system for the new Olympic Centre and South East False Creek development.

In Markham, Ontario, planning for a new urban downtown, Markham Centre, provided the opportunity to advance principles of sustainable development, defined as linking environmental enhancement, economic development and community well-being. A performance checklist was created to help developers meet sustainable development objectives. The checklist included specific energy reduction targets and how these targets could be met through the energy-efficient design of a building and by connecting to the Markham District Energy system.

Municipalities can help create the right land use configurations to support a district energy system by:

- understanding the role, types and distribution of energy within a community;
- developing a Community Energy Plan that evaluates land use and community design for the more efficient use of energy;
- using the District Energy Site Selection Process to model and map existing or potential land use patterns and densities that support district energy as part of the land use development process;
- documenting and providing access to energy data that can be used to forecast heat and cooling demands;
- encouraging compact urban form and the mixed use of land uses (such as commercial, institutional, office and residential), which supports district energy;
- focusing growth in areas with district energy potential;
- using zoning to create energy or district energy zones that encourage higher densities and provide specific site standards or incentives for connecting to a district energy system.

6.2. Work with the Community

Many of the challenges experienced while initiating a district energy system result from a lack of public awareness of how a district energy system can contribute to meeting the energy and sustainable development objectives of the community. Although community members might be interested in reducing reliance on centralized energy, encouraging alternative and renewable electricity generation, and reducing

Community Energy Planning

Natural Resources Canada has outlined a community energy planning process to help municipalities develop a community energy plan. The guide assists communities in reducing their dependency on fossil fuels by better understanding the role of energy within their community. The Community Energy Planning Guide (CEP-SGCN) can be downloaded from http://www.smartgrowth.ca. Municipalities that have created a community energy plan using the guide or other process include: the Regional Municipality of Halifax, the City of Guelph, the City of Yellowknife, Strathcona County and the Resort Municipality of Whistler. For more information, visit Natural Resources Canada, Sustainable Building and Communities program, http://www.sbc.nrcan.gc.ca.

greenhouse gas emissions, local opposition to district energy may focus on concerns about local emissions, noise and aesthetics. Engaging stakeholders and regulatory bodies early on can help establish a broad base of support and streamline the regulatory process.

Developers, operators and owners of the most successful district energy systems have usually worked closely with local municipal representatives, including elected officials. The systems are incorporated into the long-term sustainability development objectives of the community, forming part of the vision for the future of a community. There is invariably a senior representative at the municipal level or community/business leader who is familiar with the concept of district energy and actively champions its use in the community. Community involvement in planning for a district energy system can ensure a long-term commitment to the project.

When a community begins to consider district energy, engaging stakeholders is important. Municipalities and other public-sector agencies can help identify important stakeholders and initiate discussion among various parties.

When the Bécancour, TransCanada Energy district energy combined heat and power system was proposed, most community members did not understand what district energy was or how it worked. Although they had a general sense of the potential environmental benefits that a district energy CHP system could provide in reducing local emissions from the burning of oil, they remained sceptical about a large-scale energy production facility. The project development team for Bécancour engaged in a community-wide education and awareness program as part of the environmental approval process, to inform residents of the economic benefits relating to job creation and the environmental improvements that could be achieved from the installation of the system.

District Energy Site Selection Process

The Canadian District Energy Association has developed a tool to help municipalities and other organizations identify potential locations for district energy in a community. The tool identifies the factors required for district energy that must be determined early in the process, such as the size of buildings, thermal demand and electricity use required for a defined area, and the amount of fuel displaced and greenhouse gas emissions saved.

6.3. Use Integrated Design

The design and development of a district energy system is complex. An integrated planning approach is required to achieve the highest efficiency levels possible for the system. Traditionally, energy planning has focused on identifying potential sources of fuel for use in district energy systems and designing buildings to achieve a high level of performance and reduced energy consumption.

6. Overcoming Challenges to Implementing District Energy

Today, communities are using integrated energy planning to assess how district energy systems can serve as "energy brokers" to collect, generate and distribute energy within communities efficiently and economically. Integrated energy planning can give communities an entirely different way of meeting local energy requirements by examining opportunities to:

- lower energy use across an entire community;
- improve the energy efficiency and operating performance of buildings;
- turn community "wastes" (biomass, sewer heat, and landfill gas) into energy assets;
- recover excess energy from sources such as local industrial processes;
- use district energy to meet sustainable development objectives.

For the Halifax Regional Municipality, the process of preparing a community energy plan provided an opportunity to involve a broad cross-section of the community in identifying clean energy sources, including renewable energy, as well as more efficient ways to use energy. The plan established a clear set of actions that the municipality can take to encourage businesses to incorporate energy considerations into daily decision making, including tax incentives for industry to improve operational performance, new energy-efficient building codes, and land use regulations to encourage compact urban form.

As the efficiency of district energy systems and the approach to designing buildings has improved, district energy design teams need to be involved from the beginning of a project. An integrated design process (IDP), like integrated energy planning, assesses each phase of construction, from site selection to the choice of the HVAC system, to achieve the maximum environmental potential of a building. Design teams and all affected stakeholders work together throughout the project to evaluate opportunities to realize design cost savings while maintaining future flexibility and efficiency.

In the initial development of the Lonsdale Energy Corporation (LEC) system in the City of North Vancouver, British Columbia, design teams for the plant and the engineering teams working for the local developer did not come together. As a result, the new residential building controls failed to ensure efficient operation of the district energy system and the heating demand for residential buildings was overestimated, resulting in the oversizing of the system. LEC operators and management recognized this issue and now work with local residential and commercial building development teams to plan the infrastructure and controls needed to connect to the system and have created detailed design guidelines for developers.

District Energy - It's More Than Just Distribution Workshop Series and Energy Selection Framework Tool

The Canadian District Energy Association has developed a process to help encourage community participation from a broad cross-section of stakeholders in the development of a district energy project. The Workshop Series can be used to enhance local community knowledge of district energy and enhance the general understanding on the challenges and solutions to implementing district energy. For more information on the workshop series, visit www.cdea.ca/decrc

6.4. Build Knowledge, Know-How and Technical Skills

Keeping informed on the latest advancements in the application of district energy is a challenge. Community planners, engineers, architects, builders, developers, government officials and the general public may not be familiar with district energy and how it can benefit municipalities and businesses. For instance, consultants with limited experience of district energy might fail to recommend the technology to developers, or apply "conventional rules of thumb" in evaluating the efficiencies and effectiveness of systems that do not include current costs and performance considerations.

Smaller municipalities and small and medium-sized companies also may not have the technical skills or experience to properly evaluate the potential contribution of district energy.

Tours of successful district energy systems are an effective way to involve community stakeholders, from local business leaders to councillors, and familiarize them with the technologies involved. By visiting systems in other communities, local leaders can talk to their counterparts who have successfully implemented a system. A municipal or business district energy management team can also benefit from system tours on which they meet plant owners, operators and system design teams.

In the development of the Drake Landing Solar Community in Alberta, project design team members visited precedent-setting solar thermal operations in Europe, where the technology is well established. Up to that point, using solar energy at the neighbourhood level for space heating and domestic hot water in Canada was at the experimental level only. By speaking with operators and users of existing systems, the team gained important insights into the technical, economic and market considerations for a residential renewable district energy system.

Developing a district energy system requires a team of experts with a diverse range of experiences and skills, including mechanical, electrical and structural engineers; contractors and equipment suppliers; a project manager; environmental consultants; and financial managers. Municipalities and businesses with time constraints or limited support might not be able to provide the needed oversight.

Ownership Options for District Energy

Ownership models for district energy systems in use across Canada include municipal ownership, ownership by a corporation established by the city (such as a utility), ownership by a city with operation by a private entity, and private ownership. Different ownership arrangements can affect the economic return on a project, in terms of access to financing and potential tax implications. See the district energy case studies on Canadian plants at www.cdea.ca/decrc

Alternatively, municipalities and businesses can hire a full-service project developer to provide the necessary knowledge of and experience with district energy systems and construction management required for large-scale projects. Organizations such as the Canadian District Energy Association are available to advise on appropriate consultants and engineers.

6.5. Partner to Improve Project Financing and Reduce Development Risk

Reducing investment risk is an important consideration for the start-up and on-going operation of a district energy system. Working closely with a municipality and developing the right partnerships can help put the development of a district energy system on the right financing approach.

District energy typically requires an initial large up-front investment to cover the capital costs of building a new plant and installing pipes to transport hot or chilled water. Without close cooperation and support from a municipality, it is sometimes difficult to predict when and where development might occur, but this information is needed to help determine the size of a plant, the cost of the system and the potential return on investment. There is also the additional challenge of ensuring access to public and private rights-of-way and easements for the installation of district energy infrastructure to service potential users.

Given these challenges to development, district energy systems are often seen as economically unattractive to small-scale developers and energy investors. Local utilities often have the financial resources to fund district energy systems, but tend to promote their existing services and fuel options ahead of district energy, since district energy is seen as reducing demand for their revenue-generating services.

Deciding whether and how to finance a district energy system involves evaluating who can operate a district energy system most effectively and who has access to potential sources of private equity and government grants. The structure of financing and plant ownership affects project costs, control and flexibility, and the long-term ability to generate revenue.

Since most district energy systems have a long payback period, attracting private-sector investment can be difficult. Most local district energy systems are initiated by the public sector because municipal governments

Public-Private Partnerships

Public-private partnership in the design, construction, ownership and operation of a district energy system can contribute to success. In these arrangements, the community becomes a stakeholder in the project; it can be easier to attract customers; financial risk is reduced because development barriers can be removed (the municipality provides access to public rights-of-way, secures commitments to connect, and increases the density of built form), and risk is transferred away from the community and onto private-sector equity holders.

tend to have a longer-term planning focus, a greater interest in meeting environmental objectives, better access to capital, lower required rates of return on investment, access to senior levels of grant funding and exemption, in some cases, from income taxes. Once the initial development and investment risk have been lowered, it becomes easier to attract private-sector investment.

Many new district energy systems are being developed through some form of public-private partnership.

Across Canada, many new district energy systems are being developed through some form of public-private partnership. Private-sector partners bring expertise and financing to the development of district energy systems. In many cases, the private-sector partner provides a "turnkey" service whereby a qualified development company is selected to design or build the project, and that company turns ownership and operation of the facility over to an owner once the plant is complete. Using a full-service developer can transfer development responsibility and risk, and improve access to financing.

In the City of Sudbury, working with a private-sector partner to build the Sudbury District Energy Corporation system contributed to reducing the development risk by providing access not only to knowledgeable construction expertise but also to additional equity for project development. The project highlighted the importance of having a clear understanding of the goals of the project. Unclear expectations between partners about a district energy initiative can lead to discontent and halt the development of the project. Similar innovative development and financing arrangements were used to support or expand the Revelstoke Community Energy Project and PEI Energy Systems in Charlottetown.

6.6. Build a Customer Base Early and Get "Green" Certified

The success or failure of a project is often determined by "windows of opportunity." Most established customers will connect to a district energy system only when it suits their timetable (for example, when existing equipment needs replacement), unless they are offered financial or other incentives. For developers of new buildings, the option to connect to a district energy system may depend on the ability to connect to existing infrastructure or a guarantee that infrastructure will be in place to meet thermal and electrical requirements when the building is complete.

6. Overcoming Challenges to Implementing District Energy

Identifying potential users of district energy early on in a project can contribute to the development of a district energy system that can grow to meet increasing demands, as well as provide an attractive competitive marketing advantage. The chance to secure users of a district energy system occurs before design concepts of energy systems are considered and schematic designs of buildings are produced.

From the moment district energy is proposed in a community to final commissioning and operation, attracting customers is an ongoing activity. Members of the community, including large potential end users of a system, need to be informed about the concept, the benefits and the potential challenges. Careful consideration should be given to securing the first (anchor) customer. Often, the initial user of a district energy system, such as a commercial office or government building, will provide the impetus for other local users to consider the services provided by a district energy system and serve as a champion of the project. Part of the process for attracting customers to a district energy system involves marketing to users who are interested in the potential savings generated through lower operating and capital costs. An important consideration when outlining the competitive advantages of district energy is highlighting the ability of a system to be comparatively priced to prevailing fuels or energy services in a community.

Attracting customers is an ongoing activity… [but] careful consideration should be given to securing the first (anchor) customer.

Discussions about the potential for district energy should involve representatives of local government agencies, major users of thermal energy, large landowners (such as universities or hospitals), industry, commercial building owners and operators, local utilities and government agencies responsible for the approval and regulation of a system.

Developing the customer base should include engaging end users interested in:

- potential savings generated through lower building operating and capital costs;
- security of supply concerns;
- exposure to volatile energy price markets;
- improved air quality and reduced greenhouse gas emissions.

An important part of attracting potential users of district energy is conveying the environmental benefits, particularly improved building performance and energy efficiency. This task is becoming easier every year. At the dawn of the 21st century, few builders and developers were familiar with "high-performance" design or concerned about environmental friendliness.

6. Overcoming Challenges to Implementing District Energy

LEED rating systems acknowledge that district energy systems can integrate community renewable energy and waste heat recovery resources with high-performance and high-efficiency buildings.

In less than a decade, "green" building has become synonymous in Canada with sustainable development principles and greenhouse gas emission reduction. Increasingly, developers are investing in energy efficiency in new homes, condominiums and offices and ensuring that consumers are aware of their efforts.

A well-recognized sustainable building evaluation and design guideline system in use across Canada is the Leadership in Energy and Environment Design (LEED) rating system. The LEED system, administered by the Canada Green Building Council, is designed to encourage the incorporation of best practices for environmental and efficient design of commercial, high-rise residential, institutional and industrial buildings. Developers, governments and industry are exploring the potential for new buildings to meet or adhere to the LEED guidelines.

LEED rating systems acknowledge that district energy systems can integrate community renewable energy and waste heat recovery resources with high-performance and high-efficiency buildings.

To assist developers, governments, building owners and investors with identifying high-efficiency district energy systems that can contribute to improving the energy efficiency of a building and reduce dependence on non-renewable energy sources, district energy operators are certifying plants using the nationally recognized EcoLogo™ program of Environment Canada's Environmental Choice Program. EcoLogo™ provides a transparent process, by using independent third-party verification, to assess whether district energy systems are meeting a high standard of energy consumption reduction in the heating or cooling of buildings.

7. Preparing for District Energy

Developing a district energy system is a multi-stage process that includes preparing a market assessment, technology analysis, schematic design of the system, and finally implementation and operation. At each stage, it is important to capitalize on the community's resources that support district energy – urban form, access to local fuels, thermal and electricity markets and the planning process – and assess their strengths.

The checklist on the following pages will help communities assess their readiness for district energy. It is organized into five sections: sustainability profile, urban form, energy security, energy markets and fuel sources. The questions can be used by any organization interested in district energy without professional assistance.

Answering *no* to any of the checklist questions does not mean that the community is unprepared or unsuitable for district energy. Instead, it probably means that some additional steps need to be taken to promote district energy. The checklist includes suggested actions that a community might take to change the *no* to a *yes*.

For more information on the EcoLogo™ program, and the process for registering a district energy system, visit http://www.environmentalchoice.com/. Two district energy systems, Markham District Energy Inc. and Hamilton Community Energy, are registered under the EcoLogo™ program.

7. Preparing for District Energy

7.1. A Checklist for Success

	Factors for Success	Yes	No	Getting to Yes
Sustainability Profile				
	Is energy planning part of the community development process?			Consider using the Community Energy Planning process developed by Natural Resources Canada to incorporate energy into decision making practices. At the municipal level, attempts should be made to include energy planning in the Official Plan.
	Does the municipality or your organization have an energy and/or GHG reduction target?			Review community energy plans established to reduce GHG emissions. An excellent starting point for developing a greenhouse gas inventory is outlined by the Canadian GHG Challenge Registry and the Natural Resources Canada, Office of Energy Efficiency.
	Does the municipality or your organization maintain a GHG or energy use inventory?			Most approaches for identifying the potential for district energy include preparing a catalogue of thermal resources – type of alternative, renewable, fossil and waste heat fuels used in a community – for heating, cooling and electricity needs. Consider using the *District Energy Site Selection Process* to begin the catalogue.
	Is there community leadership and support for GHG and energy reduction?			Influential leadership in the public and private sector can improve the potential for district energy in a community. Work with municipal staff or business leaders to develop an energy efficiency and GHG awareness program.
Urban Form				
	Are concentrated mixes of different land uses and building types present in the community?			District energy systems work most effectively when located near a concentration of buildings with different uses. Apply the *District Energy Site Selection Process*.
	Is there new construction or revialization innitiatives under way in your community?			Work with local officials, developers, and local industry to identify opportunities to concentrate urban form and potential sources of waste heat. Use the *More Than Just Distribution Workshop Series* and apply the *District Energy Site Selection Process* to identify or create the right land use configurations that can support district energy.
	Can undeveloped areas of land be developed with a mixture of building types and high density form?			The more compact a development area is in terms of potential thermal heat or cooling demand, the better the operating efficiency of district energy systems. Use the Community Energy Planning process to incorporate energy considerations into land uise decision making practices.

7. Preparing for District Energy

	Factors for Success	Yes	No	Getting to Yes
Urban Form, cont...	Can expansion or renewal of local energy and other infrastructure be used to support district energy?			Municipal services can provide sources of heating such as heat from sewers and cooling from naturally extracted cold drinking water (Deep Lake Water Cooling) that can be used in a district energy system. Ensure terms of reference for land use planning studies and infrastructure development include requirement to assess inclusion of district energy applications. Costs of developing a district energy system can also be reduced through cost sharing with utilities, such as locating all services, including pipes for a district energy project, in one utility trench.
	Can physical or geographical barriers, including easements and rights of way be removed to ensure that consumers can connect to the system?			Locating district energy infrastructure close to a customer reduces distribution costs and improves plant efficiency. Cost overruns often occur because of "unknowns" exposed during excavation. Municipalities should make information on underground services and utilities easily available.
Energy Security				
	Is there a need to provide high-quality power or stand-by power in a community?			Develop a better understanding of central grid reliability and energy needs of the community by meeting with local utilities. Use the U.S. EPA calculating reliability benefits tool to assess the economic value of backup power from district energy.
	Are there concerns about access to a long-term affordable energy supply (e.g. reducing use of imported fuels)?			Energy security is an important way to ensure the economic competitiveness of a community. Where local fuels are available (e.g. biomass), consider their use in district energy systems. See Heating Communities with Renewable Fuels, available from Natural Resources Canada.
Energy Markets				
	Does the community have one or more large users of thermal energy and/or electricity?			A single large thermal user can provide the impetus for a district energy system. Apply the *District Energy Site Selection Process*.
	Are reliable, low-cost energy sources readily available for generating space heating and cooling on a building specific basis?			An important feature for the competitive success of district energy is the capacity to offer various thermal services and electricity at similar rates (or lower) relative to existing or other potential alternative sources of energy in a community. Examine the potential for CHP to provide even more cost effective energy sources. Use *HEATMAP/TM©* software designed to evaluate district heating and cooling systems.

	Factors for Success	Yes	No	Getting to Yes
Energy Markets, cont...	Are any major thermal users (such as hospitals and universities) seeking to replace or upgrade their heating and cooling systems?			Timing is a critical factor for the success of district energy systems when considering construction and for getting customers. Established customers will often connect to a district energy system when it meets their needs. Upgrades or replacements of large-scale energy infrastructure provide excellent opportunities for the consideration of district energy. Refer to the *More Than Just Distribution Workshop Series and the Energy Selection Framework Tool* to develop an approach to attract potential end-users to a district energy system.
	Does the municipality have the ability to finance a district energy initiative?			District energy has a number of advantages, but requires front-end investment by a developer, owner or operator. Public-private partnerships can contribute to the success of a project.
	Is there private-sector interest in advancing a local district energy system?			Consider hosting a meeting with key community stakeholders to assess interest in advancing a district energy project. The *District Energy – It's More Than District Energy Workshop Series* can help to bring together a variety of community members together to assess the potential for district energy in a community.
Fuel Sources				
	Is there immediate access to large bodies of naturally cooled water?			Using naturally cooled water can provide an affordable and environmentally friendly way to cool buildings, improving air quality and reduce the urban heat island in cities. Where naturally cooled water is not available, investigate the lowest impact methods of cooling water for district systems.
	Are there sources of local biomass in the community (sewer heat, crop residues, dedicated energy crops, logging wood products etc.)?			For more information on potential sources of biomass and the use of alternative energy technologies in your community, visit Natural Resources Canada, Canadian Renewable Energy Network.
	Is there local access to sources of biogas (landfills, waste digesters and treatment facilities)?			Municipal landfills and water treatment facilities produce biogas from the breakdown of organics. This gas can be used to fuel district energy, combined heat and power systems, such as in Hamilton Ontario.

7. Preparing for District Energy

	Factors for Success	Yes	No	Getting to Yes
Fuel Sources, cont...	Do sources of excess thermal heat (reject heat) exist that can be used for thermal energy generation (e.g. heat from industrial activities)?			Use the *District Energy Site Selection Process* to begin identifying potential major thermal energy producers in a community.

Results of Checklist

There are 20 questions in the checklist. For each of the *yes* answers, score 1 point. At the end of the checklist, total your number of *yes* answers. Scores of 15 and over indicate the community is ready and there is good potential for district energy. Scores of lower than 10 suggest that more work needs to be done to help get the community ready for district energy.

8. Quick Starting District Energy

Municipalities and businesses that have already identified energy as part of their long-range planning, growth management or integrated community sustainable planning are likely to be more receptive to the potential application of district energy.

The early stages of exploring the potential for district energy in a community are often performed by people who are not familiar with the technology. This section summarizes some of the early considerations for promoting the implementation of district energy.[10]

1. Understand the concept of district energy
   - District energy is a recognized approach for meeting the heating, cooling and domestic hot water needs of buildings. District energy serves to manage the thermal energy needs of customers and of communities.
   - District energy includes the:
     - i. collection and/or generation of thermal energy;
     - ii. distribution of the thermal energy from plant sites;
     - iii. transfer of thermal energy to the end user.
   - District energy can improve energy security for communities, contribute to the efficient use of energy sources, keep dollars spent on energy in a community, contribute to meeting a range of environmental goals (better air quality and reduced GHGs), support compact urban form, and provide owners and operators of buildings with a range of benefits, including reduced maintenance costs.

2. Assess initial interest
   - Municipalities and businesses that have already identified energy as part of their long-range planning, growth management or integrated community sustainable planning are likely to be more receptive to the potential application of district energy.
   - If a local municipality has engaged in a process to address sustainability issues, this is also likely to contribute to broader awareness. Achieving community sustainability objectives will be more successful when there is a commitment in terms of leadership and allocation of the proper resources to undertake activities such as planning for district energy.

3. Review community needs and resources
   - A community or business may have started examining energy issues due to concerns over high fuel costs or issues associated with waste disposal problems. District energy is particularly promising when the evaluation process can address a community or business need that is not being met.

8. Quick Starting District Energy

- District energy is also a good candidate when there is access to local sources of renewable fuels, such as biomass, or stable amounts of heat rejected by industrial or municipal operations.

4. Find and support a champion
   - Leadership for a district energy system from the public and private sector greatly enhances the potential for establishing a project. Developers, operators and owners of successful district energy work closely with municipal representatives, paticlarly elected officials.

5. Undertake a preliminary screening of project viability
   - Use the *District Energy Site Selection Process* as a preliminary screening tool to identify potential locations for the establishment of a district energy system.
   - To keep costs at a minimum, preliminary screening should involve people who are experienced with district energy systems, as well as people familiar with the needs of the community.
   - The process will identify whether a community has the right mix of needs and resources to ensure the success of a district energy project.

As a community begins to consider the potential for district energy, it will become important to identify and involve stakeholders in the project.

6. Identify key stakeholders and involve the community
   - As a community begins to consider the potential for district energy, it will become important to identify and involve stakeholders in the project. Stakeholders are those organizations and individuals who could benefit from the establishment of a district energy system.
   - Stakeholders can include business, governments and organizations involved in the design, construction and operation of a system. Other stakeholders to consider involving include the largest potential customers and potential suppliers of thermal energy (e.g. local industry that rejects heat or has excess thermal capacity).
   - Refer to the *More Than Just Distribution Workshop Series and Energy Selection Framework Tool* to help identify community stakeholders, enhance stakeholder knowledge of district energy and enable stakeholders to become better informed on the challenges and solutions to implementing district energy.

7. Plan system organization and financing with stakeholders
   - The structure for financing and plant ownership can impact project costs, control, flexibility and the long-term ability of a system to generate revenue. Key questions to consider when working with stakeholders should include:

- Who will own the plant and distribution system?
- Who can operate the system most effectively for the benefit of customers and the community at large?
- Who has access to potential sources of private financing and government grants?
- Can capital costs and financing responsibility be shared among stakeholders?

8. Conduct a pre-feasibility assessment
   - The pre-feasibility assessment will identify any barriers of a technical and regulatory nature that need to be resolved. A pre-feasibility assessment is more expensive than the initial screening process, but less costly than a full feasibility study or engineering design.
   - The pre-feasibility assessment will provide the first full cost estimate of capital costs for the project, identify the potential number of buildings and heat load for a system, the amount of fuel required to run the system and estimate the reduction in emissions and fossil fuel displacement.
   - The pre-feasibility assessment should be carried out by an entity with engineering experience and expertise in the design, development, financing, construction and operation of a district energy system. The Canadian District Energy Association and Natural Resources Canada, Sustainable Building and Communities program can assist with advising on appropriate consultants and engineers.

9. Carry out more in-depth investigation
   - More detailed investigation might be required to assess the viability of the project to assure stakeholders that no major barriers exist. During the refinement of technical information, stakeholders will be involved throughout the process, allowing for improved understanding of the benefits to be received from the system and increased confidence in the technology and process for project development.
   - At this stage,a public entity might decide in principle to proceed with a project to own and operate the system; or engage a private partner who would be responsible for undertaking a full feasibility study, including identification of interested customers and additional partners to assist with financing and operating the system.

10. Move forward with project development.
    - Make a go or no-go decision for District Energy.

Glossary of Terms

Absorption Chillers: cooling devices that use a hot medium (steam, hot water, or waste heat) to provide air conditioning.

Acid Rain: precipitation (rain, snow or fog) that is acidic and caused by NO_x and SO_x discharge into the atmosphere, usually the result of burning fossil fuels, especially coal and oil.

Biomass: any organic matter that can be burned for energy.

Boiler Efficiency: the efficiency with which a boiler converts natural gas to usable thermal energy (in the form of domestic hot water and space heating).

Carbon Dioxide (CO_2): a greenhouse gas produced as a product of fuel combustion. It is non-toxic and also released by breathing animals and is absorbed by plants.

Cogeneration: see Combined Heat and Power

Combined Heat and Power (CHP): an energy source for a district energy system that involves the production of thermal energy (hot water or steam) and electrical power using one type of fuel input. CHP technologies recover thermal energy that would be wasted in an electricity generator, and save the fuel that would have been used to produce thermal energy in a separate system. CHP is usually achieved by generating electrical power and having exhaust heat recovered from the process for heating water or producing heat to drive a turbine and generate electric power.

Compression-ignition engines: predominantly four-stroke direct-injection machines fitted with turbochargers and intercoolers: they accept diesel, natural gas or a mixture of both.

Distribution Network: a network of pipes that connects heat or energy production plants or sources of waste energy to a building that uses the heat or energy.

District Energy (DE): an approach to meeting the heating, cooling and domestic hot water needs of buildings that can support the process heating requirements of local industry. District energy accommodates the different energy demands of buildings and industries that use energy in different amounts and patterns. By linking buildings and industrial activities together through a thermal network, district energy aggregates the varying energy demands into a steady thermal load that can be efficiently managed.

Energy Intensity Factor: the number of gigajoules of energy utilized per year per square metre.

Energy Transfer Station: the point at which heat energy is transferred between the district energy system and a consumer building.

Feasibility Study: a study of the potential for district energy. The process involves an examination of capital costs, operating expenses, potential energy demands and cost effectiveness of a proposed system.

Fossil Fuels: coal, oil and natural gas, which are considered non-renewable energy and cannot be regenerated over a human time scale. The combustion of fossil fuels is a major source of CO_2.

Fuel Cells: a technology that converts the chemical energy of hydrogen and oxygen into electrical energy through an electrochemical reaction. Typical fuel cells produce only a small voltage (~1 volt), but combined in a series, they produce enough power for distributed generation applications.

Generators: equipment used to convert the mechanical energy of a rotating engine shaft into electricity. Synchronous generators operate in isolation from other generating plants and the grid. Asynchronous generators can operate only in parallel with other generators, usually the grid.

Gigajoule (GJ): 1 x 109 joules (see Joules) This unit is used by most government agencies across Canada when analyzing energy reduction opportunities and financial incentives.

Heat Exchanger: a device that transfers heat from one fluid to another that is used in district energy systems.

Heat Load: the level of heat demand required by a building or district of buildings that are connected to a district energy system at any time.

Heat to Power Ratio: the ratio of the thermal output to power output.

Joules (J): the international unit of measurement for energy. It represents the energy produced by the power of one watt flowing for one second. There are 3.6 million joules in one kilowatt-hour.

Methane: an explosive, non-toxic, gas that can be used in combustion. It is a potent greenhouse gas produced by decaying organic matter in the absence of oxygen. Landfill gas is one example of methane.

Micro turbines: machines able to generate 25kW to 200kW of electricity in high-speed generator power plants, with only one moving part. They are fuelled primarily by natural gas, but can also operate with diesel, gasoline or other similar high-energy fossil fuels.

NO_x: nitrogen oxides, air pollutants that are released from burning certain fuels, including fossil fuels and biomass.

Peak Demand Rate: a building's monthly (energy) peak demand.

Prefeasibility Study: a preliminary study of district energy. The preliminary process is used to identify potential locations, economic vialbility and preliminary system schematics before conducting a full feasibility study.

Prime Mover: a reciprocating engine, steam turbine, gas turbine, micro turbine or fuel cell that drives an electricity generator from which usable heat can be recovered.

Reciprocating Engine: an internal combustion engine similar to an automobile engine, ranging in size from $20kW_e$ to $50MW_e$.

Renewable Energy: energy sources that are self-renewing such as solar, water power, biomass, wind, wave, and geothermal. All of these sources of energy are ultimately derived from the sun's energy.

SO_x: sulphur oxides, air pollutants implicated in acid rain that are caused primarily from burning coal and oil, but not by burning biomass.

Spark-ignition engines: derivatives of diesel engine systems that can provide cooling water as a heat source.

Space Heating/Cooling: the use of energy to generate heat for warmth or to cool in a housing unit or structure.

Stakeholders: individuals, businesses, municipalities, or other institutions that have a major interest in the establishment and success of a planned district energy system.

Sustainable Development: development directed at environmental enhancement but also economic development and increased community well-being.

System Operator: the company responsible for the operation of the district energy system.

Turbine (Power): a device that uses hot, pressurized fluid to create rotational energy that turns a shaft connected to electrical generators.

Waste Heat Recovery Units: a boiler that recovers heat from the exhaust of gas turbines or reciprocating engines. The simplest is a heat exchanger through which exhaust gases pass as the heat is transferred to a boiler to produce hot water or steam.

Endnotes

1 For a more detailed review on the concept of district energy see Church, Ken. (2007). "The District Energy Concept" *Municipal World,* vol. 117 (11): 31-34.

2 Combined heat and power (CHP) is one energy source for a district energy system and involves the production of thermal energy (hot water or steam) and electrical power using one type of fuel input. CHP technologies work to recover thermal energy that would be wasted in an electricity generator, and save the fuel that would have been used to produce thermal energy in a separate system. CHP is usually achieved by generating electrical power and having exhaust heat recovered from the process for heating water or producing heat to drive a turbine and generate electric power.

3 List of applications for district energy derived from the U.S. Department of Energy. (2007). *The Potential Benefits of Distributed Generation and Rate Related Issues that May Impede Their Expansion: A Study Pursuant to Section 1817 of the Energy Policy Act of 2005.*

4 Government of Canada. *Turning the Corner: An Action Plan to Reduce Greenhouse Gases and Air Pollution.* (2007). Available at: http://www.ecoaction.gc.ca/turning-virage/index-eng.cfm

5 TWh (terawatt-hour) = Watt-hour x1012. Natural Resources Canada. (2006). Canada's Energy Outlook The Reference Case 2006. Available from: http://www.nrcan.gc.ca.

6 Estimates prepared on behalf of the Canadian District Energy Association (CDEA) for the Urban Energy Solutions initiative (2007). Based on data from Natural Resources Canada, Comprehensive Energy Use Database Tables.

7 Edwards, G. et al. (2000). *Overcoming Barriers to Implementation of District Energy Projects, vol.2, Calgary: Canadian Energy Research Institute*.

8 Maker, Timothy, and Penny, Janet. (1999). Heating Communities with Renewable Fuels: The Municipal Guide to Biomass District Energy. Government of Canada. Natural Resources Canada.

9 The estimate of GHG and GJ reduction is based on the generation of electricity from natural gas-fired CHP plants displacing electricity production at centralized fossil fuel power plants.

10 Process for quick starting district energy derived from Maker, Timothy, and Penny, Janet. (1999). *Heating Communities with Renewable Fuels: The Municipal Guide to Biomass District Energy*. Natural Resources Canada and United States Department of Energy.

Table 3 Source: Modified table based on information from interviews with system operators across Canada, Natural Resources Canada (1999). *The District Energy Option in Canada.* Ottawa: Government of Canada; Bond, Gordon. (1993). *IEA District Heating: Promotional Manual for District Energy System.* International Energy Agency; Edwards, G., et al. (2000). *Overcoming Barriers to Implementation of District Energy Projects,*

Vol. 2. Calgary: Canadian Energy Research Institute; U.S. Department of Energy (2007). *The Potential Benefits of Distributed Generation and Rate Related Issues that May Impede Their Expansion: A Study Pursuant to Section 1817 of the Energy Policy Act of 2005;* and James, Jamie et al. (2006). *Combined Heat and Power Generation for Highrise Condominiums in Toronto: A Look At Opportunities For Market Based Demand Management Strategies Using Distributed Generation Technologies in the Multi-Residential Building Sector.*

Table 4 Source: Modified chart. U.S. Department of Energy. (2007). *The Potential Benefits of Distributed Generation and Rate Related Issues that May Impede Their Expansion: A Study Pursuant to Section 1817 of the Energy Policy Act of 2005*.

Table 6 Source: Modelling prepared on behalf of the Canadian District Energy Association (CDEA) for the Urban Energy Solutions initiative (2007). Modelling based on a high performance natural gas supplied CHP district energy system. Contact CDEA at cdea@canurb.com for more information. The estimates include reductions in emissions from central electricity generators based on the Ontario, Canada fuel mix.

Table 7 Source: Modified table based on information from interviews with system operators across Canada; Bond, Gordon (1993). *IEA District Heating: Promotional Manual for District Energy System.* International Energy Agency; Edwards, G. et al. (2000). *Overcoming Barriers to Implementation of District Energy Projects, Vol.2*, Calgary: Canadian Energy Research Institute; U.S. Department of Energy (2007). *The Potential Benefits of Distributed Generation and Rate Related Issues that May Impede Their Expansion: A Study Pursuant to Section 1817 of the Energy Policy Act of 2005*; and James, Jamie et al. (2006). *Combined Heat and Power Generation for High-rise Condominiums in Toronto: A Look At Opportunities For Market Based Demand Management Strategies Using Distributed Generation Technologies in the Multi-Residential Building Sector*.

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