WR COMMUNITY ENERGY

TOWARDS AN INTEGRATED THERMAL ENERGY STRATEGY FOR WATERLOO REGION

A strategic assessment of the value of thermal energy

CONTENTS

Acknowledgements

The development of this report has been led by WRCE with contributions from:

- Karen Farbridge & Associates Ltd.
- KEB Engineering & Project Management
- WRCE Governance Committee
- Thermal Utility Steering Committee
- Region of Waterloo Climate and Sustainability Team
- Mayors McCabe, Vrbanovic, Liggett and Chair Redman for their early support and encouragement.

IN PARTNERSHIP WITH

1. EXECUTIVE SUMMARY

In the last century, our society has reached unprecedented growth and quality of life thanks to the work and infrastructure of three dominant energy systems: electricity, natural gas, and gasoline. In Ontario, we have regulated utility energy systems to ensure they are safe, reliable, and affordable. While these 20th century energy forms, fuels, and policies got us to where we are today, they will not get us where we need to go. Our current energy transition will impact nearly everything about our economy, our communities, and our quality of life. The transition requires an energy system that is reliable but also clean, local, and equitable. For Waterloo Region, that means considering the essential overlap of energy and land uses and by integrating **market, policy**, and **infrastructure** solutions.

This report provides a draft strategic framework for how to do this by localizing and decarbonizing ~40% of our low-grade thermal utility energy.

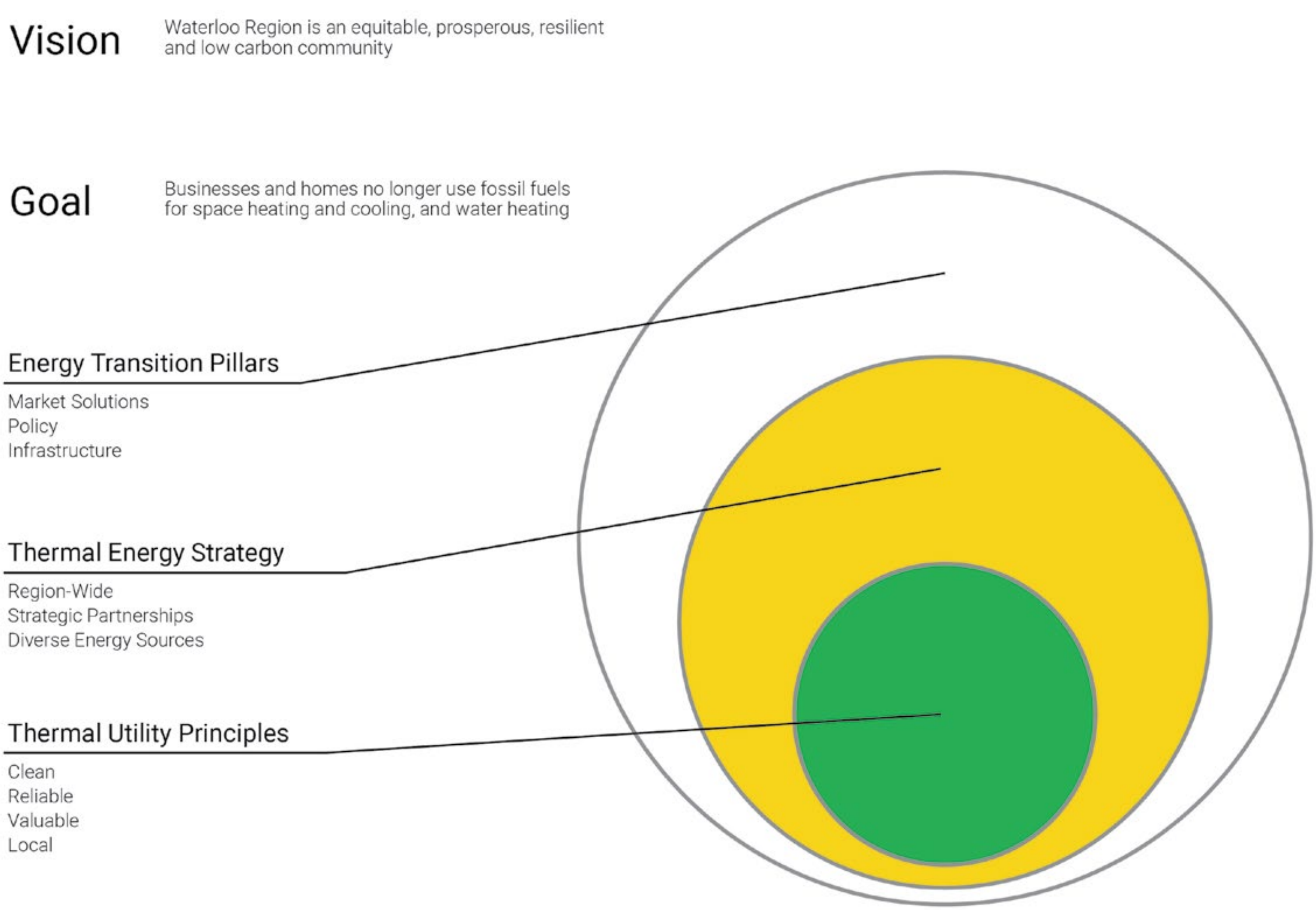
Thermal energy is all around us. It is in the ground and in the air. We release heat into the environment from our buildings, industry, and all manner of human activities. In Canada, we have overlooked this opportunity in central energy planning, not fully grasping the magnitude of its potential.

This thermal energy has real **economic, social**, and **environmental value**. This report documents 15 potential objectives for a thermal energy strategy including its potential for **local, clean, and equitable** space and water heating and cooling. It builds a case for developing an integrated thermal energy strategy for Waterloo Region that starts with a municipally owned thermal utility.

Waterloo Region has a long history ensuring residents and their communities have access to high quality energy services. It is home to two municipally-owned electrical utilities and, uniquely, the City of Kitchener owns its own gas utility. This positions Waterloo Region particularly well to respond to the energy transition. Leveraging national and international experience, a well-scoped local thermal utility could facilitate the integration of land use and energy policy to minimize risk and increase the social good of thermal energy development. This report outlines potential policies, governance models, and maps thermal energy supplies (sources) and demands (sinks) to show how this could work. By understanding the value of Waterloo Region's thermal energy assets, municipal leaders will be better informed on future decisions about energy investments, expansions, and ownership models.

Three key principles have been identified by WRCE to guide the development of the thermal energy strategy and include: ensuring we develop **region-wide solutions**, establishing **strategic partnerships**, and building a **diverse energy portfolio** for the community.

The successful development of these opportunities must happen at scale. It asks our community leaders to align actions with our shared interests in a coordinated and collaborative way.



2. PURPOSE & OVERVIEW

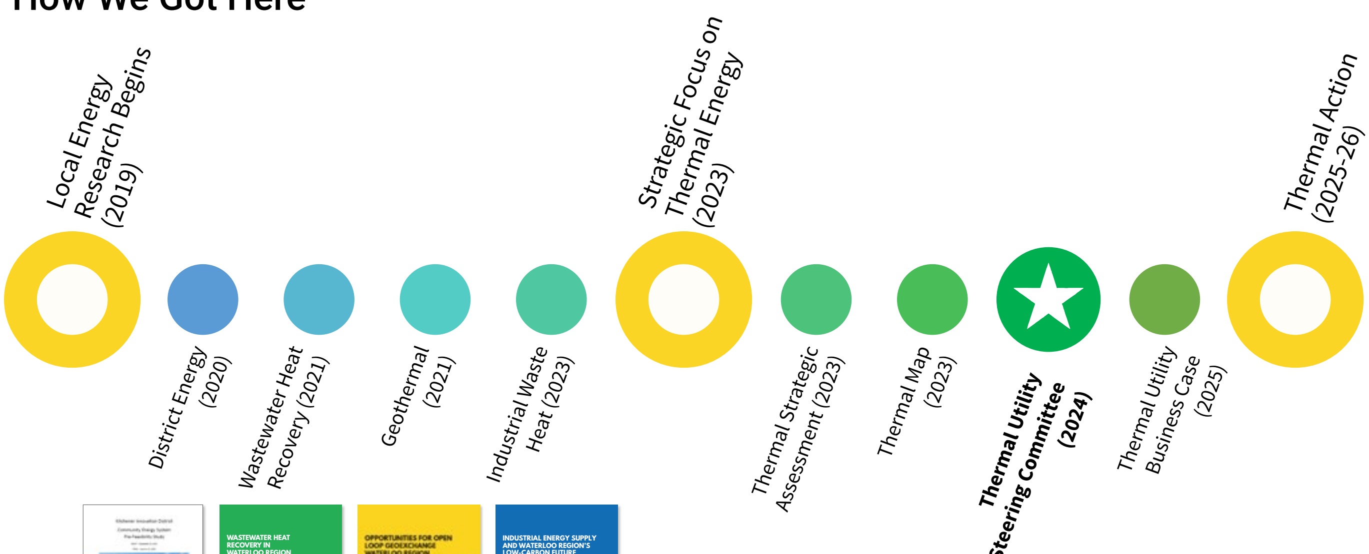
Towards integrated low-carbon thermal solutions.

WR Community Energy (WRCE), the Region of Waterloo and the City of Kitchener have undertaken several studies to explore the potential for harnessing low-carbon thermal energy in Waterloo Region. Based on positive findings, WRCE is leading the development of an integrated thermal energy strategy for Waterloo Region with the goal of replacing the use of fossil fuels (primarily natural gas) for space heating and cooling, and domestic hot water heating (i.e., low-grade heat) with low-carbon thermal energy. This report is one step in that journey towards achieving that goal.

The purpose of this document is to:

1. Recommend the development of a region-wide thermal energy strategy for Waterloo Region. The report consolidates findings of previous studies, provides additional data and information, and outlines opportunities to support the strategic development of a wide range of thermal energy sources, technologies and systems.
2. Recommend setting up a thermal utility to implement the thermal strategy and develop low-carbon thermal resources to achieve community objectives as well as address early barriers to implementation.
3. Showcase preliminary decision-making tools and next steps.

How We Got Here



"It's wise to take a risk on something like this"

-Bruce Lauckner

By understanding the value of Waterloo Region's thermal energy assets, municipal leaders will be better informed on upcoming decisions about energy investments, expansions, and ownership models.

The following table provides a summary of each section in the report.

Section	Description
1. Executive Summary	Provides a summary of the main findings of the report.
2. Purpose and Overview	Articulates the purpose of the report and how it is organized.
3. Introduction: An Ambitious Next Step	Provides a brief summary of climate and energy leadership in Waterloo Region, the current use of natural gas for space and domestic hot water heating, pathways to decarbonization, the experience of leading jurisdictions, and the growth of thermal energy systems in Canada.
4. Sixteen Integrated Objectives	Summarizes multiple benefits of transitioning from single-building fossil fuel use to community-focused decarbonized thermal energy for space heating and cooling and domestic hot water heating.
5. Thermal Energy Assets	Consolidates the findings of previous studies, provides additional data and information, and outlines opportunities to support the strategic development of a wide range of thermal energy sources, technologies and systems.
6. A Community Project	Defines the project scope to optimize the benefits for the community, partners, and stakeholders.
7. A Thermal Utility	Evaluates the opportunities for creating a thermal energy utility to implement the thermal strategy and develop our low-carbon thermal resources to achieve community objectives and address early barriers to implementation.
8. A Preliminary Framework for a Thermal Energy Strategy for Waterloo Region (2023-2026)	Proposes a preliminary framework for a thermal energy strategy.
9. Recommended Actions	Recommends preliminary actions to develop a Waterloo Region Thermal Strategy including the development of a thermal utility.

3. INTRODUCTION: AN AMBITIOUS NEXT STEP

The communities of Waterloo Region have a long history in ensuring local residents and communities have had access to affordable and reliable energy services.

At the beginning of the 20th century, local leaders joined the Power to the People movement which was instrumental in bringing cheap and abundant Niagara power to communities in Southern Ontario (Figure 1). Today, local municipalities still own two electrical utilities and, uniquely, the City of Kitchener owns its own gas utility. Waterloo Region is well positioned to respond to the urgent call to address climate change.

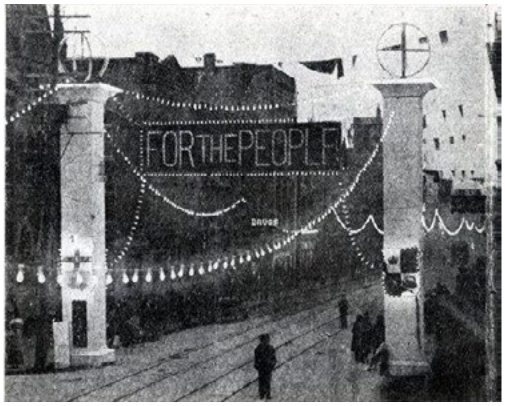


Figure 1: Downtown Kitchener (formerly Berlin) celebrating the arrival of Niagara power in 1910.

3.1 Energy and Climate Leadership

Transform Waterloo Region into an equitable, prosperous, resilient low carbon community.

Waterloo Region has demonstrated considerable energy and climate leadership in the last few years. In 2018, the Community Energy Investment Strategy (CEIS) was approved. This was the beginning of a growing partnership between local municipalities and utilities to engage in the energy transition proactively and collaboratively and it led to the formation of WR Community Energy (WRCE). The purpose of the CEIS is to coordinate targeted energy investments in Waterloo Region designed to benefit from the energy transition and keep energy dollars local.

In 2021, the Region of Waterloo and all seven area municipalities endorsed TransformWR. TransformWR serves as a guide for the community's transition away from fossil fuels. TransformWR seeks to transform Waterloo Region into an equitable, prosperous, and resilient low carbon community achieving an 80% greenhouse gas (GHG) emissions reduction by 2050 below 2010 levels. Below is a summary summarizing four calls to action (Figure 2). This report delivers on the second call to action: transform the way we build and operate spaces.

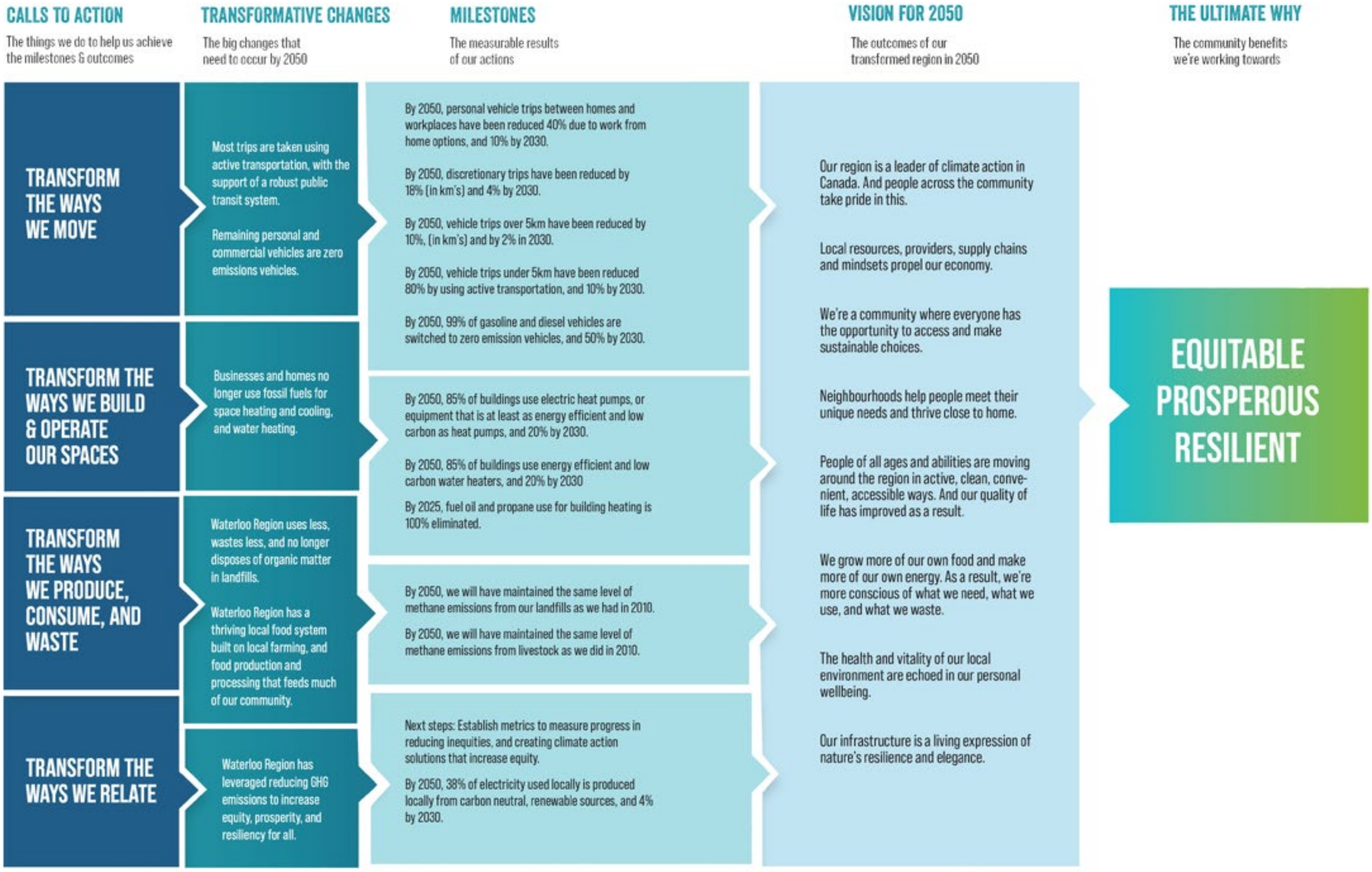


Figure 2: Summary of the calls to action in TransformWR.

3.2 Fossil Fuel Use in the Building Sector

Business and homes will no longer use fossil fuels for space heating and cooling and domestic water heating by 2050.

Natural gas and electricity are the major sources of non-transportation energy in Waterloo Region. Natural gas is the largest of the two energy sources accounting for nearly two-thirds of the community's utility-level energy measured as a percentage of total joules. End-users are categorized by three community sectors: residential, commercial (including multi-residential), and industrial. There is roughly an even-split of energy use between all three sectors measured as a percentage of total joules.

Natural gas is used for space and water heating, and industrial activities. Natural gas combustion takes place at a high temperature (approximately 1,960°C). While high temperatures are required for many industrial activities (medium- and high-grade heat), space and water heating can be efficiently provided by low-grade heat sources (see insert for definitions).

Figure 3 illustrates the flow of non-transportation-related energy (electricity and natural gas) through Waterloo Region highlighting the supply of low-grade heat.

WRCE has estimated that low-grade heat represents 39% of the total energy (electricity and natural gas) supply. Low-grade heat demand contributes approximately 28% of the Waterloo Region's GHG emissions or 1.2 million tonnes CO2 (Figure 4) representing a significant opportunity for decarbonization.

What is low-, medium - and high-grade heat?

Low-grade heat refers to hot water supplied between 40 and 70 degrees Celsius (ºC). Medium-grade heat refers to hot water above 70ºC. High-grade heat refers to high pressure steam and industrial processes at high temperatures.

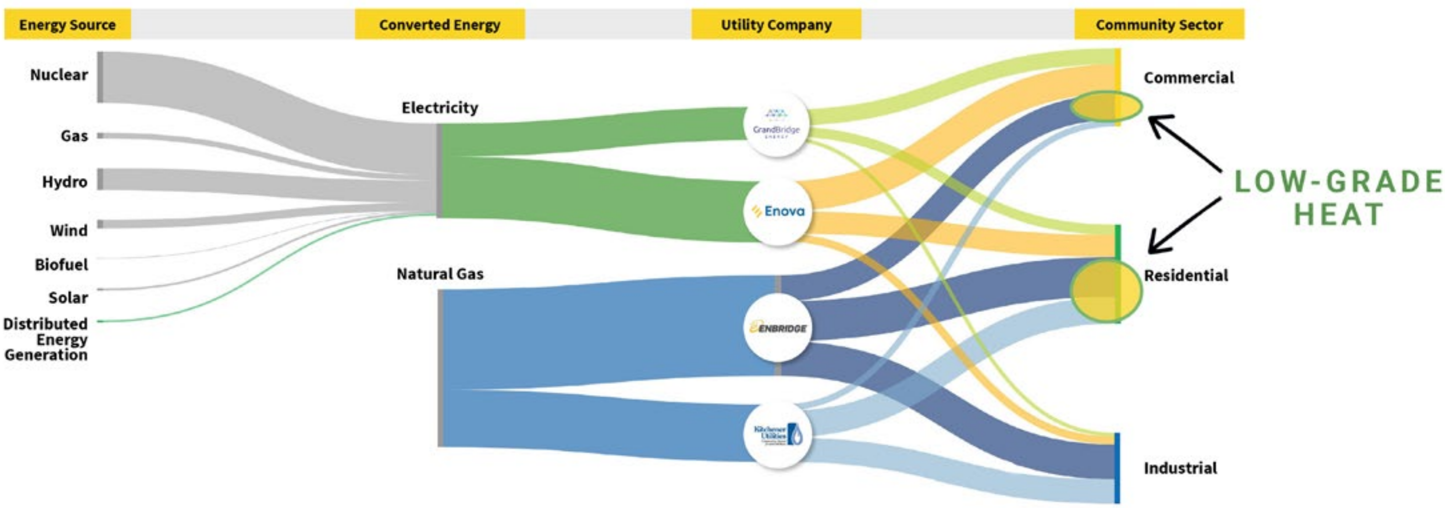


Figure 3: Electricity and natural gas flow through Waterloo Region highlighting (yellow circles) the supply of low-grade heat.

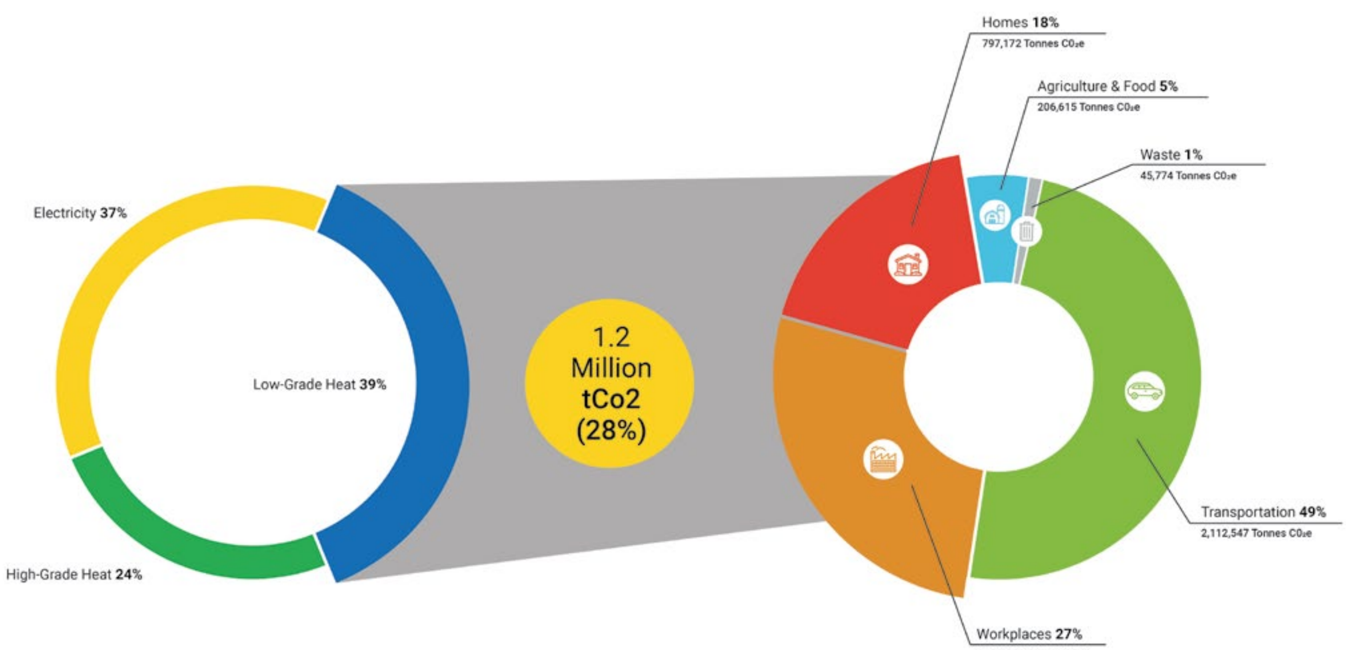


Figure 4: Low-grade heat demand and emissions (1.2 million tonnes CO2) in Waterloo Region.

TransformWR identified several measures to address emissions from the building sector including increasing the energy efficiency of existing buildings, setting performance standards for new construction, and transitioning to renewable energy sources. One of the six Transformative Changes on which TransformWR was built is "businesses and homes will no longer use fossil fuels for space heating and cooling and domestic hot water heating" by 2050: this is the focus of this report.

3.3 Pathways to Decarbonization

Highest and best use of energy resources.

The energy transition is challenging communities to value and manage energy in new ways. An important principle of community energy planning is to avoid using high-quality energy (with high-carbon intensity) in low-quality applications. With a limited carbon budget, we want to spend our allowance of fossil fuels on high-grade heating activities only. In the short term, an industrialized community like Waterloo Region should preserve gaseous fuels for high-grade industrial uses until viable low-carbon alternative are found.[1] Low-grade heat, on the other hand, is the largest and most carbon-intensive use of energy in the building sector that we can currently and economically decarbonize.

In addition to reducing demand, two other pathways are recognized to decarbonize low-grade heat to buildings. They use different energy carriers: electricity and thermal energy (i.e., hot and chilled liquid distribution). Canadians are familiar with using electricity to take advantage of a variety of renewable and non-renewable energy source for a variety of end uses including heating and cooling. However, while common in other parts of the world, systems that distribute heating or cooling to end users which has been harnessed from a variety of local low-carbon renewable energy sources is only now beginning to grow in Canada.

What is an energy carrier?

An energy carrier is a transmitter of energy. They occupy intermediate steps in the energy-supply chain between primary energy sources and end users. They transport energy in a usable form from one place to another.

While hydrogen is also an energy carrier, it is not anticipated to play a significant role in space or water heating. As outlined in the Clean Hydrogen Ladder, it may play a role providing high-grade, low-carbon heat in the industrial sector.[2]

3.3.1 Electrification

Electrification is considered one pathway to decarbonize the supply of low-grade heat to buildings. Notably, Ontario's electricity system is 94% emissions free and has one of the lowest carbon intensity rates in the world. Electricity is needed for multiple purposes including lighting, heating, cooling, and refrigeration, and to operate appliances, computers, electronics, and machinery. Road transportation is also rapidly electrifying with Waterloo Region's ION system and the shift to electric vehicles (EVs), bicycles and scooters. Consequently, electricity demand is growing rapidly. Large-scale electrification of low-grade heat will further increase demand.

Understanding the implications of adding electrification of space and water heating to existing demand is an important consideration when evaluating energy transition pathways.

From the perspective of becoming an equitable low carbon community, large-scale electrification, while essential for some sectors, is anticipated to be costly. It has been estimated Canada's power infrastructure would need to more than double by 2050 to meet such demand.[3] Some estimates suggest a three-fold increase in electricity infrastructure.[4] Such a massive infrastructure program in less than 30 years will come with significant technical challenges and costs. The Independent Electricity Supply Operator (IESO) has estimated the cost in Ontario at around $400 billion.[5] These costs would ultimately be borne by ratepayers.

From the perspective of becoming a prosperous community, regional supply constraints could impact economic development. Community opposition and legal challenges frequently delay large-scale energy projects in Canada which would put achieving the 2050 targets at risk.[6]

From the perspective of becoming a resilient community, large-scale electrification exposes the community to greater impacts should the electricity grid fail as a result of climate-related extreme weather events or any reason.[7] While we are without a reliable electricity forecast for Waterloo Region, Enova Power Corp. and GrandBridge Energy are advocating for a new distribution model that will position our communities to address the need for electrified heat.[8] Diversifying energy delivery systems builds local resilience.

And from the perspective of community energy planning, it is important to optimize the use of all energy delivery systems.

3.3.2 Distribution and Storage of Thermal Energy

While significant investments in electricity infrastructure will be required to support the net zero transition, a complementary pathway is deployed in other jurisdictions which can release capacity on the electricity grid. Several proven technologies, either deployed at a building- or community-level, can harness local sources of low-carbon thermal energy for heating and cooling our buildings.

At the building-level, heat pump technologies extract

The evolution of district energy systems

(see Figure 5, next page)

Coal-based **first generation** district heating systems were steam-based reaching up to 200°C to transport heat primarily to small urban industries that used steam in their processes and large heat consumers like hospitals and large residential building complexes.

Using coal and oil, **second generation** district heating systems used pressurized superheated water at temperatures above 100°C to transport heat. This generation enabled the use of combined heat and power plants which increased the efficiency of waste heat utilization.

With advances in materials and technologies, **third generation** district heating systems operated at temperatures lower that 100°C. Coal, biomass, and waste were preferred fuel sources.

Fourth generation district heating is a generic term for all low-temperature pressurized water systems having supply temperatures between 40 and 70°C. Lower temperatures enables a greater diversity of fuel sources, including renewables and waste heat recovery. This generation was designed to address climate change.

Fifth generation district heating and cooling networks are characterized by low temperature supply (close to ground temperature) and can provide heating and cooling simultaneously.

heat from the surrounding air, the ground, nearby water source or waste heat from an industry. These systems amplify heat and transfer it to where it is needed (or in the case of cooling, they extract heat from a building and release it to the environment). As they rely on electricity to run the pump, they highlight opportunities when taking an integrated approach to energy planning.[9]

At the community-level, investing in fourth and fifth generation district energy systems (DESs) is globally recognized as an effective pathway to use decarbonized energy for urban heating and cooling, and domestic hot water heating.[10,11] They can take advantage of low-carbon energy resources not considered by centralized energy planning. They facilitate access to low-carbon energy sources that are not technically or financially feasible at the scale of an individual building. Consequently, community energy plans frequently identify DESs as a missing utility in Canadian urban areas. They can deliver low-grade heat to multiple buildings in a district, a neighbourhood, or a city from a single central energy plant or from several interconnected distributed plants.[12]

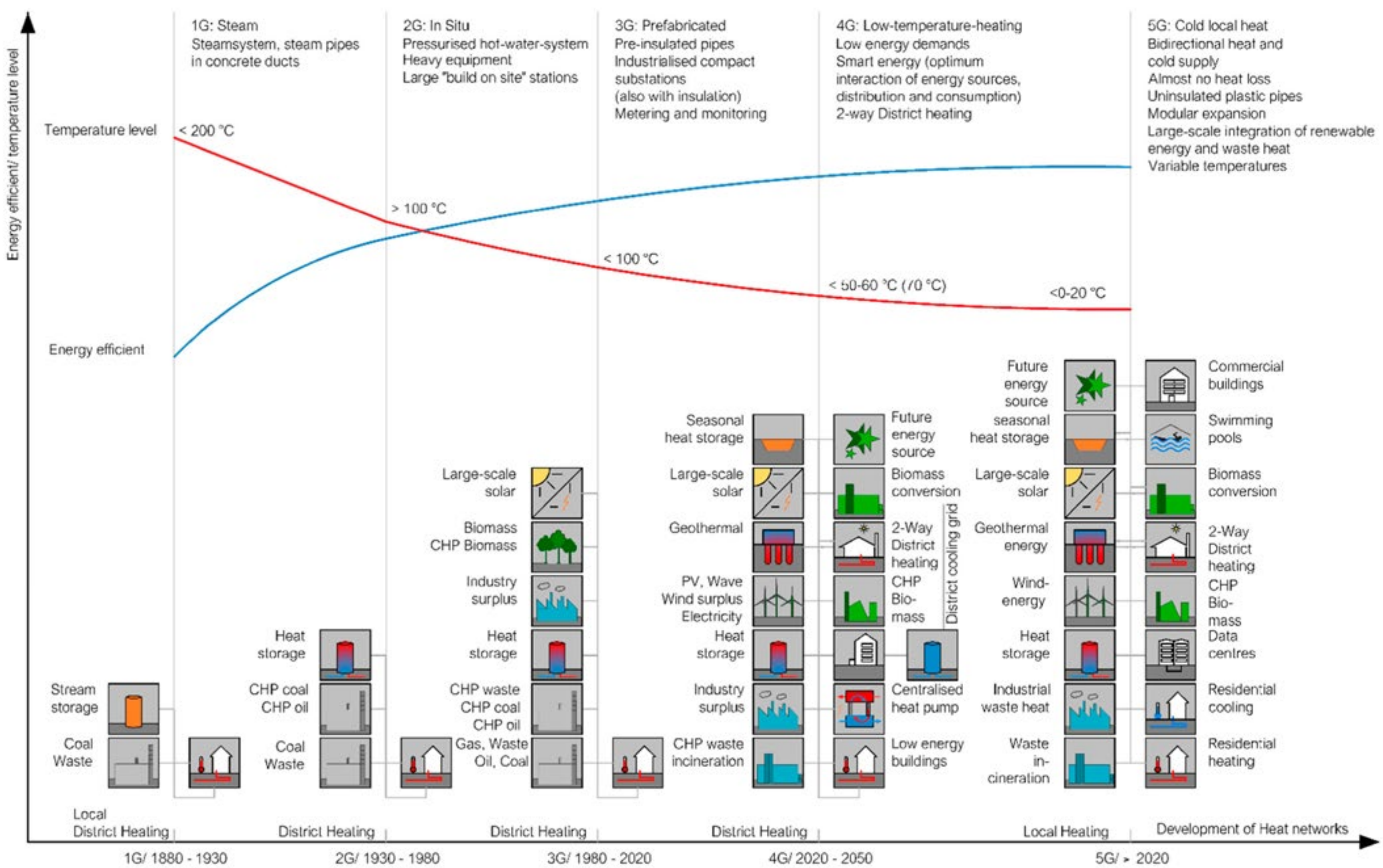


Figure 5: District heating networks from the first to the 5th generation over the last 150 years.[13]

DESs are comprised of three main parts (see Figure 6):

- A central energy plant or energy centre (EC) which generates hot water and/or chilled water and can include thermal energy storage tanks
- A two or four-pipe underground distribution system (hot water supply and return and/or chilled water supply and return) which pipes hot and/or chilled water from the central energy plant to end-users
- An energy transfer station (or heat exchanger) within each building to match the building design.

Building- and community-level thermal energy systems offer several benefits that align well with becoming an equitable, prosperous, resilient low carbon community (see Section 3. Objective Setting).

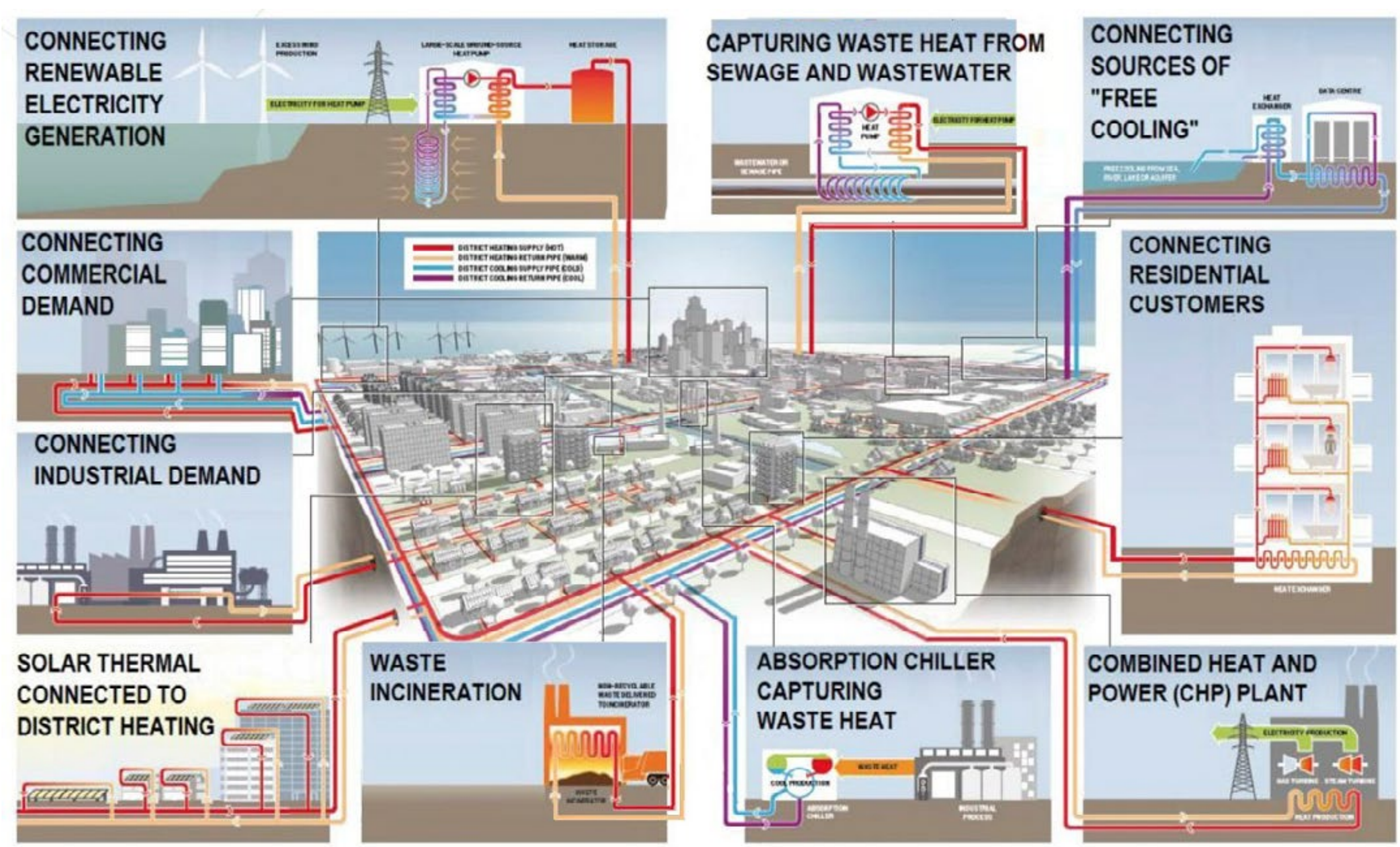


Figure 6: Illustration of a typical district energy system (DES). [14]

3.4 Experience of Leading Jurisdictions

Learn from global and national best practices.

Many European communities, particularly after the 1970s oil crisis, improved energy efficiency, reduced their reliance of imported fossil fuels and made better use of local, renewable, and alternative fuel sources by encouraging decentralized energy production and distribution including heat pumps for single-family homes and DESs for multi-family homes. For example, Sweden doubled its district heating production from 1973 to 2010, while cutting carbon dioxide emissions in half and other toxic air pollutants by almost 100%.[15] In the 1970s, three-quarters of Swedish homes were heated with oil boilers. Their early shift away from fossil fuels to electric heat pumps in most single-family homes was achieved through a combination of regulation and incentives.[16]

Copenhagen today meets 98% of the city's heating needs with district energy. By 2025, the Greater Copenhagen Utility will make the system carbon neutral by transitioning from coal, oil, and natural gas to sustainable biomass. To produce carbon neutral heating, the utility will replace fossil fuels at large combined heat and power (CHP) plants with wood pellets from sustainably grown forests. It will also deploy large-scale heat pumps that run on wind energy and geothermal energy and incorporate thermal storage provided by large water tanks.[17]

In the wake of the Russian invasion of Ukraine and energy system disruptions, the European Union has mandated heating and cooling plans from all municipalities with populations over 45,000. New or refurbished DESs will be required to increase the share of non-fossil sources in their supply mix over time with the goal of a fully decarbonized district heating and cooling supply by 2050.[18] In 2023, the United Kingdom's Energy Security Bill introduced heat network regulations.[19]

New York State is creating a regulatory framework to promote thermal energy networks. The New York Public Services Commission will soon require the seven largest, investor-owned utilities to each submit one and up to five proposed thermal network pilot projects for review, with at least one pilot project located in a disadvantaged community within each utility service area.[20]

3.5 Growth of Thermal Energy in Canada

Transitioning from natural gas to low-carbon thermal energy for space and water heating (low-grade heat).

Canadian interest in thermal energy is growing (Figure 7). In 2019, the Canadian Energy & Emissions Data Centre identified 217 operating DES in Canada. Almost half of these systems had been commissioned since 2000 with a quarter built in the past 8 years. Ontario and British Columbia accounted for half of all the systems in Canada (29% and 22%, respectively). These systems provide a range of services including heating, cooling, and electricity. Two thirds of all systems offer heating only and one fifth of systems offer heating and cooling. The remainder offer electricity through cogeneration with heating and/or cooling. Canadian systems use a variety of fuels including gaseous and liquid fossil fuels, biomass, geoexchange, heat recovery from industrial processes, energy extracted from untreated sewage influent or treated wastewater effluent, sea; aquifer; and lake water for cooling, municipal solid waste, and solar energy.[21]

Figure 7: Distribution of district energy systems in Canada. Source: International District Energy Association.

Most systems serve a single campus (57%) with almost all systems providing thermal energy to five or fewer customers. These customers include institutional buildings, educational facilities, multi-residential and commercial buildings, community and recreational facilities, and government offices.[22]

Several Canadian municipal governments have developed district energy strategies either city-wide or for a specific area in their community. A growing number of municipalities own a thermal utility providing heating and/or cooling services to meet the needs of an emerging market for thermal energy. Other municipalities promote market development of DES. Federal and provincial governments are also providing incentive programs to promote the uptake of building- and community-level thermal energy technologies. Canadian examples are provided throughout this document.

Early studies (summarized in Section 5) undertaken by WRCE, the Region of Waterloo and the City of Kitchener have begun to identify thermal energy sources in Waterloo Region which offer the potential to transition away from using natural gas to low-carbon thermal energy sources to meet demand for space and water heating. The conversion from natural gas-fired equipment to thermal energy systems will substantially reduce GHG emissions. The replacement of electric resistance heating will also reduce the GHG emissions and release capacity on the electric grid. There are also opportunities to supply cooling to buildings using thermal energy technologies.

A comprehensive thermal energy strategy that builds on the information summarized in this report will provide local policy and decision makers with a deeper understanding of the value of thermal energy in Waterloo Region.

4. SIXTEEN OBJECTIVES FOR A THERMAL STRATEGY

Optimize the benefits of the thermal energy strategy for the community.

Community engagement will be critical to the success of the Waterloo Region Thermal Energy Strategy. Thoughtful community engagement will help to establish strong public, institutional and political support for the thermal energy strategy while building the capacity and motivation of key partners and stakeholders to support implementation. Several factors may pique the interest of an individual or organization in a thermal energy project: geographic boundaries; communities of interest; scope of the project; impact of the decision; history of the area; and history of the issue. Thermal energy strategies can deliver multiple benefits and their communication to stakeholders will be important for success.

Sixteen objectives have been identified based on four primary considerations:

- environmental
- economic
- energy systems
- urban management

4.1 Environmental Considerations

Objective	Description
Address GHG emissions	Thermal energy technologies are an important measure for communities committed to achieving 100% renewable energy or carbon neutral targets.[23] A low-carbon thermal utility is a decarbonization solution for building owners.
Reduce air Pollution	Using low carbon sources of energy improves air quality and reduces the health affects of air pollution.
Promote a circular economy	Thermal energy technologies can harness heat for useful purposes reducing waste and pollution.

4.2 Economic Considerations

Objective	Description
Reduce energy costs for consumers and developers	Thermal energy technologies can significantly reduce energy costs. Compared with other competitive technologies, DESs are frequently more cost effective – by up to 50% – compared with individual buildings producing their own heating or cooling.[24]
Retain energy dollars	When energy dollars are invested in local clean energy generation and distribution instead of financing external energy imports and development, they support the local economy.
Grow local jobs	Local jobs are created to install building-level technologies and for the design, construction and operation of DESs.
Improve economic resilience	Unlike a natural gas boiler, DESs are fuel and technology neutral. DES systems are often able to switch fuels in response to changing economic, security or environmental imperatives. The diversification of the local energy supply mix strengthens the resilience of the local economy.
Business attraction and retention	As businesses implement plans to mitigate their clean energy transition risks, they will look to municipalities that are demonstrating leadership. Some industries will be attracted municipalities where their waste energy can be sold for additional revenue.

4.3 Energy System Considerations

Objective	Description
Enhance energy security	In dense urban areas, community-level DESs enhance energy security with local energy stations, thermal storage of hot water in the distribution piping, and hot water storage tanks. For low density and rural areas, the same resilience can be found in well insulted building envelops and storage technologies. As a climate adaption measure, DESs that deploy combined heat and power (CHP) (discussed in Section 4 – Data and Information) can maintain critical power during extreme weather events when grid electricity service is interrupted. By diversifying their local energy supply mix, a community gains greater control over their energy future. Reducing a community's reliance on imported natural gas reduces the risks associated with changes to market pricing, supply availability and carbon taxes.
Offset growing electricity demand	A thermal strategy will help mitigate the impact of increased loads on electrical grids by helping us to plan for a more predictable demand curve. The electrification of transportation and space heating needs to be considered wholistically.
Diversify utility business models	For both electricity and natural gas utilities, the transition to thermal energy offers potential new business opportunities for local distribution utilities and help meet customers changing energy needs.
System optimization	DESs create valuable synergies between the production and supply of heating, cooling, domestic hot water, and electricity.[25] Up to 60% of non-renewable fuels used to generate electricity at a provincial scale are lost primarily as heat at point of generation. When electricity is generated locally through CHP, waste heat can be harnessed reducing system conversions losses (and related emissions and costs) for a community.

4.4 Urban Management Considerations

Objective	Description
Integration with urban systems	The United Nation's District Energy in Cities Initiative notes that DESs can be integrated with several municipal systems including power, sanitation, sewage treatment, transport, and waste as well as promote the efficient use of land, transportation, building design, infrastructure, and waste management.[26]
Improve growth management	The operation, management, and control of energy consumption in Waterloo municipalities will improve general knowledge of how we maintain our systems. It will reduce dependence on the provincial planning and allow Waterloo municipalities to take a more active role in energy planning, both thermal and electric. This will be help manage regional growth including the affordability of the region.
Accelerate adoption of green energy standards	The adoption of a municipal green development standard will promote an awareness and knowledge of improved construction design and construction methods for future proof buildings and a good quality of life for the residence in our region.
Enhance local energy expertise	It will broaden the necessary skills and knowledge of design, construction, operating and maintenance crews in the region and among private sector clients necessary to build and maintain the energy transition.

5. THERMAL ENERGY ASSETS

This section includes data and information on a range of assets that are necessary for developing a successful thermal energy strategy:

- **Supply** – sources of thermal energy in Waterloo Region
- **Demand** – sinks for current and future thermal energy in Waterloo Region
- **Policies** – policy directions to promote thermal energy in Waterloo Region
- **Ownership models** – public, private and hybrid ownership models
- **Funding** – potential funding sources

Data and information are provided for both building-level and community-level thermal energy systems. DESs are only financially viable for higher density urban neighbourhoods. Depending on local conditions, building-level solutions or less infrastructure intensive community energy solutions (i.e. community solar, thermal loops) can be considered for other neighbourhoods. The business case for building-level and community-level continues to improve.

This section looks at Canadian precedents and shows the wide-availability for low-carbon thermal solutions in Waterloo Region based on best-available data.

5.1 Supply (Sources)

Understanding the potential sources of low-carbon thermal energy within a community is an important step in building a thermal energy strategy. This section provides information on the following potential sources of low-carbon thermal energy in Waterloo Region:

- Renewable thermal energy
- Waste heat recovery
- Renewable fuel combustion

5.1.1 Renewable Thermal Energy

This section provides information on three sources of renewable thermal energy:

- **Solar thermal** – thermal energy harnessed from the sun
- **Geothermal** – thermal energy harnessed from the Earth including the ground, aquifers and surface water
- **Aerothermal** – thermal energy harnessed from the air

5.1.1.1 Solar Thermal

Solar thermal systems capture thermal energy for domestic hot water and heating support. Typically, these systems are mounted on building roofs or walls. Solar thermal energy systems are currently being used in Waterloo Region for pool heating and, in the case of Evolv1 in Waterloo, space heating.[27] There is also a Canadian example of a solar thermal DES (see insert). While this source of thermal energy is zero-carbon, the systems rely on electric pumps to operate and are considered a low-carbon thermal energy source in Ontario.

Canadian Example – Solar Thermal DES

Municipality: Town of Okotoks, AB
Ownership: Private
Thermal source: Solar thermal

More than 90 percent of space heating needs for the Drake Landing Solar Community's 52 single-detached homes is met by solar thermal energy. Solar thermal energy is collected in the summer, stored underground, and then returned to the homes as heat during the winter.

5.1.1.2 Geothermal

Geothermal heat pumps, also referred to as geo-exchange systems, supply heating and cooling to buildings. There are two main types of geothermal systems: closed-loop and open-loop.

Most closed-loop geothermal heat pumps circulate an anti-freeze solution through a closed loop that is buried in the ground (ground-source) or submerged in a body of water. Closed-loop systems can be designed horizontally or vertically depending on space availability.

Open-loop geothermal heat pumps (also referred to as direct-source) use extraction wells or surface bodies of water as the heat exchange fluid source. Once the water has circulated through the system, it is returned to the ground through injection wells or surface discharge.

Open and closed geothermal systems utilize heat exchangers (HX) to transfer thermal energy to and from buildings via fluid – open systems employ groundwater and closed systems employ a water and anti – freeze solution. Heat pumps in buildings are utilized to raise low grade thermal energy temperatures to meet design

Canadian Example – Geothermal DES

Municipality: City of Richmond, BC
Ownership: Municipal owned utility (Lulu Island Energy Company)
Thermal source: Geothermal/Aerothermal

The Alexandra District Energy Utility (ADEU) is Richmond's first DES and currently services more than 2,200 residential units, 12 buildings and 2.3 million square feet of floor space. This includes 314,000 ft2 of commercial floor space and the first ever Wal-Mart to be connected to a DES.

Campus: University of British Columbia
Ownership: University-owned and operated
Thermal source: Geothermal

The University of British Columbia DES provides heating and cooling to twelve academic buildings totalling about 90,000m² use a geo-exchange system.

requirements. Heat pumps employ reversing valves to also deliver cooling to the conditioned space. Geothermal systems require electricity to operate – power for the heat pumps as well as fluid circulation and distribution pumps. The source of thermal energy for geothermal systems is “zero – carbon”, however, the source of the electricity to power these systems may be low – carbon or not, dependent on the generation. In DES applications, the heat pumps and circulation pumps may be part of a central energy plant (CEP) providing hot and chilled fluid to buildings or may be configured as a heat exchange fluid piping network with circulation pumps and heat pumps located in individual buildings.

Geothermal energy technologies can be deployed at the building-level or community-level. Canada’s Greener Homes Grant currently offers an incentive for homeowners to install closed-loop, ground-source geothermal energy systems.[28]

Geothermal energy potential in Waterloo Region

In 2021 WRCE commissioned a report on the Geothermal Energy Potential for the *Waterloo Region Building Sector*.[29] The report identified the following potential geothermal energy sources:

- surface water features (including reservoirs, ponds, lakes, etc.)
- overburden materials (e.g. soils)
- groundwater aquifers, in overburden and bedrock
- bedrock formations (esp. limestone, dolostone)

There are various types of low-grade geothermal resources available to Waterloo Region. Below a certain depth, generally 1.8m to 4.5m, the temperature of the undisturbed ground remains seasonally stable roughly approximating the mean annual outdoor ambient temperature (~8 to 10ºC). Geothermal systems take advantage of the relatively warm ground in the Winter and relatively cool ground in the Summer to provide energy efficient heating and cooling. WRCE estimates there is enough geothernal energy in Waterloo Region to meet our low grade energy demands 10 times over.

The ground heat exchanger / source can take many forms including:

- Closed – Loop Vertical systems
- Closed – Loop Horizontal systems
- Closed – Loop Water Body systems (lake, pond, river)
- Open – Loop Groundwater systems
- Open - Loop systems (lake, pond, river)

Sufficient energy can usually be obtained from shallow soils or private wells (<100m) to heat and cool rural homes, agricultural buildings and small commercial buildings. Large commercial, institutional, and industrial building require drilling into the bedrock (100 – 260m). Closed-loop vertical boreholes have high density polyethylene (HDPE) piping and grout inserted that forms a ground heat exchanger. Open-loop systems use extraction wells drilled into aquifers (or through multiple aquifers). Reinjection wells are typically drilled into the same aquifer to return the extracted water to its source.

Bedrock in Waterloo Region is generally dolomite or limestone which are commercially easier to drill than materials such as granite or quartz. The report identified several existing examples of open-loop and closed-loop geothermal systems in Waterloo Region.

Deep Geothermal, also referred to as 'hot rocks', is a source of high - temperature heat from within the earth with the goals of either producing electricity or providing space heating. No investigation of deep geothermal has been carried out in Waterloo Region because of the high cost of importing capable drilling rigs.

In all cases, deployment of geothermal systems must carefully manage the risk of drinking water contamination.

5.1.1.3 Aerothermal

An air-source heat pump can provide cooling in the summer, heating in the winter and domestic hot water throughout the year. For the same reasons as geothermal energy, aerothermal energy is considered a low carbon energy source. The Government of Canada's *Oil to Heat Pump Affordability Program* helps Canadian homeowners who are currently heating their homes with oil to transition to electric cold climate air source heat pumps. The switch from oil to aerothermal energy significantly reduces energy costs and GHG emissions.[30] Canada's *Greener Homes Initiative* also offers an incentive for homeowners to install heat pumps.[31] Homeowners can purchase or lease heat pumps from energy services companies. In addition, the Province of Ontario has launched a pilot program, in collaboration with Enbridge, in select northern and southern communities to test hybrid heating systems – i.e., electric air-source heat pumps with smart controls to reduce natural gas consumption in homes.[32] With the business case improving and the assistance government financial incentives, the deployment of air-source heat pumps in Waterloo Region is growing. Similar to shallow-soil geothermal systems, air source heat pumps are ideal for rural / low-density parts of Waterloo Region where the electric grid has higher capacity.

5.1.2 Waste Heat Recovery

Heat can be captured from a variety of sources that might otherwise be wasted including:

- Combined heat and power (CHP)
- Wastewater heat recovery
- Energy-from-solid waste
- Process waste heat from industrial stack discharge and effluent streams
- Heat recovery from cooling towers (ice rinks, freezer storage facilities, data centres, industrial facilities)

5.1.2.1 Combined Heat and Power (CHP)

When fuel is combusted to generate electricity, some energy is lost in the form of heat. CHP is a distributed energy technology that produces both electricity and heat using a range of energy technologies and fuels (see Section *5.1.2 Renewable fuels*). CHP can be located on its own to supply heat and power to a building or a facility or paired with a DES to distribute heat to multiple end

Canadian Example – Combined Heat and Power

Municipality: City of Richmond, BC
Ownership: Municipal owned utility (Lulu Island Energy Company)
Thermal source: Natural gas transitioning to wastewater heat recovery

Lulu Island's Oval Village District Energy Utility (OVDEU) provides new mixed-use communities adjacent to the Richmond Olympic Oval with space heating and domestic hot water heating. The OVDEU currently services 3.4 million square feet of space across 13 buildings, with a capacity of 15MW. The OVDEU is currently serviced by two interim energy plants that use natural gas boilers to generate energy. Once enough buildings are connected to the system, a permanent wastewater recovery energy plant will be constructed. This is a good example of how natural gas can be used as a transition fuel.

users. Electricity can be used on site (i.e. behind the meter) or fed into the grid or a microgrid to provide power to multiple end users. Typically, CHP can convert of 100% fuel input to 40% of electricity and 50% waste heat.

The CHP plant can operate on different fuels as discussed in the following chapters. The technology to convert fuels to electricity and heat will differ, but it is a well established and proven technology. The reason waste heat has not been captured in many natural gas-fired power plants operating in the province of Ontario is the lack of a thermal distribution network (i.e. thermal grid). Once the grid has been constructed it is beneficial to add CHP to add generation capacity for the municipality.

It should be noted that natural gas can be a transitional fuel for short term needs to add further electrical and thermal energy generation as an initial DES is being constructed. Long term, these plants need to be converted to renewable fuels or replaced by waste heat recovery opportunities. The merits of using natural gas as a transitional fuel for DESs in Waterloo Region requires further analysis.

5.1.2.2 Wastewater Heat Recovery

Thermal energy is lost down the drain whenever we take a shower, flush the toilet, do the laundry, or wash dishes. On average, the wastewater flowing from homes and buildings is 20 to 22ºC. Waterloo Region's sanitary sewer systems collect a considerable amount of warm wastewater every day. Proven heat recovery technologies can capture this thermal energy as a renewable energy source.

Wastewater Heat Recovery Potential in Waterloo Region:

The report *Wastewater Heat Recovery in Waterloo Region* was commissioned by WRCE in 2021.[33] The report focussed on trunk sewer lines in the cities of Waterloo, Kitchener, and Cambridge with dry flow in excess of 100 litres per second. This represented approximately 40 MW_{th} which is the equivalent of providing baseload of heating and cooling for approximately 1,300,000 m² or 7,000 single detached homes. This translates into a reduction of 1,600 tonnes of CO_2e during the annual heating season (5 months per year).

Canadian Example – Wastewater Heat Recovery

Municipality: Vancouver, BC
Ownership: Municipal owned utility
Thermal source: Untreated influent

False Creek Neighbourhood Energy Utility (NEU) was the first in Canada to recover waste heat from a municipal wastewater treatment system (untreated wastewater). Originally developed for the Vancouver Olympics, the utility began operations in 2010 to support the Vancouver Olympics and has rapidly expanded to serve over 6.4 million square feet of residential, commercial, and institutional space, as of 2021.

Municipality: Halifax, NS
Ownership: Municipal owned utility
Thermal source: Untreated influent

Cogswell District Energy System is being developed by Halifax Water, a municipal owned utility, and will supply thermal energy from treated wastewater effluent at the nearby Halifax Wastewater Treatment Facility to the Cogswell District Redevelopment. Halifax Regional Municipality (HRM) is redeveloping the existing Cogswell Interchange area located in downtown Halifax.

Municipality: Whistler, BC
Ownership: Municipal owned DES
Thermal source: Treated influent

Cheakamus Crossing District Energy System was constructed for the 2010 Winter Games Whistler Athletic Village to meet space and domestic hot water heating needs using the thermal energy of treated wastewater from the Whistler Wastewater Treatment Plant.

In 2023, the report *Waterloo Region Water and Wastewater Systems Heat Recovery* was commissioned by the Region of Waterloo which confirmed opportunities to recover heat from wastewater. Heat recovery at WWTPs is considered most compelling due to economies of scale and the ability to extract more heat from wastewater downstream of the treatment process. The report identified the following two priorities:

- Heat recovery from treated effluent at the Waterloo WWTP (24% of the total heat recovery from the Region's WWTP facilities) could supply a low-carbon DES serving central Waterloo including Conestoga College, Wilfrid Laurier University, the University of Waterloo, and large building along the University Avenue corridor. Each education institution is committed to net-zero carbon emissions and are retrofitting their campuses for hot water / generation 4 DESs. This opportunity has the potential to reduce GHG emissions by an estimated 20,000 to 30,000 tonnes of CO_2^e per year from the education campuses alone.
- Heat recovery from treated effluent at the Kitchener WWTP (37% of the total heat recovery from the Region's WWTP facilities) could supply the Region's Control Centre and Laboratory Building located on the Kitchener WWTP site with low carbon heating and reduce water use for cooling as well as potentially serve Conestoga College – Kitchener-Doon campus reducing campus emissions by approximately 1,500 tonnes of CO_2^e per year.

Heat recovery from treated effluent at the Preston WWTP has the potential to supply low carbon heating at Cambridge Memorial Hospital. Similar to the University of Waterloo, this would require converting the second to third generation DES (i.e. steam) to a hot water fourth generation DES. There is no current or planned work to consider this opportunity.

Canadian Example – Wastewayer Heat Recovery

Municipality: Toronto Western Hospital
Ownership: University Hospital Network
Thermal source: Untreadted influent

The system is expected to supply 90% of Toronto Western Hospitals heating and cooling requirements significantly reducing use of existing electricity and natural gas systems. Thermal energy will be extracted from wastewater flowing through a nearby.

5.1.2.3 Process Waste Heat

Industrial plants use high energy processes for various manufacturing activities generating low-grade heat which is typically vented to atmosphere or released into the sanitary sewer. Data centers contain servers that generate low-grade heat as they process information. Industrial waste heat can be recovered to meet the heating needs of the industry and/or be a thermal asset for a DES providing an additional revenue stream for the industry.

WRCE has established an *Industrial Waste Heat Working Group*. The following maps highlight some of the opportunities to capture industrial heat from facilities in Waterloo Region.

Local Opportunities - Process Waste Heat

Municipality: Kitchener

Bleams Road and Manitou Drive Industrial Area may have the potential to serve as a source of low-grade heat for a DES. Of note, this industrial area is located approximately 3 to 4 kilometres from the Kitchener WWTP. An anchor load, Conestoga College – Kitchener Doon Campus, is also located approximately 1 to 2 kilometres from the Kitchener WWTP.

Airboss has two open-loop wells providing cooling water for a rubber manufacturing process. These have an estimated heat recovery opportunity of about 1 MW_{th}.

Municipality: Cambridge

Toyota has several heat recovery opportunities including an operating CHP plant.

Municipality: Woolwich Township (Elmira)

CCC Sulphur Products produces steam as a biproduct of sulphuric acid production which is supplied to a steam turbine generator (STG). Electricity is currently only generated to meet internal demand only. Heat recovery opportunities also exist. Exhaust steam from the STG is discharged into the air-cooled condenser: this could be replaced with a heat recovery system to provide hot water to a future DES with an estimated heat recovered of 3 MW_{th}. Cooling towers cool water from 43°C to 29°C: this could be replaced with a heat recovery system to provide hot water to a future DES with an estimated heat recovery of 5.8 MW_{th}.

Figure 8: Wastewater Heat Recovery in Waterloo Region

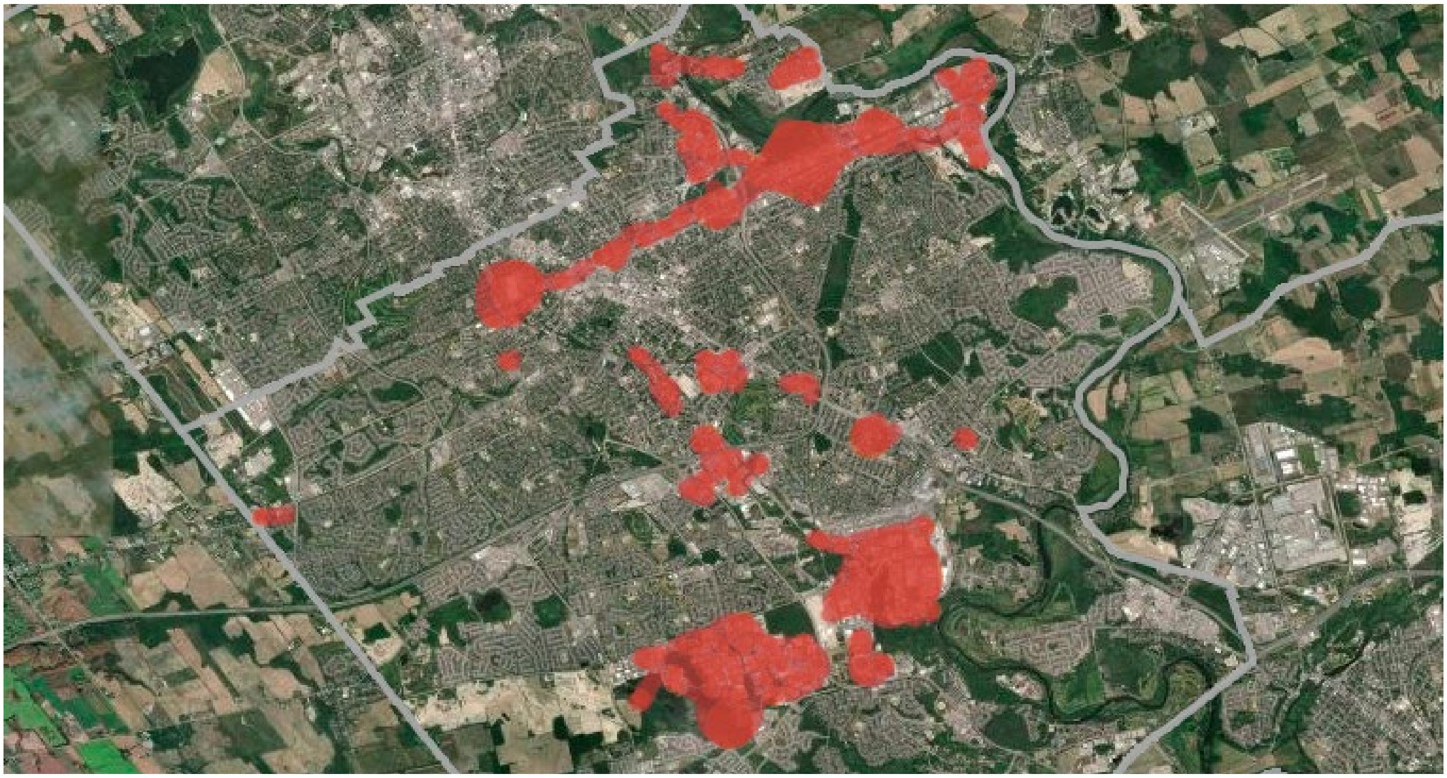


Figure 9: Estimated Industrial Waste Heat in Kitchener

Figure 10: Estimated Electric Heat Recovery from Industry

5.1.2.4 Heat recovery from institutional and municipal facilities

Waste heat can be recovered from the cooling towers[34] providing a heat source for a DES. The City of Kitchener has expressed interest in harnessing this low-carbon thermal energy source.

5.1.3 Renewable Fuels

Boilers can generate heat for a building or a DES by combusting:

- Biomass
- Municipal solid waste
- Municipal or industrial sludge
- Renewable natural gas

5.1.3.1 Biomass

Biomass is solid, liquid, or gaseous organic material from plants and animals (excluding fossil fuels) in which solar energy has been stored as chemical energy. Bioenergy is the useful energy released from organic matter when it is burned. Combustion of biomass releases chemical potential energy as heat. Notwithstanding the emissions associated with its combustion, bioenergy is considered a low carbon renewable energy if harvested in a sustainable manner because natural occurring processes capture as much CO_2 as it releases. Biomass can be used as fuel in boiler generating high pressure steam that will generate electricity with a steam turbine generator. Some biomass systems are using hot oil and other fluids to generate electricity. The waste heat will be used to supply hot water for the central district energy plant. WRCE is open to supporting a further investigation of the opportunity to establish a biomass hub.

5.1.3.2 Municipal Solid Waste

Energy is generated from waste combustion of municipal solid waste to produce heat and/or electricity in Waterloo, Cambridge, and Elmira. Municipal solid waste can be a fuel source for CHP as an alternative to incineration or landfill. The Region of Waterloo's landfill will reach capacity in approximately 25 years.

5.1.3.3 Municipal or Industrial Sludge

Sludge, the product of wastewater treatment and industrial processes, with a moisture content of less than 50% can be used in sludge boilers using similar technologies to what has been discussed under biomass to generate electricity and/or waste heat. Waterloo Region's Biosolids Strategy recognizes the potential to recover the energy content collected with solids at the wastewater treatment plant.[35]

5.1.3.4 Renewable natural gas

Renewable natural gas is primarily composed of methane. Common sources of renewable natural gas (also referred to as biomethane or upgraded biogas) include landfills, animal manure, food scraps and wastewater sludge. Green bin programs represent opportunities for this energy source in Waterloo Region.

5.2 Demand (Sinks)

All buildings require low-grade heat for space and domestic hot water heating. Building-level systems that can provide low-carbon space and domestic hot water heating are considered in *Section 7: Technical Options.* However, a major cost of a community-level systems is the distribution system. The higher the density of the neighbourhood, the larger and more efficient DES systems are likely to be. The section identifies Waterloo Region neighbourhoods that have the highest potential for DESs and includes consideration of:

- Existing and planned high-density nodes and corridors
- Current heat demand profile
- Future heat demand profile
- Anchor loads
- Existing district energy neighbourhoods
- Potential district energy neighbourhoods

Cooling is currently provided by mostly with electric chillers or heat pumps in Waterloo Region. With Ontario's low carbon electricity grid, space cooling could be considered low carbon. However, electric cooling puts significant strain on the local and provincial electricity grid. Air conditioning causes our 'peaking power plants' to turn on. Peaking plants are powered by natural gas – our dirtiest form of electricity. A DES can produce chilled water more efficiently than individual building systems and reduce the need for peak electricity. The chilled water is delivered to individual buildings throughout the distribution network.

Local Examples – Renewable Natural Gas

Municipality: Cambridge
The Cambridge Landfill Gas Collection System was established in 1994. Since 1996, the Region has partnered with Gerdau Ameristeel, a steel manufacturer, to use the landfill gas in their reheat furnace and reduce their need for natural gas.

Municipality: Waterloo
Toromont Energy generates electricity from landfill gas (methane) at the Waterloo Waste Management Site (925 Erb Street West) which is sold to the electric grid providing green electricity for approximately 4,000 to 6,000 homes. Waste heat is released to the atmosphere which could be recovered. The facility is projected to operate 24 hours a day for the next 50 years although the production of landfill gas will drop over time.

Municipality: Elmira
BioEn Power Inc. in Elmira, a privately owned biogas R&D facility, generates electricity from the 110,000 tonnes of waste it collects from various municipal and business partners.

5.2.1 Existing and Planned High-Density Nodes and Corridors

In general, medium-density and high-density urban nodes and corridors offer potential opportunities for DESs. The Regional Official Plan identifies three Urban Growth Centres (the downtowns of Waterloo, Kitchener and Cambridge), Major Transit Station Area within 500-800m of ION station stops, and adjacent Built-Up Areas and Urban Designated Greenfield Areas. The ION Light Rail Transit Corridor is also helping to focus new development and investment in the region's cores and is a priority candidate for DESs.

5.2.2 Current Heat Demand Profile

Areas where heat demand is currently high represent potential opportunities for a DES. With more detailed data from our natural gas distribution partners, we can refine our heat sink map for Waterloo Region.

5.2.3 Future Heat Demand Profile

Areas where heat demand is anticipated to grow represent potential opportunities for a district energy node. This analysis would be part of developing a thermal energy strategy and will consider development sizes and the increased efficiency of building standards.

5.2.4 Anchor Loads

Anchor loads (or large, stable, diverse heat sinks) have a heavy demand for heating and cooling over a 24-hour period. The presence can support the development of a DES. Anchor loads located close to renewable thermal energy sources are also advantageous. Typical examples of anchor loads include:

- University and Colleges
- Hospitals
- Municipal facilities like swimming pools and libraries
- Industrial and large commercial offices

5.2.5 Existing District Energy Neighbourhoods

There are several examples of heat sharing between buildings in Waterloo Region:

- The largest existing DES belongs to the University of Waterloo. Most of the Waterloo University South Campus is heated (steam) and cooled (water) by a first/second generation DES.[36] Currently using natural gas boilers, the University of Waterloo is interested in decarbonizing their DES.
- Grand Valley Institution for Women in Kitchener.
- The HUB in Waterloo uses a single open loop geoexchange well to heat three residential towers.
- The CCC-Group in Elmira sells excess steam to their industrial neighbours for operations.

5.2.6 Potential District Energy Neighbourhoods

There are potential district energy neighbourhoods that have been the subject of a feasibility study and/or business case, are existing high density or planned intensification areas or greenfield developments.

In 2019, case studies were completed on four potential development sites as part of an exercise to consider municipal tools for catalyzing net-zero energy development: Bramm Yards, New Hidden Valley, Dundee North and a Waterloo industrial site.[37]

In 2020, continuing in 2024, further investigation has been undertaken on the Downtown Kitchener (innovation Hub).

This report highlights three other sites: Victoria St. N, Southwest Kitchener, and University Ave, Northfield at Conestoga Parkway.

When considering district energy opportunities, WRCE considers sites that meet the following four conditions: mixed use developments (i.e. diverse energy demands), developments with over 100,000m² in heated space, to be built within 10 years, near local thermal energy sources.

Innovation Hub (Downtown Kitchener)

Due to its density, demand on existing energy infrastructure, capacity for renewable energy, and municipal interest, WRCE conducted a pre-feasibility study Downtown Kitchener in 2020. Downtown Kitchener is an area of existing high and planned high density development and mix of uses that could serve as customers of a DES. Significant public buildings can also provide a strong customer base for a DES. A Feasibility Study and Business Case have been undertaken by the City of Kitchener and are discussed further in *Section 7 – Technical Options*.

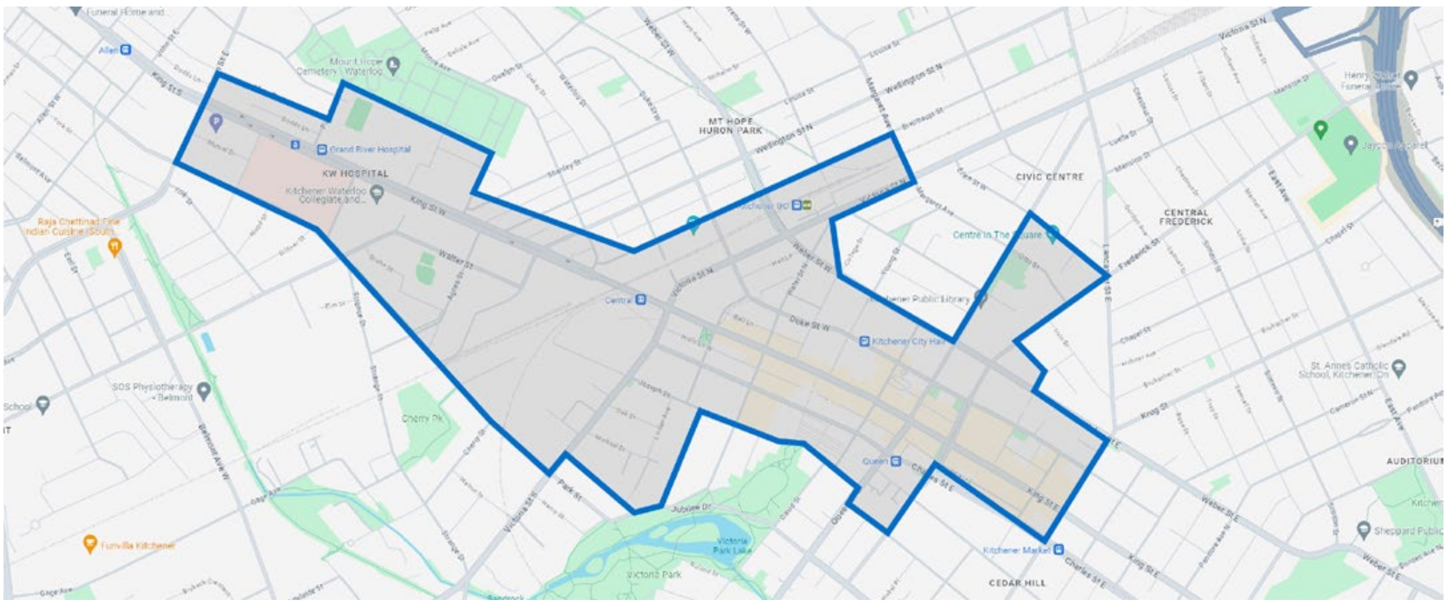


Figure 11: Downtown Kitchener innovation hub

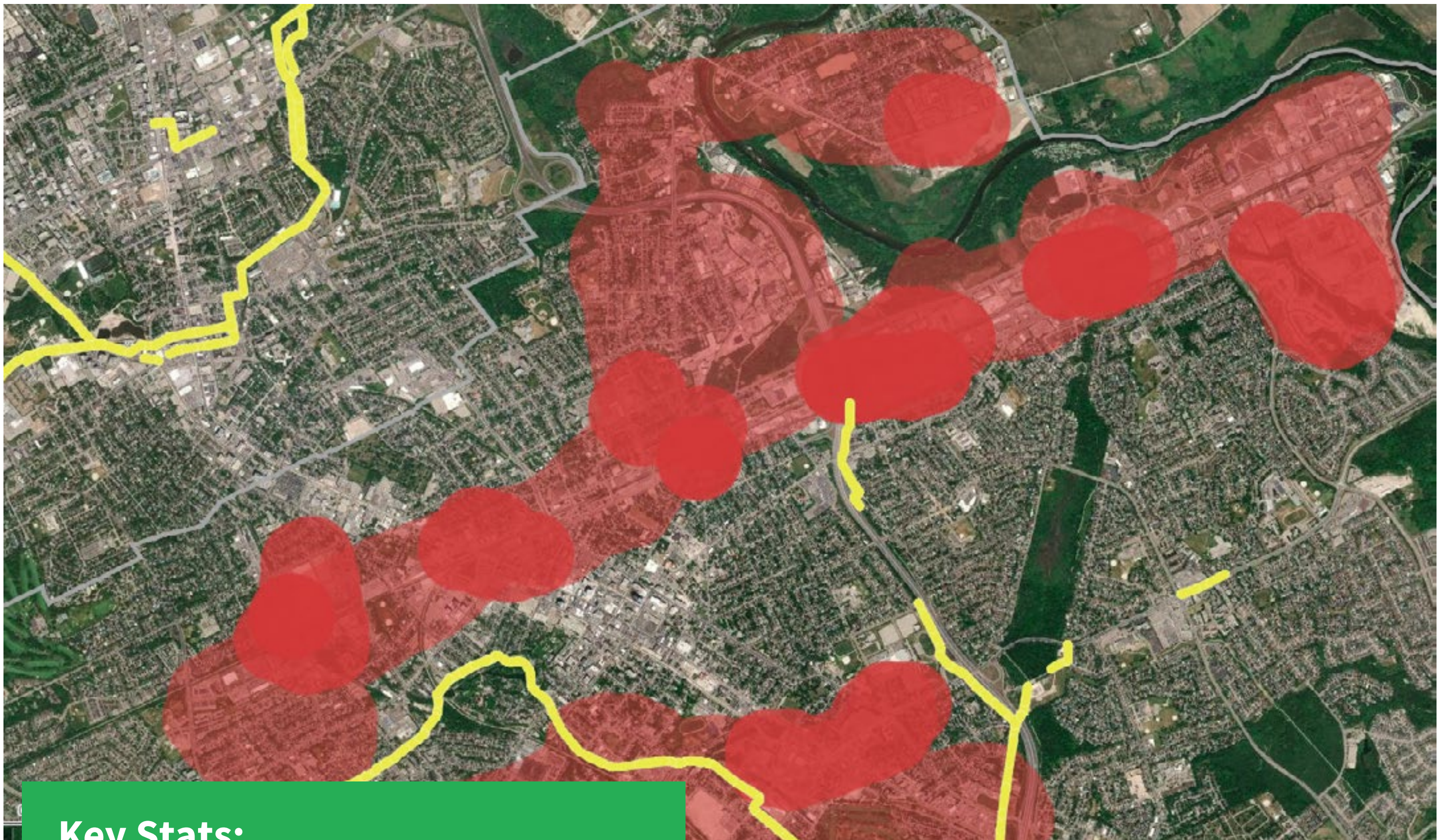
University Avenue Corridor

Three anchor loads are located along the corridor which could be DES customers: the University of Waterloo, Wilfrid Laurier University and Conestoga College. The three anchor nodes are within 2 to 4 kilometres of the Waterloo Wastewater Treatment Plan (WWTP). The Waterloo WWTP has been identified as an important thermal energy asset in Waterloo Region and could serve as a source of thermal energy for the three campuses. The University of Waterloo DES would need to be upgraded to a fourth-generation DES to distribute thermal energy from the Waterloo WWTP (see *Section 5.1.1.2 Wastewater Heat Recovery* above). Of note, University Avenue between Albert Street and Weber Street North is scheduled for reconstruction starting in 2024 and completed in 2027. The University Gateway Project, as it is known, is currently going through detailed design. Following the reconstruction of University Gateway Project, University Avenue between Albert Street and Westmount Road will be rebuilt from 2031 to 2032. Wilfrid Laurier University and Conestoga College's University Avenue Campus are exploring Open-Loop Geothermal systems which would further support a DES in this area.

Victoria St. East, Kitchener

Victoria St. North in Kitchener has a diverse source of industrial surplus heat from the auto, food and beverage, and material processing industries. Combined with the potential for densification on a major urban artery, Victoria St. is a potential district energy growth area.

Figure 12



Key Stats:

Current Thermal Energy Demand Density:

12,435 GJ/KM²

Recoverable Thermal Energy Density:

141,565 GJ/KM²

Value of Environmental Attributes (@170/tonne):

$13,225,963

GHG Savings:

77,800 tonnes

Thermal Energy Sources (GJ/yr):

51,000 Electric

152,000 Industrial Process

25,000 Wastewater

1,400,000 Geothermal

Total: **1,628,000 GJ/yr**

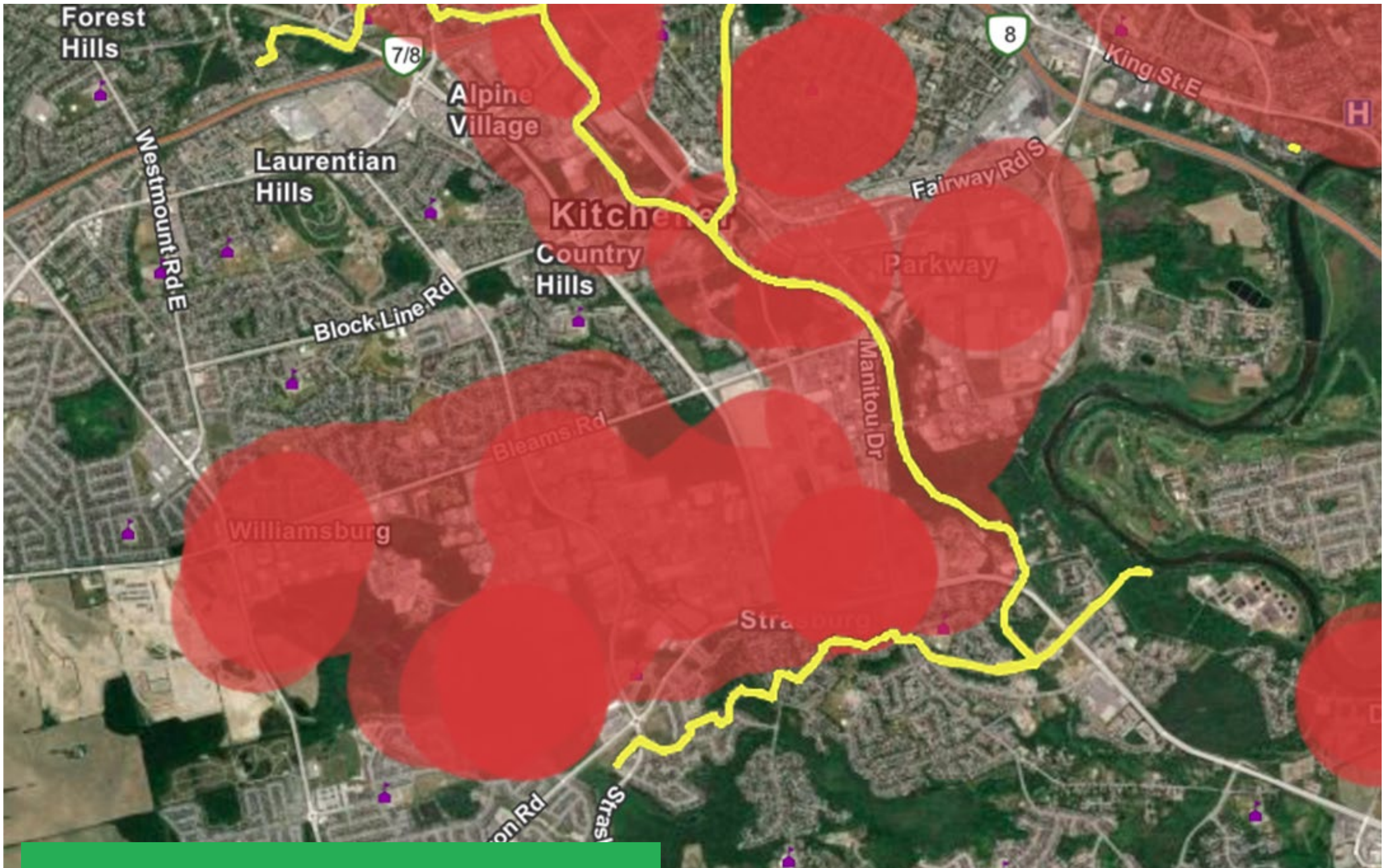
Estimate Low-Grade Thermal Sink (/yr)

143,000 GJ

South Kitchener Industrial Area

This area meets several DES conditions for success including the largest industrial and manufacturing area in Kitchener. Combined with the Kitchener wastewater treatment plant within 4 kms, there is an abundance of surplus heat to power any nearby developments. Conestoga College – Kitchener Doon Campus, is also located approximately 1 to 2 kilometres from the Kitchener WWTP and could act as an anchor load.

Figure 13



Key Stats:

Current Thermal Energy Demand Density:

24,312 GJ/KM²

Recoverable Thermal Energy Density:

124,128 GJ/KM²

Value of Environmental Attributes (@170/tonne):

$10,991,848

GHG Savings:

64,658 tonnes

Thermal Energy Sources (GJ/yr):

57,600 Electric

158,400 Industrial Process

123,000 Wastewater

1,353,000 Geothermal

Total: **1,353,000 GJ/yr**

Estimate Low-Grade Thermal Sink (/yr)

265,000 GJ

Northfield and Conestoga Parkway

This is an area of planned high-density and mixed-use that could serve as customers of a DES. The proposed neighbourhood is south of Northfield Drive between Conestoga Parkway and Conestogo Road in the City of Waterloo.

The planning process needs to be integrated with energy forecasting to get better on sustainable solutions during the early stages of project developments. Currently there is limited planning for electric thermal energy demands to meet new development requirements. There is a clear need for a coordinated planning to be done for all services water, sewer and energy.

An energy plant serving this development could be constructed with a central CHP facility or linked to a geothermal open loops system. While we don't currently have energy data for the area, it is expected to be comparable to other industrial areas in Waterloo Region.

Other Opportunities

Other notable opportunities include the area around Kitchener's WWTP, the area around Galt's WWTP, and major transit station areas along the Ion Corridor.

5.2.6.3 Greenfield Development

Greenfield development provides an opportunity to plan for a net zero development. The development of Secondary Plans for greenfield developments is an important opportunity to establish conditions to promote low-carbon thermal energy. WRCE is establishing a Net Zero Community Working Group.

5.3 Storage

Thermal energy storage can reduce peak demand and level demand by storing energy when there is less demand and releasing when there is high demand.

The size and timing of implementing thermal storage (cisterns) is an operational and commercial decision of the thermal utility/DES operator. Typically, thermal storage would be integrated into the central energy plant or at a mutually agreed location on a customer site. Theoretically, this can include stormwater ponds and pools when combined with an appropriate conversion system.

5.4 Policy

Thermal energy policies play a key role in reducing risk and building the market for thermal energy investments.

5.4.1 Planning for Thermal Energy

The inclusion of thermal energy policies in land use planning tools is a key enabler of thermal energy strategy. While outside scope of this report, a review of regional area municipalities' land use planning tools would be beneficial to address any gaps and to promote alignment between municipalities. Table 1 provides a summary of potential policy inclusions for different regulated land use planning tools. In addition, DES considerations should also be integrated into the scope of Environmental Assessments and infrastructure master plans.

Overall, land use policies that promote high-density, compact urban forms with mixed land uses offer the best potential for the development and expansion of DES. It should also be noted that policies that promote efficient homes and buildings also support the business case for all thermal energy technologies.

Table 1: Potential policy inclusions for regulated land use planning tool to accelerate the uptake of low-carbon thermal energy technologies.[38]

Regulated Land Use Planning Tool	Potential inclusions
Official Plan and Secondary Plans	• General policies regarding energy and emissions. Enabling thermal energy policies (e.g., enabling district-energy ready buildings, area specific requirement for district energy). • Policy directions to implement recommendations of neighbourhood-scale community energy plans. • Potential locations for future energy infrastructure (e.g., DES central energy plant, waste heat recovery, geoexchange opportunities, and energy services distribution networks). • Development phasing and implementation measures, including all energy considerations (e.g., responsibilities for and timing of energy services infrastructure). • Include detailed community structure and infrastructure considerations. • Policies that consider the compatibility of energy infrastructure with adjacent land uses. • Recognize the importance of natural heritage features that support carbon sequestration. • Include a requirement for energy management plans or other energy related studies.
Zoning By-law	• Include zoning regulations to achieve policy objectives. • Regulations by zone, especially related to height and setbacks of energy infrastructure (e.g., renewable energy technology, ground source geothermal systems, etc.). • Include direction for providing on-site renewables "as of right" while ensuring appropriate setbacks and mitigating potential land use conflicts.
Plan of Subdivision, Plan of Condominium	• Implementation objectives. • Requirement for energy management plans especially where DES central energy plants and DES connections are required. • Design to ensure energy use is minimized • Coordinate
Environmental Assessment	• Ensure that energy infrastructure is included in servicing approach (e.g. allowance for district energy piping in right-of-way design or wastewater heat recovery infrastructure
Site Plan Control	• Ensure energy infrastructure is considered in site design (e.g. how building mechanical equipment is DE ready for future connection) • Sustainability elements are included as conditions of site plan approval
Site plan and Green Development Standards	• Guidance on sustainable building and neighbourhood design and materials, as well as location and scale of on-site renewable energy and DES connections. • Incentives to deploy thermal energy technologies.

Land use planning policies can accelerate the uptake of thermal energy technologies for low-grade heat demand. Policy direction will differ by neighbourhood type. Appendix 1 provides a summary of the policy direction by neighbourhood type for a green-field Secondary Plan in the City of Brampton.

Solar thermal systems and heat pumps are proven technologies that can be integrated into most homes and buildings especially in low density residential and rural neighbourhoods. Fourth generation district energy is a proven technology for providing low-carbon heating and cooling services to higher density urban neighbourhoods.

Figure 14

5.4.2 Planning for District Energy-Ready Buildings

Where the development of a DES is planned or anticipated, all new buildings or retrofits to buildings larger than 10,000 m2 should incorporate district energy-ready features.[39] In addition to an efficient building envelop, QUEST identifies three low-cost actions developers can take during construction to make a building district energy ready: use the same sized pipes through the building so thermal energy can be supplied from the ground level, use a hot water (hydronic) heating system, and leave some space on the ground floor for a future energy transfer station.[40] In addition to land use planning policies and industry incentives, education and outreach to inform the market about the benefits of DES and engaging stakeholders from the early stage of urban development are best practices.

Canadian Example – District Energy-Ready

Municipality: City of Richmond, BC
Ownership: Municipal owned utility (Lulu Island Energy Company)
Thermal source: Wastewater heat recovery

City Centre District Energy Utility (CCDEU) is developing a plan to construct a DES that will connect to new developments throughout the entire City Centre area. In the meantime, Lulu Island Energy Company has been coordinating with developers to ensure that new construction in the City Centre area is ready to be connected to the future CCDEU.

The City of Toronto Design Guideline for District Energy Ready Buildings identifies the following key elements of a DE-ready building: [41]

- Ability to supply thermal energy from ground level
- Adequate space at or below ground level for a future energy transfer station
- An easement between the mechanical room and the property line to allow for thermal piping
- Two-way pipes placed in the building to carry the thermal energy from the district energy network to the section in the building where the future energy transfer station will be located
- A low temperature hydronic heating system that is compatible (i.e., large temperature differential or ΔT) with a district energy system in order to reduce the pipe sizes and associated valves, fittings, etc.
- Appropriate thermal energy metering

5.4.3 Planning for Net Zero Greenfield Neighbourhoods

Through the secondary planning process, greenfield development provides an ideal opportunity to plan for no retail natural gas to low-density residential neighbourhoods and natural gas service limited to DES central energy plants and certain industrial uses in medium and high-density, mixed-use neighbourhoods. Education and outreach to inform the market about the benefits of DES and engaging stakeholders early in the secondary planning process are best practices.

5.4.4 Planning for DES linear infrastructure

Ontario municipalities have the authority to create and enforce their own by-laws and regulations related to the use of the municipal right of way. Policies and regulations should be established for planned and anticipated district energy neighbourhoods and corridors.

Canadian Example – Net Zero Greenfield Development

Municipality: City of Brampton, ON

The Heritage Heights Community Secondary Plan includes energy and climate policies that align with the municipal Community Energy Plan (CEP) and the Heritage Heights Community CEP. Low-density residential areas in the Heritage Heights Secondary Plan will be designed for the use of air-source heat pumps with supplementary solar thermal and electric induction heating, or other on-site renewables. All major growth and intensification nodes policies will be served by DES. All development within mix-use areas, employment areas, civic and institutional areas must be designed to be district energy ready. An Integrated Energy Strategy will be required at the Precinct Planning Stage. Individual developments will be required to submit an Energy Management Plan to outline approaches related to such factors as building design, efficient technologies, and behavioural change initiatives. The Secondary Plan commits the City of Brampton to work with appropriate partners to develop a thermal energy utility that will facilitate the establishment of DES.

All road construction projects should include consideration of DES linear infrastructure in medium and high density residential and mix-use neighbourhoods.

5.4.5 Planning for Open Loop Geothermal

The WRCE report (2021) – *Opportunities for Open Loop Geoexchange in Waterloo Region* – identified the following policy recommendations:

- Amend the Region of Waterloo Official Plan to incorporate clear guidance on areas suitable for open and closed loop geothermal systems and acknowledge linkages with policies and regulations related to source water protection plans.
- Align area municipality policies and regulations to reflect the difference between open loop and closed loop geothermal technologies to remove barriers.
- Encourage planners to comment on open loop geothermal opportunities for new developments over 5,000 m^2 and on sites larger than 10,000 m^2 that lie outside of wellhead protection areas.
- Establish a working group to support the development of open loop geothermal opportunities.

5.4.6 Planning for Wastewater Heat Recovery

The WRCE report (2021) – *Wastewater Heat Recovery in Waterloo Region* – identified the following policy recommendations:

- Educate planners and WWTP operators on the opportunity.
- Monitor, collect data, and create a shared database for temperatures in the trunk sewer system.
- Develop increasingly detailed energy maps and models.
- Ensure system-wide coordination of wastewater heat recovery opportunities
- Consider heat recovery when designing sanitary sewer systems.

5.5 Governance

By understanding the value of Waterloo Region's thermal energy assets, municipal leaders will be better informed when faced with a decision of how to develop these resources.

5.5.1 Building-Level / Campus Level

Ownership models for building-level thermal energy systems include:

- owned by the building / campus owner
- leased by the building owner from a public utility or an energy services company

5.5.2 Community-Level

Ownership models for community-scale thermal energy systems include:

- owned by a public entity (including a municipal owned corporation)
- owned by a private entity
- owned public-private joint venture (hybrid model)

Several factors must be considered when determining the ownership model for a new DES including:

- achieving community objectives
- the equitable sharing of benefits
- the experience required to deliver and operate the system
- the proportion of public and private sector involvement
- managing risk and tolerance
- managing profit and tax considerations
- access to and/or cost of capital
- ability and mandate to deliver at scale

According to the Canadian Energy & Emissions Data Centre (CEEDC), most Canadian DESs received at least some funding from senior government (27%), local or municipal (14%), and educational institutions (29%). Private entities, including utilities, also provided a source of investment (14%). Some systems received investment from more than one source.[42] The CEEDC provides a spreadsheet of public, private and hybrid systems in Canada.

According to research undertaken for the City of Mississauga, the approximate breakdown of DES ownership in Canada is:

- 30% institutionally owned
- 20% publicly owned
- 20% privately owned
- 30% other (Crown, First Nations, cooperative or hybrid)[43]

5.5.2.1 Public Model

Establishing a municipal corporation (i.e., thermal utility) to own DES assets is a best practice for the public model.

This report has provided several Canadian examples of municipal owned DESs. Municipal ownership ensures close alignment with community objectives (e.g., maximizing emissions reductions, catalyzing neighbourhood revitalization).

Municipal owners can develop policies and regulations to encourage DES connections which can address key barriers to developing DESs like 'load risk'. Load risks refers to uncertainty of future development as well as uncertainty of connection.[44]

Municipal ownership allows for a lower cost of capital as well as access to low-cost government infrastructure funding which can help in addressing first cost (or ratepayer) risk. These advantages, coupled with a willingness to accept a lower rate of return than a private entity, can result in lower rates for customers as well as create better conditions for future DES expansion. However, financial risk, primarily due to financial exposure and legal liability from contracts, is carried by the municipality in this model.[45] Understanding and mitigating financial, legal, and cultural constraints must be considered carefully by the municipality (see *Section 5.6.1* and the role that the Canadian Infrastructure Bank is playing). The public model could take a few forms: partnerships, municipal service corporations, or an Electricity Act s. 142 corporations.

Using a municipal-owned corporation – existing or new – to own all or part of a DES has several advantages:

- streamlines procurement processes
- provides a more flexible regulatory environment
- able to integrate municipal policies in support of energy policies
- offers enhanced flexibility to raise capital through selling shares
- new business and revenue generating opportunities
- closer partnerships with other municipal-owned utilities

In some cases, a municipal owned local distribution company (LDC) has been involved in the early stages of development (e.g., Markham and Hamilton). This approach provides the benefits of a utility management structure during development and construction. In the cases of Markham and Hamilton, the DES was subsequently spun off as a separate corporation with dedicated staff. Markham District Energy is owned by Markham Enterprises Coporation while Hamilton Community Enterprises is owned by Hamilton Utilities Corporation. Both Markham Enterprises and Hamilton Utilities are municipal owned.[46]

DESs have also transitioned from publicly owned or joint ventures ownership models to private ownership in Canada.

Canadian Example – Transition to Private Ownership

Municipality: City of Toronto, ON

The company was originally established as the Toronto Hospitals Steam Corporation in 1969 to provide heating services for several hospitals in downtown Toronto. In 1980, the system was renamed the Toronto District Heating Corporation and expanded to provide services to other medical institutions, the University of Toronto and the provincial government. The corporation was privatized in 1998, with shares going to the Province of Ontario, City of Toronto, University of Toronto and four founding hospitals. The corporation was renamed as Enwave in 1999 and over time only two shareholders remained (City of Toronto (43%) and the Ontario Municipal Employees Retirement System (57%). In 2012, the entire company was acquired by Brookfield Asset Management through a partnership. Current investors include: IFM Investors and the Ontario Teachers' Pension Plan. Enwave now owns DESs in Toronto, London, Windsor, Markham and Charlottetown.

5.5.2.2 Private Model

Several private entities own and operate DESs in Canada. From a municipal perspective, the primary advantage of this ownership model is the private entity assumes the financial risk and generate up-front capital for the project. However, a higher cost of capital coupled with a requirement for a higher rate of return can result in higher energy rates for customers tied to an unregulated private company. Moreover, the private entity may not share the same objectives as the municipality. The need for higher rate of return may become a barrier to system expansion.[47] Notably, private ownership does not fully absolve the municipality from risk should something go very wrong with the DES for any reason as ratepayers may turn to the municipal government.

5.5.2.4 Public Private Partnership Models

Hybrid models also exist in Canada. Depending on the partnership, municipalities may be able to maintain closer alignment with community objectives while contributing capital at a lower cost. While risks are mitigated, some remain with the public sector including the complexity of managing the partnership.[48]

5.6 Funding

5.6.1 Canada Infrastructure Bank (CIB)

The CIB is working with municipalities to develop DESs.[49] Putting in an initial DES is quite costly, and municipalities already have many competing priorities for capital investment. DESs are long-term assets with payback spread out over 30 or 50 years. As a long-term investor, CIB can bridge this business model financing gap to consider future growth while assuming the risk of the ratepayer on behalf of the municipality until they are no longer required. Systems are built in phases. Once the first phase is built and customers are buying heat, the business case for subsequent phases becomes easier. The CIB has made significant investments in DES in Markham ($135 million) and Richmond ($175 million) in the last two years alone. [50]

5.6.2 FCM Green Municipal Fund

The FCM Green Municipal Fund offers funding to municipalities for feasibility studies and capital project funding for energy recovery projects.[51]

6. AN INTEGRATED COMMUNITY SOLUTION

Earlier work has created a strong foundation for developing a thermal energy strategy.

6.1 Strategic Alignment

A Thermal Strategy would align with the *TransformWR*,[52] specifically:

- Overall goal: Transform Waterloo Region into an equitable, prosperous, resilient low carbon community.
    - Transformative Change #3: Business and homes will no longer use fossil fuels for space heating and cooling and domestic water heating by 2050.

A Waterloo Region Thermal Energy Strategy would align with the Community Energy Investment Strategy,[53] specifically:

- To improve and sustain Waterloo Region's economic competitiveness and quality of life through the coordination of targeted energy investments.
    - Enhance local energy generation and security.

6.2 Principles

As a thermal energy strategy is developed, WR Community Energy proposes to be guided by the following principles to ensure key outcomes are achieved:

Principle	Key Outcomes
Region-Wide Solutions	• replicable and scalable approaches are given priority • shared community objectives are given priority • community-wide understanding of the value of thermal energy assets • the needs of rural and urban neighbourhoods are integrated • a coordinated approach is suited to the fact that several key thermal assets are currently controlled by the Region of Waterloo
Strategic Partnerships	• collaboration is optimized • benefit from our positive experience with local utility ownership • funding sources are maximized
Diverse Energy Portfolio	• a wide range of thermal energy solutions (thermal energy sources and technologies) are made available to local consumers • resilient local energy system and economy • understanding of highest and best use of regional energy resources

6.3 Stakeholders

The successful development of a thermal energy strategy will require robust stakeholder engagement. The following primary stakeholder groups are identified:

- Regional and Municipal Government
  - Region of Waterloo
  - Cities of Cambridge, Kitchener, Waterloo
  - Townships of Wellesley, North Dumfries, Woolwich, Wilmot
- Utilities
  - Enova Power Corp, Kitchener Utilities, Grandbridge Energy
- Regulators
- Institutions
  - Universities
  - Colleges
  - School Boards
  - Hospitals
- Industry
- Consumers
- Energy Services
- Funders

The value proposition and partnership opportunities for each stakeholder group, and even individual stakeholders within a group, will differ. It will be important to identify who they are and why they would be interested.

The success of a decarbonized thermal system in Waterloo Region will rely on collaboration where the good of whole outweighs the interests of the parts. The development of a framework to support effective collaboration is recommended.

There may also be an opportunity to consolidate existing programs into the responsibilities of a thermal utility e.g., WR Community Energy or Retrofit WR (the net-zero retrofit program partnership project) or other efficiency and low-carbon programs such as green development standards, biomass research, etc.).

7. ESTABLISHMENT OF A THERMAL UTILITY

WRCE is working towards the development of a thermal energy strategy for Waterloo Region. As previously noted, this report is one step in that journey.

As a strategic assessment, this report consolidates the findings of previous studies undertaken in Waterloo Region and gathers additional information to serve as a foundation for the next step in the journey – the development of the strategy.

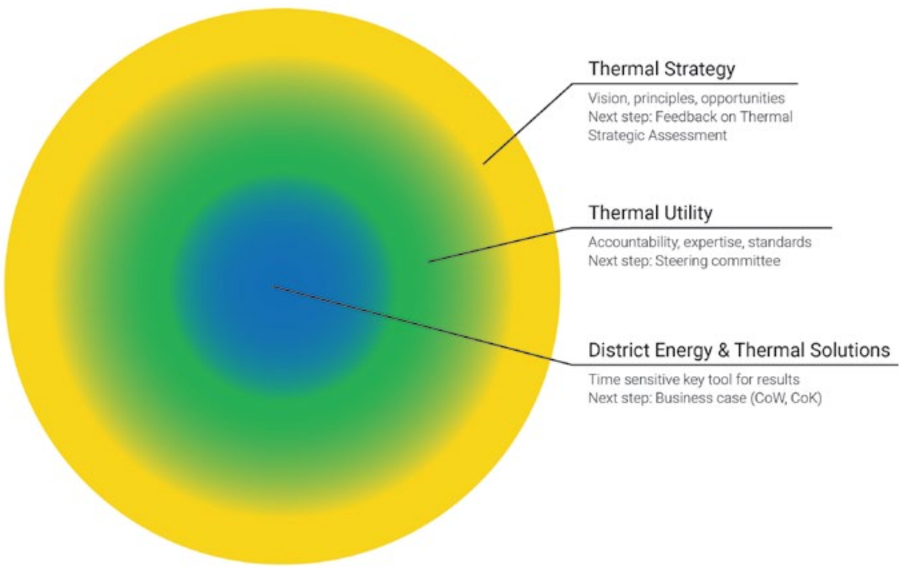


Figure 15: Relationship between strategy, governance and execution.

To effectively advance integrated market solutions, WRCE recognizes the need for an entity that will lead the implementation of the thermal energy strategy and is recommending the establishment of a thermal utility based on the review of literature (see Section 5.5) and Canadian experience.

A thermal utility would be the legal entity to execute on the thermal strategy, managing and operating DESs and related programs delivering thermal energy solutions to Waterloo Region (Figure 8).

The right thermal solutions will depend upon a variety of factors including building density, neighbourhood type, energy distribution within individual buildings, regulations, changing land uses (energy profiles and density), speed of development, accessibility of low-carbon energy sources, electricity capacity, carbon taxes and more. The thermal utility would have a region-wide mandate delivering thermal solutions to the entire community including low density and rural neighbourhoods and high density urban neighbourhoods.

Based on the findings of the strategic assessment, several opportunities have been identified for low density and rural neighbourhoods and two potential priorities have been identified for high density urban neighbourhoods. Both are described below.

7.1 Potential Thermal Solutions for Low Density and Rural Neighbourhoods

Depending on local conditions, the following systems can replace natural gas for space heating and domestic hot water heating in low density and rural neighbourhoods at the building level:

- Solar PV systems
- Solar thermal systems
- Heat pumps (ground source and air-source systems)
- Electric resistance heaters
- Biomass-fueled boilers

As all systems, with the exception of biomass-fueled boilers, rely on electricity, potential impacts on the electricity grid would need to be addressed especially as we become a winter-peaking community in the coming years.

Distribution of heat with an in-floor hydronic heating in combination with hot water storage is one of the most energy efficient distribution within the home. The benefit of in-floor hydronic heating is that it optimizes the use of thermal energy systems supplying low temperature heat (i.e., about 40°C). The cooling of the home would require separate ducting and enter the rooms high to get the benefit of cold air falling.

Smaller towns, like Elmira, with a growing downtown core might consider developing a smaller DES to prepare for future densification. Economics will dictate the feasibility of such a development.

7.1.1 Solar PV

While not a thermal technology, solar PV can support the decarbonization of space heating and cooling and domestic hot water heating by powering the heat pumps and reducing the strain on the distribution grid. Community solar systems may also be an opportunity.

7.1.2 Solar Thermal

Solar thermal has applications for heating water.

7.1.3 Heat Pumps

Heat pumps for space or domestic hot water heating are significantly more efficient than electric baseboard heaters. They also have the advantage of providing cooling in the summer.

7.1.3.1 Closed-loop geothermal systems

Closed-loop geothermal systems in combination with ground source heat pump will be an energy efficient method of heating and cooling individual homes. The benefit of ground source heat pumps is that coefficient of performance (COP) of 3 to 5, meaning that for 1 kW of electricity input the heat pump will produce 3 to 5 kW of heat. It is important to manage the geothermal loops by taking out the same amount of heat during the winter and reintroducing the heat during the summer cooling phase. This way the short -term (annual) underground temperatures will fluctuate, but not have a long-term detrimental impact on the ground-loop temperatures and the geothermal resource will maintain its value. In certain situations, it may be beneficial to install a shared closed-loop geothermal systems for homes in a subdivision.

7.1.3.2 Air-source heat pumps

Air-source systems will have reduced efficiency during cold winter days and will typically have a COP of 2 to ~3 kW of heat from 1 kW of electricity. The lower efficiency will be during cold winter weather.

7.1.4 Electric resistance heating

Baseboard heaters are the most common electric heating option in use across Canada. They're powered by electrical resistance heating, just like your toaster and oven. The elements are inexpensive to install but very expensive to operate with a COP of 1, for 1 kW of electricity the baseboard heater will produce 1 kW of heat.

For domestic hot water heating, electrically heated instantaneous hot water heater to avoid having to maintain the hot water storage tank for smaller households

7.1.5 Biomass-fired boilers

Biomass-fueled boilers use woodchips, sawdust, shavings, pellets, and wood waste with less than 30% moisture content. The boiler can be connected to a hydronic heating system. Some boiler system will be equipped with electrical back up heating when you are away from your home or unable to attend to the fuel feed into the boiler.

7.2 Potential Priorities for High Density Urban Neighbourhoods

Several factors must be considered when evaluating whether a neighbourhood for district energy including the current and planned density, the timing of development, the presence of existing systems, anchor loads, and thermal energy sources.[54] The following criteria has been considered in identifying priority district energy nodes:

- High-density mixed-use nodes or corridors identified in the Official Plan (current and planned)
- Planned high-density mixed-use neighbourhoods (greenfield or for intensification) with a minimum of 100,000 m^2 (1,000,000 ft^2) with build out within 10 years[55] and/or a heating energy demand density of 113 MJ/ha or higher[56]
- Master planned developments
- Areas where regional and municipal governments have greater control over the development process
- Presence of potential anchor load(s) including municipal owned facilities
- Presence of low carbon thermal energy source(s)
- Presence of existing neighbouring high-density buildings that could be considered for future connection to a new DES
- Proximity to an existing DES
- Feasibility study or business case underway or completed

7.3.1 High Priority District Energy Neighbourhoods

While work will continue to identify and promote heat sharing across Waterloo Region, the following high priority neighbourhoods have been identified through work that has already been underway:

Innovation District Geothermal (Kitchener Downtown DES)

The Feasibility Study confirmed that 450,000 m^2 (4.5 million ft^2) of forecasted new floor space is sufficient to support a DES. Six energy centre concepts were evaluated with the option of developing a DES paired with open loop Ground Source Heat Pump being considered further. A DES utilizing open loop geoexchange technology was found to have a 53% reduction in GHG emissions, compared to a business-as-usual trajectory for building heating and cooling. The system envisioned for Downtown Kitchener is a 4th generation DES. Load assumptions were conservative. Most forecasted load is on publicly owned land that is slated for future development. Additional customers could be connected including private development and retrofits of exiting buildings (e.g., City Hall). Based on the positive technical findings, the City of Kitchener, with Kitchener Utilities, proceeded with the development of a business case.[57] Based on the positive outcome using a conservative financial model, the City of Kitchener continues to advance this project.

University Avenue Wastewater Heat Recovery (Waterloo Uptown DES)

Three anchor loads are located along the corridor which could be DES customers: the University of Waterloo, Wilfrid University and Conestoga College. The three anchor nodes are within 2 to 4 kilometres of the Waterloo Wastewater Treatment Plan (WWTP). The Waterloo WWTP has been identified as an important thermal energy asset in Waterloo

Region and could serve as a source of thermal energy for the three campuses. The University of Waterloo DES would need to be upgraded to a fourth-generation DES to distribute thermal energy from the Waterloo WWTP. University Avenue between Albert Street and Weber Street North is scheduled for reconstruction starting in 2025 and completed in 2027. The University Gateway Project, as it is known, is currently going through detailed design. Following the reconstruction of University Gateway Project, University Avenue between Albert Street and Westmount Road will be rebuilt from 2031 to 2032. Conversations have been initiated to assign space in the right of way for district energy linear infrastructure.

Table 2: Evaluation of the Kitchener Downtown DES and University Ave. DES based on the criteria for identifying a high priority DES node.

Criteria	Kitchener Downtown DES	University Ave. DES
High-density mixed-use nodes or corridors identified in the Official Plan	Yes	Yes
Planned high-density mixed-use neighbourhoods (greenfield or for intensification) with a minimum of 100,000 m^2 (1,000,000 ft^2) with build out within 10 years	Yes	TBD
Heating energy demand density of 113 MJ/ha or higher	Expected	Expected
Master planned developments	No	No
Areas where regional and municipal governments have greater control over the development process	Yes	Possible with Green Development Standards
Presence of potential anchor load(s) (esp. municipal owned facilities	Yes	Yes
Presence of low carbon thermal energy source(s)	Yes (geothermal)	Yes (wastewater heat)
Presence of existing neighbouring high-density buildings that could be considered for future connection to a new DES	Yes	Yes
Proximity to an existing DES	No	Yes
Feasibility study or business case underway or completed	Yes (completed)	No

8. A PRELIMINARY FRAMEWORK FOR A THERMAL ENERGY STRATEGY FOR WATERLOO REGION (2023-2026)

This section offers a preliminary framework for a thermal energy strategy for 2023 to 2026 recognizing that the strategy will be refined with additional analysis and engagement of partners and stakeholders.

8.1 Draft Vision

Waterloo Region is an equitable, prosperous, resilient and low carbon community.[58]

8.2 Draft Goal

Businesses and homes no longer use fossil fuels for space heating and cooling, and water heating.[59]

8.3 Draft Thermal Strategy Principles

The following principles will guide our decision making:

- Region-Wide Solutions
- Strategic Partnerships
- Diverse Energy Portfolio

Refer to Section 6.2 Principles for a description of the proposed key outcomes associated with each principle.

8.4 Draft Thermal Utility Principles

The following are identified as draft principles for the thermal utility:

- Clean – offer decarbonized heating and cooling solutions to Waterloo Region
- Reliable – provide reliable and competitive services to consumers
- Valuable – deliver an equitable source of energy at an affordable price or otherwise demonstrate quantified community benefits
- Local – optimize community partnerships

8.5 Strategic Pillars, Draft 2023-2026 Objectives and Success Measures

WR Community Energy identifies three strategic pillars essential to promoting the energy transition. Draft strategic objectives have been identified for 2023-2026 for each pillar:

8.5.1 Market Solutions

- **Establish a thermal utility** – to lead implementation of the thermal energy strategy (including the development and operation of district energy systems).
  Success measure: Thermal utility established and marketing the deployment of intra-regional thermal energy solutions in Waterloo Region.
- **Set data-informed targets** - based on robust energy modelling, set short, medium and long-term targets for the decarbonization for space heating and cooling, and water heating in WR.
  Success measure: Market relevant targets set.
- **Build a Strategic Implementation Network** - develop a strategy, based on customized value propositions, to engage key stakeholders and build a network of implementation partners within and outside the community.
  Success measure: Waterloo recognized as a Canadian leader in thermal energy marketplace.

8.5.2 Policy

- **Enable thermal energy solutions** – create a policy environment to promotes the uptake of thermal energy solutions.
  Success measure: Enabling regional and municipal polices, and programs approved.

8.5.3 Infrastructure

- **Build thermal energy infrastructure** – catalyze the development of thermal energy infrastructure.
  Success measure: A minimum of one new district energy system under construction.

9. RECOMMENDED ACTIONS: FINDING AND ADDING VALUE

WRCE recommends establishing a Thermal Utility Steering Committee to determine next steps following the preliminary strategic framework summarized in *Section 8* along with the following actions. These actions recognize that Waterloo Region is on a journey and will need to continue to refine the framework as more data becomes available. Additional analysis is required to fully understand the value of the thermal energy assets in Waterloo Region to support investment decisions.

9.1 Market Solutions Actions

Establish a Thermal Utility

Action	Lead	Status
Establish a Thermal Utility Steering Committee (TUSC).[60]	WRCE	Complete
Develop a Memorandum of Understanding (MOU) to identify future work and complete necessary studies.	TUSC	Not started
Develop RFP to undertake a thermal utility feasibility study.	TUSC	Not started

Set Data-Informed Targets

Action	Lead	Status
Undertake robust geospatial thermal energy modelling and mapping to develop a heat guide for WR.[61]	WRCE	In progress
Identify market relevant KPIs and thermal energy targets.	WRCE	Not started

Build a Strategic Implementation Network

Action	Lead	Status
Identify key stakeholders.	WRCE	In progress
Develop value propositions and partnership opportunities.	WRCE	In progress
Develop an engagement strategy to guide the development of a Strategic Implementation Network.	WRCE	Not started
Develop a framework to promote collaborative leadership.[62]	WRCE	Not started
Engage academic institutions to promote the development of thermal energy talent and skills in the regional workforce.	WRCE	Not started
Establish an energy innovation concierge to de-risk innovative low-carbon building-level thermal solutions.	WRCE	In progress

9.2 Policy Actions

Enable Thermal Energy Solutions

Action	Lead	Status
Establish Green Development Standards that include thermal energy solutions.	Green Development Standards Working Group	In progress
Work with Regional and Area Municipal Planners to integrate thermal energy policies into land use planning tools and municipal masterplans.	WRCE	In progress
Identify greenfield developments for net zero secondary planning.	Net Zero Community Working Group	In progress
Develop District Energy-Ready Building Guidelines for builders and developers.	WRCE	Not started
Establish Waste to Energy Transfer, Open-Loop GeoExchange Guidelines.	Region of Waterloo	Not started

9.3 Infrastructure

Build Thermal Energy Infrastructure

Action	Lead	Status
Refine and advance the business case, including partnership opportunities, for the innovation DES (Downtown Kitchener).	City of Kitchener	In progress
Undertake a feasibility study for the University Avenue Wastewater Recovery DES.	TBD	Not started
Engage industry in process and building waste heat discussions.	Industrial Wast Heat Working Group	In progress

Glossary

Aerothermal energy
Thermal energy harnessed from the air.

Anchor load
A large and heavy demand for heating and cooling over a 24-hour period.

Bioenergy
The useful energy released from organic matter when it is burned.

Biomass
Solid, liquid, or gaseous organic material from plants and animals (excluding fossil fuels) in which solar energy has been stored as chemical energy.

Carbon budget
A concept used in climate policy to help set emissions reduction targets in a fair and effective way.

Carbon neutral
Achieving net zero carbon dioxide emission by balancing carbon dioxide emissions with carbon dioxide removal or eliminating carbon emissions altogether.

Carbon sinks and sequestration
The capture and storage of carbon dioxide, through means such as urban forestry, urban farming, green roofs, naturalization, and natural heritage conservation.

Centralized energy systems
The supply of energy through large-scale energy generation infrastructure that delivers energy via a vast distribution network, often far from the point of use.

Climate change
Changes in global climate patterns caused by increasing levels of atmospheric greenhouse gases arising from human activities.

Climate mitigation
Decreasing the human-induced sources of climate change to reduce future impacts, such as minimizing the amount of greenhouse gas emitting fossil fuels burned for energy or enhancing carbon sinks that store greenhouse gases.

Cogeneration
See Combined Heat and Power for a definition

Combined Heat and Power (CHP)
An energy technology that generates electricity and captures the heat that would otherwise be wasted to provide useful thermal energy – such as steam or hot water – that can be used for space heating, cooling, domestic hot water and industrial processes.

Community
In the context of community energy planning, the word "community" is meant to be inclusive of all citizens, groups and stakeholders that share the common attribute of being residents with a prescribed geographic boundary and direct and indirect consumers of energy.

Community energy planning
Is a methodology for understanding where and how energy is used and emissions are released in a community to identify local opportunities and priorities for increasing energy efficiency and reducing greenhouse gas emissions.

Conversion losses
The energy that is lost, usually as heat, when a primary energy source is converted to a secondary energy source (energy carrier).

Distributed energy resources
Small-scale energy generation, operation, and/or energy storage used to provide an alternative to or an enhancement of the traditional electric power grid.

District energy system
An energy system that supplies thermal energy (heating and/or cooling) to multiple buildings from a central plant or from several interconnected but distributed plants.

Energy carrier
Transports energy in a usable from one place to another.

Energy efficiency
Using less energy to perform the same task and eliminating energy waste.

Energy-from-waste
Combustion of municipal solid waste to produce heat and/or electricity.

Energy security
Maintaining an adequate and resilient supply of energy while also addressing issues of affordability, accessibility, and reliability.

Energy transition
A major and long-term structural change in energy systems, often including a significant transformation in how energy is sourced, distributed, and/or utilized.

Geo-exchange system
Energy system designed to harness geothermal energy

Geothermal energy
Thermal energy harnessed from the Earth including ground, aquifers and surface water

Gigajoule (GJ)
1 billion Joules.

Greenfield
Undeveloped land typically dominated by agriculture, open space, and/or natural heritage features.

Greenhouse gas
Any gas that absorbs thermal radiation from the sun and emits it back into the earth's atmosphere, including water vapour, carbon dioxide, methane, nitrous oxide, and ozone.

Heat
Thermal energy transferred between systems due to temperature differences.

Heat pump
An energy technology that extracts thermal energy from the surrounding air, ground, water source or waste heat from an industrial process.

High-grade heat
High pressure steam and industrial processes at high temperatures.

Joule (J)
A standard unit that can be used to measure and compare electric energy with other kinds of energy, such as chemical (contained in fuels) and thermal (heat).

Low-grade heat
Hot water supplied between 40 and 70 degrees Celsius.

Medium-grade heat
Hot water above 70 degrees Celsius.

Municipal sludge
A source of biomass produced by municipal wastewater treatment.

Net zero neighbourhood
A neighbourhood with little or no energy drawn from the electricity grid or from pipelines, and little or no greenhouse gas emissions released.

Renewable natural gas
Methane.

Resiliency
The ability to absorb, recover, and prepare for future shocks (economic, environmental, social & institutional).

Solar energy
The electromagnetic energy emitted by the sun.

Solar thermal energy
Thermal energy harnessed from the sun.

Thermal energy
Movement of atoms and molecules

Thermal grid
A district energy system.

Thermal utility
A company that operates all the plants and networks, ensures service quality, and manages the metering and billing of the heating and cooling services associated with a district energy system or thermal grid.

Tonne
A unit of mass equal to 1000 kilograms.

Appendices

Appendix 1

The following table provides the policy direction by type of neighbourhood to accelerate the uptake of low-carbon thermal energy technologies proposed for the City of Brampton Heritage Heights Secondary Plan for illustrative purposes.[63]

Neighbourhood Type	Policy Direction
All neighbourhoods	• Encourage measures that address heating, cooling and hot water needs of buildings that do not rely on natural gas and other fossil fuels. • Discourage development that relies on natural gas or other fossil fuels as its primary energy and heating source.
Low-density residential and rural	• Builder/developers are expected to integrate high-efficiency air-based heat pumps with supplementary solar thermal and electric induction heating into all homes and buildings, or other onsite renewables • Develop incentives for developers to include heat pumps and solar thermal systems (e.g., Green Development Standards). • Review opportunities for ambient based loops to nodes of higher developments within low density residential subdivisions • Ensure the electrical infrastructure supports all-electric homes and buildings.
Medium- and high-density mixed-use, civic, and institutional	• Builders/developers are expected to design buildings to be district-energy ready in district energy nodes and corridors. • DES is incorporated into all major growth and intensification areas. • Provide comprehensive DES services (i.e., a thermal utility). • Encourage the use of waste heat[64] including combined heat and power.[65]
Industrial	Unlike a natural gas boiler, DESs are fuel and technology neutral. DES systems are often able to switch fuels in response to changing economic, security or environmental imperatives. The diversification of the local energy supply mix strengthens the resilience of the local economy.

Endnotes

1 A carbon budget is a concept used in climate policy to help set emissions reduction targets in a fair and effective way. It looks at the maximum amount of cumulative net global anthropogenic carbon dioxide (CO2) emissions that would result in limiting global warming to a given level. When expressed relative to the pre-industrial period it is referred to as the total carbon budget, and when expressed from a recent specified date it is referred to as the remaining carbon budget.

2 More information on the Clean Hydrogen Ladder can be found here

3 IESO's report Pathways to Decarbonization can be downloaded here.

4 Enbridge's report Pathways to Net-Zero Emissions in Ontario (2023) can be downloaded here.

5 For additional consideration of large-scale electrification, Positive Energy's report Canada's Energy Future in an Age of Climate Change: How Partisanship, Polarization and Parochialism are Eroding Public Confidence (2019) can be downloaded here.

6 More info here.

7 This also provides rationale for developing local distributed generation within the Region of Waterloo including renewable electricity generation and combined heat and power generation to support both the electrical grid and thermal grid.

8 More information on potential distribution models can be found here.

9 Source: https://www.iea.org/reports/the-future-of-heat-pumps/how-a-heat-pump-works

10 Source: http://www.districtenergyinitiative.org

11 Source: https://doi.org/10.1016/j.energy.2019.116727

12 Source: http://www.districtenergyinitiative.org

13 Source of graphic: Zeh, Robin & Ohlsen, Björn & Philipp, David & Bertermann, D. & Kotz, Tim & Jocic, Nikola & Stockinger, Volker. (2021). Large-Scale Geothermal Collector Systems for 5th Generation District Heating and Cooling Networks. Sustainability. 13. 6035. 10.3390/su13116035.

14 Source of graphic: UNEP (2015)

15 Source: http://www.districtenergyinitiative.org/

16 Source: https://www.cbc.ca/news/science/sweden-heat-pumps

17 Source: https://www.c40.org/case-studies/cities100-copenhagen-carbon-neutral-district-heating/

18 Source: https://ec.europa.eu/commission/presscorner/detail/en/IP_23_1581

19 Source: https://www.gov.uk/government/publications/energy-security-bill-factsheets/energy-security-bill-factsheet-heat-networks-regulation-and-zoning

20 Source: https://www.governor.ny.gov/news/governor-hochul-announces-progress-toward-implementing-utility-thermal-energy-network-and-jobs

21 Source: https://www.sfu.ca/content/dam/sfu/ceedc/publications/facilities/CEEDC%20-%20District%20Energy%20Report%202019.pdf

22 Ibid.

23 Source: https://www.unep.org/resources/factsheet/district-energy-cities-initiative

24 Source: https://www.unep.org/resources/factsheet/district-energy-cities-initiative

25 Source: https://www.unep.org/resources/factsheet/district-energy-cities-initiative

26 Source: https://www.unep.org/resources/factsheet/district-energy-cities-initiative

27 Source: http://www.merlynpower.ca/Solar%20Pool%20Heating.html

28 More information on Canada Greener Homes Initiative can be found at: https://natural-resources.canada.ca/energy-efficiency/homes/canada-greener-homes-grant/start-your-energy-efficient-retrofits/plan-document-and-complete-your-home-retrofits/eligible-grants-for-my-home-retrofit/23504

29 The WRCE report Geothermal Energy Potential for the Waterloo Region Building Sector Source can be downloaded at: https://wrcommunityenergy.ca/wp-content/uploads/2021/11/Geothermal-Report-FINAL.pdf

30 More Information on the Oil to Heat Pump Affordability Program can be found at: https://natural-resources.canada.ca/energy-efficiency/homes/canada-greener-homes-initiative/oil-heat-pump-affordability-program-part-the-canada-greener-homes-initiative/24775

31 More information on Canada Greener Homes Initiative can be found at: https://natural-resources.canada.ca/energy-efficiency/homes/canada-greener-homes-grant/start-your-energy-efficient-retrofits/plan-document-and-complete-your-home-retrofits/eligible-grants-for-my-home-retrofit/23504

32 More information on the Province of Ontario's pilot program can be found at: https://news.ontario.ca/en/release/1002324/ontario-launches-clean-home-heating-initiative

33 The report Wastewater Heat Recovery in Waterloo Region (2021) can be downloaded at: https://wrcommunityenergy.ca/wp-content/uploads/2021/11/Waste-Water-Heat-Recovery-Report-FINAL.pdf

34 A water-cooling tower is used to cool water and is a huge heat exchanger, expelling building heat into the atmosphere and returning colder water to the chiller.

35 Source: https://www.regionofwaterloo.ca/en/living-here/biosolids.aspx#Summary-and-final-report-for-Biosolids-Strategy

36 Source: https://uwaterloo.ca/sustainability/projects-and-initiatives/energy-and-climate-change

37 Municipal Tools for Catalyzing Net-Zero Energy Development (2019) can be found at: https://www.iea.org/reports/sdg7-data-and-projections/energy-intensity

38 Source: Garforth, P., Taylor, L. E., Farbridge, K., Kerr, R., & Hall, J. (2021). Land Use & Energy Planning: Key Considerations for Policy Integration, Heritage Heights Community Energy Plan. City of Brampton.

39 Source: https://www.districtenergy.org/resources/publications/community-energy-development-guide

40 Source: https://districtenergy.questcanada.org/district-energy-101/

41 Source: https://www.toronto.ca/wp-content/uploads/2018/01/96ab-District-Energy-Ready-Guideline_October-2016.pdf

42 Source: https://www.sfu.ca/content/dam/sfu/ceedc/publications/facilities/CEEDC%20-%20District%20Energy%20Report%202019.pdf

43 The City of Mississauga's District Energy in the Downtown Feasibility Study (2023) was downloaded here: https://yoursay.mississauga.ca/district-energy

44 Source: https://www.edmonton.ca/sites/default/files/public-files/District-Energy-Strategy.pdf?cb=1666469467

45 Source: https://yoursay.mississauga.ca/district-energy

46 Source: https://yoursay.mississauga.ca/district-energy

47 Source: https://www.districtenergy.org/resources/publications/community-energy-development-guide

48 Ibid.

49 Source: https://www.municipalworld.com/feature-story/district-energy-offering-game-changing-tool/

50 Ibid.

51 Source: https://greenmunicipalfund.ca/funding

52 Source: https://climateactionwr.ca/wp-content/uploads/2021/07/Final-TransformWR-Stragegy.pdf

53 Source: https://www.regionofwaterloo.ca/en/resources/Community-Energy-Investment-Strategy---For-Web---access.pdf

54 The City of Edmonton District Energy Strategy identifies several factors that support the development of DES: https://www.edmonton.ca/sites/default/files/public-files/District-Energy-Strategy.pdf

55 WRCE criteria

56 City of Ottawa criteria https://documents.ottawa.ca/sites/documents/files/community_energy_plan_tor_en.pdf

57 The Staff Report and Feasibility can be found at: https://lf.kitchener.ca/WebLinkExt/DocView.aspx?id=1867509&searchid=69ed4833-08b9-4ab0-b4b9-5c0fcb0b4221&dbid=0&cr=1

58 The vision has been based on TransformWR.

59 The goal has been based on TransformWR.

60 Membership includes the Region of Waterloo, City of Waterloo, Kitchener Utilities, Wilfred Laurier University, University of Waterloo, Conestoga College

61 Readers are referred to the Amsterdam Heat Guide as a model of thermal energy planning. The Amsterdam Heat Guide can be found at: https://issuu.com/gemeenteamsterdam/docs/the_amsterdam_heat_guide

62 This recognizes the considerable need for collaboration and partnerships between multiple stakeholders to ensure the sum remains larger than the parts.

63 Source: Garforth, P., Taylor, L. E., Farbridge, K., Kerr, R., & Hall, J. (2021). Land Use & Energy Planning: Key Considerations for Policy Integration, Heritage Heights Community Energy Plan. City of Brampton.

64 These are operational decisions and negotiations between the thermal utility and the waste heat source.

65 LDCs are expected to provide interconnection, information, and other services to qualified users and operators.

WR COMMUNITY ENERGY

Contact Us

Matthew Day,
Director, Community Energy Program

phone: (519)589-6329

email: mday@wrcommunityenergy.ca

www.wrcommunityenergy.ca

IN PARTNERSHIP WITH

Region of Waterloo | Cambridge Canada It's all right here | Kitchener | The City of Waterloo | Enova | GrandBridge Energy | Kitchener Utilities Community-Owned for over 100 Years