WATERLOO REGION THERMAL ENERGY UTILITY

Conceptual Business Case

Prepared for WR Community Energy

January 2026

RESHAPE STRATEGIES

Statement of Limitations

This report has been prepared by Reshape Infrastructure Strategies ("Reshape") for the exclusive use and benefit of WR Community Energy. This report represents the best professional judgment of Reshape, based on the information available at the time of its completion and as appropriate for the scope of work. Services were performed according to normal professional standards in a similar context and for a similar scope of work.

EXECUTIVE SUMMARY

WRTEU Vision Statement

The proposed Waterloo Region Thermal Energy Utility (WRTEU) will accelerate the energy transition in Waterloo region while enhancing regional energy security, community resilience, and long-term economic growth. By keeping energy dollars within the community and monetizing local resources, the WRTEU will stimulate a local low-carbon economy and create jobs. Furthermore, increased use of diversified and local resources will increase community resilience and energy security while reducing greenhouse gas emissions.

WRTEU Objectives

TransformWR, Waterloo Region's climate action plan, aims to reduce greenhouse gas emissions by 80% below 2010 levels by 2050, with a 30% interim reduction by 2030. Buildings account for approximately 45% of the region's GHG emissions, largely from natural gas use for heating and domestic hot water.

By 2050, the region's population is expected to grow by 35% which will create the need for an estimated additional 9.2 million m^2 of new housing that will require heating and cooling. Therefore, achieving regional emissions reduction targets will require extensive energy retrofits of existing buildings and the installation of low-carbon heating systems in all new buildings.

Existing building retrofits and low-carbon new construction may be accomplished via low-carbon district energy connection in densely populated areas as well as via building-scale energy systems elsewhere. The creation of a Waterloo Region Thermal Energy Utility (WRTEU) is proposed to enable this region-wide thermal energy transition, with the following objectives:

- Leverage local, low-carbon thermal energy sources to provide low-carbon thermal energy services to new and existing buildings, at both the building and district scale, to achieve *TransformWR* goals.
- Create local jobs in a low-carbon economy, monetize local resources, keep energy dollars in the community, and create new utility business models.
- Deliver safe and reliable energy, and increase community resilience and energy security, by offsetting increasing demands on the electricity system and optimizing the electrification of heating.
- Leverage opportunities for efficiency, economies of scale, low-cost financing and grants to deliver affordable low-carbon energy in a financially sustainable manner.

WRTEU Value Proposition

The proposed Waterloo Region Thermal Energy Utility (WRTEU) would deliver the services required to facilitate the region's transition from reliance on natural gas heat to low-carbon heat. Ultimately, the WRTEU would operate as a regional planning and service delivery agent for low-carbon thermal energy systems in Waterloo Region.

Initially, the WRTEU may begin as a platform for coordination amongst multiple local thermal energy utilities under various ownership models. Over time, the WRTEU could evolve into a consolidated thermal energy utility. In the long term, it is expected that consolidation would provide greater access to financial resources, increase operational efficiency, enhance service reliability, and achieve greater economies of scale in planning, and delivery. Any such evolution would be pursued collaboratively, with participating municipalities retaining local oversight while aligning governance, technical standards, and investment planning under a unified regional framework.

The value proposition for key stakeholders is summarized in Table E1.

Table E1: WRTEU Value Proposition

Municipalities and Townships	Region of Waterloo	Local Gas and Electric Utilities	University and Hospital Campuses	Building Owners and Developers
WRTEU provides a compliance pathway for high performance development standards and decarbonization policies.	WRTEU as a trusted counterparty in agreements for access to Region-owned / controlled waste heat sources	WRTEU provides new investment opportunity for utilities. Resource-efficient electrification led by WRTEU could help minimize impacts on electricity system.	WRTEU can design, build, finance, operate and maintain modernized, low-carbon campus energy systems.	Through economies of scale, standardized designs, and access to low-cost financing, WRTEU provides low-carbon thermal energy at a lower cost than one-off solutions.

Policies to Support WRTEU Success

A combination of region-wide building emissions policies, area-specific district energy policies, and region-wide energy planning policies are required to support the WRTEU value proposition and enable commercial success.

- High-Performance Development Standards can support the development of the WRTEU by establishing a requirement for low-carbon energy supply in new buildings.

- The Region of Waterloo and the area municipalities can also support the development of the WRTEU by establishing corporate sustainable building policies that commit to reducing emissions from municipally owned existing buildings, as well as a commitment for all new corporate buildings to meet strict greenhouse gas intensity limits.

- District energy (DE) bylaws with mandatory connection requirements are the strongest form of policy support for district energy. Mandatory connection policies would ensure that new buildings connect to WRTEU district energy systems, and would help to overcome the biggest barrier to new DE development.

- Area-based thermal energy transition plans integrating local data on building energy use, electric transmission and distribution systems, gas grids, and available thermal resources help identify high-priority projects and define an investment strategy for the WRTEU.

Additional policies that would support the success of the WRTEU include:

- Corporate procurement policies that enable municipalities to contract directly with the WRTEU for thermal energy services are another form of policy support.
- District energy ready requirement ensure new developments are compatible with future district energy connections.
- Specific resource-based policies, like wastewater heat recovery and geothermal energy development guidelines.

Governance Options

Thermal energy utilities, particularly district energy (DE) systems, can be structured under various ownership and governance models ranging from fully public to fully private. Success in deploying these utilities depends more on the context, design, and execution than the specific ownership model chosen. Municipal ownership is the most common model globally and provides municipalities with greater control over affordability, greenhouse gas reduction outcomes, and the balance between financial and environmental priorities.

A municipal services corporation (MSC) is a municipally owned corporation established for the provision of municipal services. In Ontario's water and wastewater sector, MSCs have emerged as a platform to provide municipalities with dedicated decision-making capacity that supports long-term sustainability and partnerships. MSCs offer several advantages over direct municipal ownership, such as enabling operational and financial scaling across municipalities, pooling expertise, accessing diverse financing opportunities, and supporting business-focused decision making by a skills-based board.

Hybrid governance models, such as the use of long-term service contracts, public-private partnerships, and split asset ownership, offer opportunities to combine public sector control over outcomes such as GHG emissions reductions with private expertise and investment. These models can reduce capital demands on municipalities and facilitate risk transfer to the private sector.

Thermal Utility Steering Committee input on WRTEU Ownership

The WRTEU Ownership Models workshop, facilitated by Reshape with the Thermal Utility Steering Committee (TUSC) in June 2025, gathered feedback on ownership objectives and evaluation criteria for the Waterloo Region Thermal Energy Utility (WRTEU). Feedback from TUSC members highlighted the importance of ownership and governance that prioritizes regional representation, collaborative planning, flexibility, and transparent governance. There was a consensus that some form of public ownership is necessary to achieve the WRTEU objectives. TUSC members favoured hybrid public ownership models that enable some risk transfer while retaining a high degree of public ownership and control.

Proposed WRTEU Ownership and Governance Framework

Rather than propose a single owner and ownership model for the WRTEU initially, it is recommended that the TUSC members pursue discrete projects under the form of ownership and governance that best suits the needs of individual projects. The proposed WRTEU governance framework is thus based on local ownership, supported by region-wide planning and contractual agreements between different parties (municipalities/municipal utilities and private sector service providers) for access to resources, provision of services, and delivery of customer contracts.

Over time, these relationships and ownership structures may evolve, potentially consolidating into larger regional entities or joint ventures, driven by regulatory changes, financial considerations, or operational efficiencies. Historical examples from the local electricity sector, and district energy sectors in Ontario and the United States illustrate how utilities have consolidated to enhance efficiency, access capital, and modernize infrastructure. These precedents provide a roadmap for evolutionary ownership of the WRTEU, emphasizing shared governance and regional coordination.

Recommended Next Steps

Based on feedback from WRCE and the TUSC, the following next steps are recommended:

Continue advancing current district energy projects, such as the Downtown Kitchener DES.

Develop area-based thermal energy transition plans for Waterloo Region to identify priority projects for further development. For each priority project:

- complete a technical feasibility study, and
- develop a project business case, including:
    - proposed ownership model
    - mechanism for securing customer commitments and/or supporting policies

Over time, these separate projects or utilities may consolidate into a region-wide WRTEU, enabling more efficient region-wide planning, operations, and access to capital.

Conclusion

The objective of the WRTEU is to enable Waterloo Region to move beyond incremental low-carbon projects towards a systemic energy transition. By establishing a forward-looking and flexible system of ownership with a focus on region-wide planning, collaboration and partnerships, the WRTEU can help Waterloo Region meet its climate commitments and drive innovation, resilience, and prosperity for generations.

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1 INTRODUCTION

The Waterloo region Thermal Utility Steering Committee (TUSC) was established in 2023 in response to the need for a thermal energy transition strategy for Waterloo region. The purpose of the TUSC is to explore the potential for establishing a new thermal energy utility to provide low-carbon thermal energy services in Waterloo region.

Reshape Strategies was engaged by WR Community Energy (WRCE) to support the development of a conceptual business case for a Waterloo Region Thermal Energy Utility (WRTEU) in late 2024. The objective for the conceptual business case is to create alignment among the Thermal Utility Steering Committee (TUSC) members[1] regarding the drivers for and value proposition of a WRTEU; facilitate a common understanding of the range of possible services the WRTEU could provide; and propose a vision for WRTEU ownership that allows ownership to evolve over time, within a coordinating framework that supports collaboration, capacity building and economies of scale.

2 CONTEXT AND OPPORTUNITY

Waterloo region's climate action pan, *TransformWR,* has set a long-term emissions reductions target of 80% below 2010 levels by 2050, with an interim target of a 30% reduction by 2030. Buildings are a major source of greenhouse gas (GHG) emissions in Waterloo region, responsible for approximately 45% of the Region's total GHG emissions. Data presented in *TransformWR* shows that natural gas use comprises 36% of the region's natural gas emissions (approximately 1,500 ktCO2e) and much of this is associated with space and domestic hot water heating in buildings.

Given the significance of building heat and domestic hot water as a source of GHG emissions, *TransformWR* established a target that by 2050, 85% of businesses and homes will no longer use fossil fuels for space heating, cooling, and domestic hot water heating, instead using low-carbon sources for heating and cooling.

In addition to replacing natural gas as the primary source of heating for existing buildings, the population of Waterloo region is expected to increase by approximately 35% over the next 25 years. This new population is estimated to require an additional 9.2 million m2 (99 million square feet) of floor area for housing (see Table 1), which, if heated with natural gas, could result in an additional 170 kt/CO2e emissions annually[2].

To ensure that new buildings do not add to the region's GHG inventory, it is imperative that new buildings are built with low-carbon thermal energy systems.[3,4]

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[1] Includes representatives for the Region of Waterloo, the City of Cambridge, the City of Kitchener, the City of Waterloo, Enova, GrandBridge Energy and Kitchener Utilities.

[2] Assuming space and domestic hot water heating energy use intensity of 85 MWh/m2 and 88% efficient equipment.

[3] Year-End 2023 Population and Household Estimates for Waterloo Region

[4] Region of Waterloo (Province of Ontario Growth Plan)

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Table 1: Estimated New Housing Floor Area Required by 2050

Area	Kitchener	Cambridge	Waterloo	Townships	Total
Population in 2023 (000s)	293	152	154	75	**674**
% of total Population	*43%*	*23%*	*23%*	*11%*	***100%***
Population in 2050 (000s)	401	208	211	103	**923**
Estimated New Housing Floor Area Required (million m2) [5]	**4.0**	**2.1**	**2.1**	**1.0**	**9.2**

In order to meet the emissions reductions targets set out in *TransformWR*, wide-spread, systematic retrofits of existing building heating systems will be required, and low-carbon heating systems or services must be installed in every new building in place of conventional natural gas heating systems. This transition must take place in both high-density urban cores as well as low density neighbourhoods and rural areas; an optimized solution may involve both district energy (or thermal energy network) solutions in high-density areas and building-scale systems in lower-density areas.

The establishment of a Waterloo Region Thermal Energy Utility was identified as a pathway for scaling-up the production and use of low-carbon thermal energy in Waterloo region to meet the *TransformWR* goals.

While many municipalities have identified thermal energy utilities as pillar of their climate action strategy, this has primarily been operationalized in the form of municipally owned district energy systems. However, there are examples of privately owned thermal energy utilities offering services at the scale of a single building[6], these have been established largely in response to the market created by local climate (green building) policies that require buildings to have low-carbon thermal energy sources.

Therefore, the core objectives of the WRTEU are to:

- Leverage local, low-carbon thermal energy sources to provide low-carbon thermal energy services to new and existing buildings, at both the building and district scale, to achieve *TransformWR* goals.
- Create local jobs in a low-carbon economy, monetize local resources, keep energy dollars in the community, and create new utility business models.
- Deliver safe and reliable energy, and increase community resilience and energy security, by offsetting increasing demands on the electricity system and optimizing the electrification of heating.

[5] Based on an allowance of 400 ft2 (47 m2) of new housing area per person.

[6] For example, Fortis Alternative Energy Services, GeoTility, Geosource, Subterra, Diverso

- Leverage opportunities for efficiency, economies of scale, low-cost financing and grants to deliver affordable low-carbon energy in a financially sustainable manner.

What is a Thermal Energy Utility?

Thermal energy utilities provide thermal energy services to their customers, as opposed natural gas or electric utilities that provide "fuel" which is converted into thermal energy with on-site equipment owned by the building (e.g. boilers, furnaces, air conditioners and heat pumps).

Thermal energy utilities may provide service at the neighbourhood scale (e.g., district energy systems) or at the scale of a single building.

Thermal energy utilities that operate at the building scale typically design, build, own and operate the thermal energy system located within the building (or on the same property). The key attributes of a thermal energy utility (at either the neighbourhood or the building scale) are that the service typically:

- Provides thermal energy to the building (not fuel energy)
- Includes construction, financing, operation, maintenance and lifecycle replacement of the thermal energy systems

Thermal energy utilities earn revenue through three main sources:

- Connection fees or capital contributions (when a building is connected)
- Rate revenue for thermal energy delivered
- Rate revenue for the thermal energy system capacity provided

3 PRIOR WORK BY OTHERS

WRCE and TUSC member organizations have already completed significant work to identify and map thermal energy sources within Waterloo region, as well as complete techno-economic analyses of specific project opportunities, including district energy systems in the cities of Kitchener and Waterloo. This section summarizes this prior work in the context of the *TransformWR* climate targets and regional growth. Prior work reviewed is listed as follows:

1. Towards an Integrated Thermal Energy Strategy for WR (WRCE, 2024)
2. WR Community Energy Investment Strategy (Waterloo Region, 2018)
3. Transform WR (Waterloo Region, not dated)
4. Region of Waterloo Water and Wastewater Systems Heat Recovery (Reshape, 2023)
5. Opportunities for Open Loop Geoexchange in Waterloo Region (WRCE, 2021)
6. Wastewater Heat Recovery in Waterloo Region (WRCE, 2021)
7. Kitchener Downtown DES Pre-Feasibility Study (FVB, 2020)
8. Downtown Kitchener District Energy System Technical and Financial Analysis – Public Release (FVB, 2024)
9. University Gateway District Energy Project (FVB, 2024)

3.1 Low Carbon Thermal Resources

Site-specific low-carbon thermal energy sources in Waterloo region include wastewater heat recovery, geothermal energy, and industrial waste heat recovery. In addition, air source heat pumps, electric boilers and bioenergy (solid biomass or biofuels) are expected to contribute to the decarbonized thermal energy supply by 2050. A summary of these resources, based on prior studies led by WRCE, FVB and Reshape Strategies is provided below.

- **Wastewater Heat Recovery:** Based on the wastewater influent flows at Kitchener, Waterloo, Galt, Preston and Hespeler wastewater treatment plants, it is estimated that up to 1,100 GWh or 14% of the region's total heating load in 2050 could be met with wastewater heat recovery. This total assumes that any upstream sewage heat recovery (in the collection system) is subtracted from available heat at the wastewater treatment plants. These estimates are based on the forecasted influent flow rates in 2050[7].
- **Geothermal:** Work commissioned by WRCE and completed by Beatty Geothermal Consulting concluded that "*The vast distribution of both overburden and bedrock aquifers in the Waterloo Region provides a unique carbon-free resource for heating and cooling the building sector. Open loop geothermal systems have the potential to drastically increase the Region's [low-carbon] energy production capacity."* While this resource has not been quantified, it is expected to represent a very significant share of the total thermal energy supply by 2050 (in an 85% decarbonized heat supply scenario).[8]
  - The Downtown Kitchener District Energy System (DES) concept is based on open-loop geothermal, and the heat supply from this system represents approximately 1% of the total heat load in 2050[9].
- **Industrial Waste Heat:** The document *Towards an Integrated Thermal Energy Strategy for WR,* prepared by WRCE identified significant industrial waste heat recovery potential in the region, based on industrial surplus heat from the auto, food and beverage, and material processing industries.
- **Air Source Heat Pumps and Electric Boilers:** Based on the balance of total low-carbon energy required to meet the *TransformWR* building decarbonization targets in 2050, it is expected that a significant share of the total thermal energy supply will be produced by a combination of air-source heat pumps (ASHP) and electric boilers, at both the individual building and district scales. In an optimized decarbonization scenario, the use of electric boilers will be limited to applications where heat pumps are not capable of meeting the heating needs alone and will be coupled with thermal energy storage to support peak electrical demand shifting and lower electricity costs.
- **Biofuels:** Biofuels such as waste wood and renewable natural gas (RNG) may also contribute to the future low-carbon fuel mix in decarbonized 2050 scenario.

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[7] This work builds on previous analysis completed by Reshape Strategies in 2023 for the Region of Waterloo as reported in the *Water and Wastewater Systems Heat Recovery* report.

[8] *Opportunities for Open Loop Geoexchange*, Beatty Geothermal, 2021

[9] *Downtown Kitchener DES Technical and Financial Analysis* report, FVB Energy, 2024

Resources such as sewer and treated effluent waste heat and industrial waste heat are better suited to use at the neighbourhood scale via district energy systems, while geothermal systems, air source heat pumps and electric boilers can be deployed at both the individual building scale and the district scale.

In dense urban areas, capital cost efficiencies, space constraints, electricity distribution system capacity constraints and building-scale retrofit costs may make low-carbon district energy the preferred decarbonization pathway. Strategic use of RNG for peaking in district energy systems may help to manage peak electrical demands and electrical infrastructure costs.

3.2 District Energy System Studies

WRCE engaged FVB energy to complete a study of DE potential in uptown Waterloo, linking the waste heat resource at the Waterloo WWTP to major heat load centres along University Avenue, including Wilfred Laurier University and University of Waterloo. This report identified up to 1.8 million square meters of floor area that could be connected to the University Gateway Wastewater Heat Recovery Project, approximately 50% of this floor area is estimated to be new buildings.[10]

Based on the estimated new floor area required by 2050 to house the region's growing population, the University Gateway Wastewater Heat Recovery Project could potentially serve up to 40% of the required new housing floor area in the City of Waterloo (Table 2).

The City of Kitchener engaged FVB Energy to complete a feasibility study for a Downtown Kitchener DES, which identified 1.2 million square meters of new development that could be served by the proposed DES, representing approximately 20% of the required new housing floor area in the City of Kitchener in 2050 (Table 2).

[10] *University Gateway District Energy Project* report, FVB Energy, 2024

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Table 2: Potential Floor Areas Served in DE Opportunity Areas of Waterloo Region

DES Opportunity Area	Downtown Kitchener DES (million m2)	University Gateway Heat Recovery Project (million m2)
Forecast of Build-out Floor Area Connected – Total	1.2	1.8
Forecast of DES Build-out Floor Area Connected – New Buildings	0.8	0.9
Estimated New Housing Built 2024 to 2050 – Total for Municipality	4.0	2.1
DES-Connected New Floor Area as % of Estimated New Housing Floor Area in Municipality[11]	**20%**	**40%**

3.3 Potential Scope of WRTEU Services

Given that Waterloo region encompasses dense urban areas such as downtown Kitchener and Waterloo, neighbourhoods of single family homes, and rural areas, WRTEU will need to develop service offerings that can be implemented at different scales. While district energy may provide the lowest-cost transition pathway in dense urban areas, it is likely that air source heat pumps and geothermal systems designed to serve a single building will be the preferred solution in low density areas. To accelerate the transition of low-density areas to low-carbon heating systems, the WRTEU should develop a range of service offerings that includes building-scale low-carbon energy systems, not just district energy.

4 WRTEU VALUE PROPOSITION

Given the scale of the thermal energy transition required in Waterloo region, the range of low-carbon energy sources available, and the potential scope for district energy, a there is an opportunity for a Waterloo Region Thermal Energy Utility to have a pivotal role in the region's energy transition.

The value proposition for a thermal energy utility operating region-wide, with a mandate to complete low-carbon energy transition plans and provide low-carbon energy services is outlined below.

[11] Not all DE connected floor area will be residential.

4.1 Region of Waterloo, Area Municipalities and Townships

For the Region of Waterloo, the WRTEU would be an agent for the delivery of the building decarbonization strategies outlined in *TransformWR*. Similarly for the municipalities, the WRTEU could provide a readily available compliance option for municipal high performance development standards with GHG emissions caps.

Since the Region of Waterloo and the municipalities own and control one of the largest waste heat resources in the region (sewer waste heat and treated effluent waste heat), the WRTEU could be a trusted partner for the delivery of energy recovery projects that interface with Regional and Municipal wastewater infrastructure.

In addition, the Region of Waterloo controls access to and use of the groundwater in aquifers, which may be used for geothermal energy systems.

In the Townships and greenfield developments across the region, a regional thermal utility could play an important role in delivering low carbon energy to new and existing buildings. The electrification of heat could avoid the need to extend gas distribution infrastructure to new development areas, as well as avoid or delay electrical distribution system upgrades.

Depending on the utility ownership model, the WRTEU may be able to access financing sources unavailable to municipalities, leveraging private capital to achieve public sector climate goals.

4.2 Local Utilities

The WRTEU represents a new business opportunity for gas and electric utilities and could provide investment opportunities. Gas utilities may transition to providing low-carbon thermal energy services as the natural gas distribution system is retired.

The WRTEU offers significant value to the region by creating new pathways for collaboration and innovation among gas and electric utilities. By facilitating the transition to low-carbon thermal energy services, the WRTEU can help utilities diversify their offerings and align with evolving regulatory and environmental expectations.

Electrification of heating via the WRTEU could help to manage the impact of the energy transition on local electrical distribution systems by leveraging local resources, thermal energy storage, and load aggregation with strategic use of the gas grid - resulting in avoided incremental costs for electricity transmission and distribution.

This collective approach supports the region's energy transition, while enabling local utilities to play a proactive role in shaping a sustainable energy future and leveraging their expertise in utility infrastructure, management and customer service.

4.3 University and Hospital Campuses

Many university, college and hospital campuses in Canada have existing district energy systems. Often these existing systems are old and have high emissions. Furthermore, some systems have deferred maintenance and require significant reinvestment to ensure reliability, others have decarbonization goals that require significant investment. Institutional investment in renewal of campus energy infrastructure reduces the institution's financial capacity to serve their core missions of education, research or healthcare.

The WRTEU could provide a solution to aging, high-carbon campus energy infrastructure through a long-term service agreement with the institution. As part of the agreement the WRTEU could take on the responsibility to:

- Design and deliver modernized campus energy systems, improving efficiency and reducing GHG emissions.
- Operate and maintain the campus energy systems, with an obligation to achieve KPIs related to efficiency and GHG emissions.
- Finance the energy system renewal.

Under this model, the WRTEU would earn a return on investment through rates paid by the institution to the utility over the term of the contract, and the institution benefits from long-term energy cost stability (although there is often still exposure to variability of commodity costs).

4.4 Building Owners and Energy Ratepayers

By aggregating the delivery of low-carbon energy retrofits and low-carbon district energy systems across Waterloo region, WRTEU may be able to deliver low-carbon thermal energy to building owners and energy rate payers at lower cost than a dis-aggregated approach to the thermal energy transition.

A region-wide thermal energy utility could achieve cost savings in a number of ways, including:

- Reducing energy system capital costs through economies scale, standardized design solutions, expertise in project delivery and more competitive procurement of standardized equipment at scale.
- Accessing low-cost financing and capital grants to reduce the costs that must be recovered from building owners and rate payers. WRTEU could be more likely to meet the requirements for financing from the Canada Infrastructure Bank by bundling projects to achieve the required scale.
- Operating cost savings through more competitive procurement for operations and maintenance contracts, a centralized depot for spare parts for standardized equipment, and optimized maintenance schedules resulting in longer equipment service life.
- Fuel cost savings through peak electrical demand management in district energy systems, access to low-cost or free sources of waste heat at scale, and better operational efficiency resulting from professional operation and maintenance.

For building owners and developers, the WRTEU could provide additional cost savings and benefits, including:

- Reduced up-front capital for low-carbon energy systems in new buildings with the balance of energy system capital costs financed by the WRTEU and recovered over time through rates.
- Low-carbon energy retrofits can be financed by the WRTEU and paid for over time through utility rates, rather than buildings owners financing retrofits directly.

- DE connected buildings realize space savings which can be used for building amenities or additional housing units, providing additional value to building developers.
- For building owners and developers, the value proposition of the WRTEU is underpinned by policies that regulate GHG emissions from buildings (see Section 5.1.1).

4.5 Long Term Value Proposition

Over time, the WRTEU could serve as a platform to consolidate thermal energy utilities where such integration would deliver demonstrable public benefits. Consolidation may offer opportunities to improve access to local resources, operational efficiency, enhance service reliability, and achieve greater economies of scale in planning, financing, and delivery. Any such evolution would be pursued collaboratively, with participating municipalities retaining local oversight while aligning governance, technical standards, and investment planning under a unified regional framework. This approach ensures that growth in WRTEU's role is guided by measurable public value and improved delivery capability.

5 POLICIES TO SUPPORT WRTEU SUCCESS

Climate and energy policies can be grouped into the categories of non-compulsory (voluntary) and compulsory. Non-compulsory policies include levers such as funding and incentives, subsidies and education and outreach.

Many years of climate inaction in the face of the widely acknowledged climate emergency has shown that non-compulsory climate and energy policies are not sufficient to meet emissions reductions targets, and it has become clear that compulsory climate and energy policies are required to drive the changes in our infrastructure necessary to reduce GHG emissions. Since the core objective of the WRTEU is to enable the low-carbon energy transition of buildings in Waterloo region, climate and energy policies that drive emissions reductions from buildings are essential to the business case for the WRTEU.

Policies to reduce emissions from buildings can be implemented at the building scale (through building-level policies) or at the neighbourhood scale through district energy polices. These policies can apply to both new and existing buildings (although proposed or pending regulations on existing building emissions are only starting to emerge in Canada, there are examples of existing building emissions regulations in other jurisdictions[12,13]).

Compulsory climate and energy policies at the building-scale may include direct regulation of energy use (such as mandatory connection to a DES, natural gas bans or electrification requirements) or direct regulation of emissions (such as GHG intensity caps or emissions reduction targets) with demonstration of compliance required to receive permits, and penalties for non-compliance in existing buildings.

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[12] New York Local Law 97 (in force in 2024).

[13] Vancouver Existing Buildings Policy (2025), Toronto Net Zero Existing Buildings Strategy (2026).

Policies that regulate energy use or emissions at the building level are a form of indirect policy support for the WRTEU, as they create a demand for the low-carbon thermal energy services WRTEU would provide. Mandatory connection requirements to WRTEU district energy systems would be a direct form of policy support for the WRTEU.

Carbon pricing is another form of compulsory climate policy which indirectly influences the energy supply for new and existing buildings and provides policy support for low-carbon thermal utilities.

Lastly, municipal or regional policies that require the development of Area-based Energy Plans for how to meet energy demands at the neighbourhood, municipality or regional level, considering existing infrastructure, growth and expected changes in energy use patterns (including decarbonization) are a form of indirect policy support for the WRTEU, by identifying and prioritizing investment opportunities and informing the business case for specific projects.

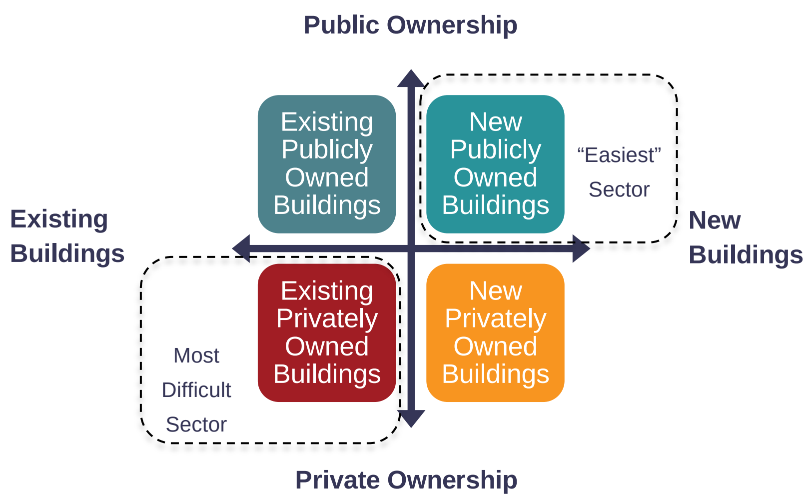
These types of policies are described in more detail in the following sections.

5.1 Direct Regulation of Building Energy Use or Emissions

To achieve the climate targets identified in *TransformWR*, regulation of building energy use or emissions will be required for both new and existing buildings. The ease with which the required policies can be implemented varies significantly between new versus existing buildings and with building ownership as shown in Figure 1. The range of possible policies for these different market sectors is summarized in Table 3.

In general, municipalities have more leverage over their own (corporate) buildings and the emissions performance of new buildings through the development approvals process (which may include energy or emissions targets in green development policies such as the Waterloo Region *High-Performance Development Standards*[14]).

Figure 1: Ease of Implementation of Climate and Energy Policies for Buildings



[14] Released for consultation in December 2024

5.1.1 High-Performance Development Standards

High-performance development standards can support the development of the WRTEU by establishing a requirement for low-carbon energy supply in new buildings. High-performance development standards are most effective as climate policy when they are compulsory and include greenhouse gas intensity (GHGI) targets that result in the need for either on-site low-carbon thermal energy systems or connection to a district energy system with a low-carbon service offering.

The value of compulsory high-performance development standards is evidenced by the expansion of privately owned thermal energy utilities serving master planned developments and single buildings in Toronto (as the result of the Toronto Green Standard) and in Vancouver (as a result of the Vancouver Building Bylaw and the Zero Emissions Building Plan).

While it is possible for developers to comply with the GHGI requirements of these policies by designing and installing the necessary low-carbon energy systems themselves (and transferring the ownership of the system to the condo board at completion in the case of condominium development), this approach requires the developer to take on additional cost, complexity and risk associated with unfamiliar technologies, and contend with potential delays in project permitting as a result of requirements for demonstrating compliance.

Low-carbon service offerings by thermal energy utilities (both district and building-scale) provide an alternative to developer-delivered low-carbon energy systems. By contracting with a thermal energy utility for the provision of low-carbon energy services, developers can transfer responsibility for the design, construction and operation of the thermal energy system for the building to the thermal energy utility. Often these agreements also include financing of the low-carbon energy system by the energy utility, allowing the developer to avoid the capital cost of an on-site thermal energy system, since the thermal energy utility will recover their costs from through utility rate revenue over the long-term contract. This feature is particularly attractive as the cost of the energy system increases with a declining GHGI requirement. Furthermore, if a developer contracts with a thermal energy utility that is recognized or pre-approved by the municipality, compliance with high-performance development standard may be streamlined.

5.1.2 Corporate Sustainable Buildings Policies

The Region of Waterloo and the area municipalities can support the development of the WRTEU by establishing corporate sustainable building policies that commit to reducing emissions from municipally owned existing buildings, as well as a commitment for all new municipal buildings to meet strict greenhouse gas intensity limits.

A corporate sustainable buildings policy that incentivizes municipally owned buildings to connect to WRTEU DES where systems are available; become anchor loads on new WRTEU DES when they are being developed; and contract with the WRTEU for building-level electrification and retrofits where DE connection is not an option, would help to establish a market for building energy system services and de-risk the development or expansion of WRTEU services.

5.2 Direct Thermal Energy Utility Policies

The objective of direct thermal energy utility policies is to secure the demand for thermal energy utility services, these policies can work at both the district and individual building scale.

5.2.1 District Energy Service Area Bylaws

The biggest barrier to DE development is connection risk; DE utilities typically rely on connecting brand-new buildings to support the initial investment in generation and distribution infrastructure. This makes connection risk a combination of two risks: Will new buildings be constructed soon enough? And will they ultimately connect to the system?

DE infrastructure is capital-intensive with high up-front investment in long-lived assets, and connection risk is a significant barrier to the development of new systems. Unlike large gas and electricity networks, which benefited from supportive policies and subsidies in the past, local DE systems cannot easily pool extension risks across a large established customer base.

A new DE utility will compete with established utilities that have historically received policy support and financial subsidies. These supports were crucial to the widespread adoption of these traditional utilities, enabling them to overcome similar infrastructure and connection risks during their formative years. Without comparable policy backing, a DE utility faces a steep challenge in building a customer base and attracting investment. Therefore, effective DE policy to manage demand risk is essential for establishing new systems.

One of the simplest ways to reduce connection risk is through a mandatory connection policy. Denmark pioneered the concepts of *heat planning* and mandatory connection to DE in specific areas as a tool to promote extensive development of DE. In these areas, connection to the DE utility can be required on the condition that the plan that demonstrates DE as the lowest-cost.[15] Consumers are further protected by a requirement for cost-based pricing (rate-setting mechanisms that are based on cost-of-service), including a non-profit principle. Mandatory connection also applied to existing buildings, although a lengthy grace period was often granted for existing buildings. Area based planning is discussed in further detail in Section 5.3.

Mandatory connection can be limited to specific areas, specific types of connections or specific time periods. Outside these parameters, connections or renewals can be voluntary. For example, the City of Vancouver has a mandatory connection bylaw covering new construction and major renovations within a designated service area for its False Creek Neighborhood Energy Utility.

Connections by existing buildings or buildings outside the service area remain voluntary. Mandatory connections may be used temporarily as a tool to support new system development by promoting an efficient layout and helping achieve adequate scale. Other large cities in BC have taken the same approach (municipal ownership with a mandatory connection requirement in a service area bylaw) including the City of Surrey, the City of Richmond and the City of North Vancouver.

[15] This comparison is usually done on a long-term levelized cost basis, which may also take into account the avoided costs of externalities, or other public benefits.

In Alberta, the City of Edmonton is developing the Blatchford Renewable Energy Utility with the support of a service area bylaw that requires buildings to connect to the utility unless the developer can demonstrate that the building will be built to at least a net-zero carbon standard.

While the above approach remains untested in Ontario, the Region of Durham is pursuing a municipally owned District Energy System with service area bylaw and mandatory connection requirement for the Courtice Transit Oriented Community in Clarington[16].

5.2.2 Corporate Procurement Policies

A corporate policy that designated the WRTEU as the preferred service provider for on-site low-carbon energy systems for regional, municipal, and utility-owned buildings (both new construction and retrofits) would further de-risk the development of WRTEU infrastructure by providing more certainty about the market for WRTEU services.

Table 3: Policy Options to Support WRTEU Development

Customer Type	Existing Buildings	New Buildings
Publicly Owned Building	❑ Corporate emissions targets for existing buildings ❑ Corporate commitment to procuring thermal energy services exclusively from WRTEU[17]	❑ Corporate High Performance Development Standard including a GHGI target ❑ Corporate commitment to procuring thermal energy services exclusively from WRTEU[17]
Privately Owned Buildings	❑ High Performance Development Standard in effect for major renovations ❑ Service area bylaws with mandatory WRTEU DES connection for major renovation[17] ❑ Existing building emissions regulations ❑ Limit on sale of natural-gas burning appliances	❑ High Performance Development Standard with GHGI target ❑ Service area bylaws with mandatory WRTEU DES connection[17] ❑ WRTEU service contract as condition of land sale or lease[17] ❑ Limit expansion of the natural gas grid ❑ Developer incentives (accelerated permitting) for buildings with WRTEU service contracts

[16] Regional Municipality of Durham, Committee of the Whole Report 2025-COW-19 (May 14, 2025)

[17] Feasibility of this approach is likely to depend on some form of public ownership of the WRTEU.

5.3 Area-Based Thermal Energy Transition Plans

Achieving the building-sector emissions reductions targets identified in *TransformWR* will require a portfolio of strategies such as building level energy system retrofits, district energy systems, and low-carbon fuels; however where and when to deploy these different strategies depends on the local context. Area-based heat transition plans are a tool for coordinating, phasing and spatially targeting transition strategies and policies for a defined geographic area. These plans aim to identify, prioritize and utilize local clean and renewable heating and cooling sources at the local level.

An area-based thermal energy transition plan integrates information on building thermal energy use, the local electrical distribution system, the local gas grid, and local low-carbon thermal energy sources or existing thermal utilities. The objectives of an area-based plan are to:

- Identify areas where district energy is expected to be the lowest cost pathway for building decarbonization; including the incremental or avoided cost of electric grid upgrades in building-scale and DE approaches; and
- Identify areas where direct building electrification (i.e. building-scale heat pumps) are expected to be the lowest cost pathway for decarbonization.
- In areas where direct electrification is preferred, area-based heat transition plans identify:
    - If, when and where grid capacity constraints are expected as a result of electrification
    - A phasing plan for building retrofits to focus first on areas without grid constraints
    - A phasing plan for electrical grid upgrades
    - Opportunities for gas grid decommissioning in specific areas

The intended outcomes of the area-based planning process are geographically targeted policies, incentives and investments that support the coordinated deployment of the area-based transition plan.

Other jurisdictions that are employing area-based plans as part of their energy transition strategies include:

- **Denmark:** Heat planning has been required in Denmark since the Danish Heat Supply Act of 1979. The original driver of area-based planning was energy security, but it has evolved to include climate goals, and consideration of impacts on electrical grids.
- **Germany:** In 2024 Germany was one of the first EU member states to establish a nationwide heat planning obligation for all cities. Cities with a population of more than 100,000 must draft heat plans by 2026. Smaller cities with more than 10,000 inhabitants must draft plans by 2028.
- **United Kingdom:** In 2023, the British Energy Regulator, Ofgem, announced the development of Regional Energy Strategic Planners (RESP). RESPs will work with local government and local energy networks to develop more strategic, coordinated, spatial and place-based energy and infrastructure plans.
- **United States:** Several U.S. states have begun piloting neighbourhood-scale decarbonization projects that require gas and electric utilities to work together and with local communities to transition buildings to zero-emission alternatives.

5.4 Supporting Policy Tools

Infrastructure and resource-related policies that can help to secure a market for the WRTEU and facilitate access to low-carbon thermal energy include district-energy ready frameworks (or design guidelines) and resource-specific policies that govern access and use of low-carbon resources such as wastewater, geothermal, industrial and data centre waste heat, and renewable natural gas.

5.4.1 District Energy Ready Frameworks

A district energy ready guideline that municipalities could adopt or require in specific neighbourhoods would provide a mechanism for preventing carbon lock-in of new developments in neighbourhoods where district energy is likely to be developed but is not available in time to connect new buildings. A district energy ready design guideline could be provided to developers to ensure that the building mechanical systems are compatible with district energy service when it becomes available in the future. Connection to the district energy system in the future may be triggered when the on-site energy systems in the building have reached the end of their service life.

5.4.2 Wastewater Heat Recovery Policies

Municipal and regional wastewater heat recovery policies can be helpful in providing a clear process and terms for securing access to municipally owned wastewater thermal resources.

For example, the Greater Vancouver Sewerage & Drainage District (Metro Vancouver) has a Liquid Waste Heat Recovery Policy whose purpose is to “enable beneficial use of waste heat and associated greenhouse gas emissions reductions from Metro Vancouver’s liquid waste system by external parties”. The policy supports Metro Vancouver’s *Integrated Liquid Waste and Resource Management Plan* goal of using waste as a resource, while emphasizing that conveying and treating wastewater remains the top priority.

The policy applies to situations where an external party is requesting waste heat from Metro Vancouver’s liquid waste system and situations where Metro Vancouver is offering waste heat to external parties.

The policy, summarized in Table 4, distinguishes between collection system projects and treatment plant effluent/outfall projects.

While Metro Vancouver does not charge a fee for access or use of wastewater heat recovery, other municipalities such as Toronto and Ottawa do charge a nominal fee for the energy.

Table 4: Summary of Metro Vancouver Liquid Waste Heat Recovery Policy

Subject	Collection System	Treatment Plant/Outfall
Method for Allocation of Resource	First-come, first serve basis. Existing/Approved projects have priority over new applications.	Access to waste heat offered through a competitive process.
Ownership & Responsibility[18]	Metro Vancouver will own and be responsible for the portion of the wastewater collection system tie-in up to and including a shut-off valve on both the diversion and return lines.	Metro Vancouver will own and be responsible for waste heat recovery infrastructure and equipment installed within the wastewater treatment plant and effluent outfall.[19]
Cost Recovery	Metro Vancouver will charge the heat user for all costs incurred to establish and maintain access to wastewater. A contract with the heat user will be established for each project that assigns the costs and benefits between Metro Vancouver, the heat user and other funding sources.	Metro Vancouver will recover the costs incurred in providing waste heat to external parties over the life of the project. A contract with the heat user will be established for each project that assigns the costs and benefits between Metro Vancouver, the heat user and other funding sources.
Profit	Metro Vancouver does not seek to profit from the provision of heat	
Environmental Attributes	Benefits associated with greenhouse gas reductions will be allocated on a case-by-case basis, in accordance with the costs and risks incurred by the parties involved in developing the heat recovery project.	

The City of Toronto's 2025 Report to Council on the Wastewater Energy Transfer Program outlines the implementation plan for the Wastewater Energy Transfer Program. The report's recommendation is to delegate authority to City officials to negotiate and execute wastewater energy transfer agreements, provided the projects meet specific conditions regarding non-detrimental impact on the city's wastewater systems. To fund the program's administration, new user fees and charges are proposed for data requests and application review, ensuring costs are recovered from applicants rather than the tax base. The report details a review process for future project applications.

The City of Ottawa does not have a sewer heat recovery policy; however, a pilot sewer energy exchange project is currently being developed.

[18] Ownership and responsibility for other equipment is defined in the contract between Metro Vancouver and the heat user.

[19] Except in cases where ownership by an external party is deemed to be preferable by Metro Vancouver.

5.4.3 Geothermal Energy Development Guidelines

The report on open loop geothermal opportunities in Waterloo region identifies provincial legislation, and municipal bylaws that regulate the construction of open-loop and closed-loop geothermal systems in Waterloo Region. Updating, and aligning these policies at the region level and developing a guideline for the development of geothermal projects in Waterloo region could facilitate increasing use of this abundant resource while safeguarding potable water supply.

6 THERMAL ENERGY UTILITY OWNERSHIP AND GOVERNANCE OPTIONS

The discussion in this section is focused on District Energy (DE) ownership models, since thermal energy utility operations have historically been focused on DE systems. There are examples of privately owned thermal energy service providers offering building-scale solutions[20], but this service sector does not feature a diverse range public and private of ownership models in the way that DE does. However, many of the characteristics, advantages and disadvantages of the DE ownership models would apply to a thermal energy utility offering building-scale thermal energy services as well.

Most DE systems fall along a spectrum from fully public to fully private and there are examples of both for-profit and not-for-profit municipal DE utilities. Between fully public and fully private, there are many types of hybrid models with varying degrees of shared ownership or governance, with many variations, and success stories and lessons to learn from all models. Success often depends more on the context, design and quality of execution than on the model itself.

6.1 Municipal Ownership

Municipal ownership typically provides the greatest degree of control over rates and affordability as well as GHG outcomes. With municipal ownership, municipalities can determine how best to manage competing priorities such as affordability, cost recovery, and environmental performance. An example of a thermal energy utility that is currently under direct municipal ownership is the City of Vancouver's False Creek NEU.

Full public ownership is the most common model globally for DE. It often takes the form of municipal ownership but can also include ownership by other public sector entities such as regional governments, state / provincial agencies, or social housing agencies. There are many variations of municipal ownership, from internal departments to stand-alone subsidiaries (e.g., municipal services corporations) with varying degrees of autonomy. DE can also be delivered via other wholly owned municipal utilities in some cases.

[20] For example, Fortis Alternative Energy Services, GeoTility, Geosource, Subterra, Diverso

Municipal ownership enables:

- Control over both the objectives and means of development. Outcomes important to the public sector go beyond commercial goals of affordability, reliability, and profitability, and often include broader climate, environmental, equity, resilience, and economic development considerations.
- Governments to determine an acceptable balance across multiple objectives and to select the specific means of achieving the desired outcomes (e.g., service areas, technologies, financing model, rate structures, rates, etc.).
- Greater opportunities for low-cost financing, grants and other direct contributions for public benefits, which can help to reduce tensions between service affordability and other policy objectives for DE.

Municipal ownership can be very helpful in the early stages of DE development and can enable more direct control over risks which may hinder private sector investment or increase private sector financing costs. Connection risk can be a major impediment to setting up DE networks or transitioning existing networks to low-carbon energy, particularly in the absence of other supporting policies. Municipalities can reduce connection risk through close coordination of DE development with municipal policy/planning or mandatory connection policies. Municipal ownership may increase public acceptance and legal support for mandatory connection policies.

In jurisdictions that regulate DE, municipal systems are typically excluded from economic regulation or regulated indirectly under more general regulation of municipal activities. In these jurisdictions, other ownership models can therefore trigger an additional layer of oversight by a public utilities commission. This may be a further driver for municipal ownership, however, thermal energy utilities are not currently economically regulated in Ontario.

While economic regulation can enhance transparency and accountability, the form of regulation can also increase administrative burdens, risks, uncertainties and constraints that may hinder the development or expansion of DE systems that are aligned with municipal policy objectives.

6.1.1 Municipal Services Corporations

A municipal services corporation (MSC) is a municipally owned corporation established for the provision of municipal services. In the water and wastewater sector, MSCs have emerged as a platform to provide municipalities with dedicated decision-making capacity that supports long-term sustainability and partnerships. An MSC must be wholly owned by one or more municipalities, or other public sector entities, and can be created as for-profit[21] or non-profit entities. MSCs are governed by a board appointed by its shareholders (the municipalities).

These key attributes make MSCs a vehicle of interest for the delivery of municipal thermal energy utility services in Ontario. In particular, the Region of Durham is considering establishing a district energy system in Clarington under MSC ownership.[22]

Municipalities in Ontario have the legal authority to create MSCs under the *Municipal Act, 2001*.

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[21] In which case, the MSC would pay dividends to its public-sector shareholder(s).

[22] Regional Municipality of Durham, Committee of the Whole Report 2025-COW-19 (May 14, 2025)

To establish an MSC, municipalities must:

- Develop a business case.
- Adopt and maintain policies regarding the transfer of assets.
- Consult with the public.

An MSC can:

- Operate in other municipalities (with permission).
- Contract with the private sector for services.
- Collect revenue through user fees and rates.

An MSC cannot:

- Directly collect development charges; however, municipalities can collect development charges and transfer them to the MSC as equity.
- Establish subsidiaries or incorporate other MSCs.
- Perform activities it was not created for.

Municipal ownership of a thermal energy utility through an MSC could provide the following advantages in terms of decision-making and organizational capability:

- MSCs can enable operational and financial scaling opportunities among groups of municipalities, facilitating infrastructure planning across municipal boundaries, pooling delivery expertise, and providing administrative efficiencies.
- MSCs can be set up to borrow and access financing opportunities that may not be available under municipal ownership, as these reduce municipal borrowing capacity. This allows MSCs to use debt for major capital expenses.
- MSC boards can have unelected officials chosen based on specific skill sets (e.g., industry expertise) to build sector expertise.
- MSC boards provide depoliticized, business focused decision making with respect to capital planning, investment and rate setting.
- The MSC board provides dedicated decision-making capacity, separate from other municipal priorities and processes.

Risks and disadvantages associated with MSCs include:

- Potential misalignment between the MSC board (which has a fiduciary responsibility to the utility) and the municipal councils (which have a broader mandate to serve the community).
- Reduced transparency of decision-making relative to council proceedings (commercial decisions are made at the MSC board level and not by council).
- Although MSCs can be set up to access private debt for financing capital projects without impacting the municipalities' borrowing capacity, the financing may be subject to higher rates (or the member municipalities may be required to guarantee the loan).

6.2 Hybrid Ownership Models

Many of the benefits of municipal ownership can, in theory, be secured through private-sector delivery with the right ownership or governance models. Hybrid ownership models can reduce or eliminate capital and organizational demands on municipalities, while also transferring risk and securing additional expertise. However, public sector influence in hybrid ownership models may be more outcomes oriented than means-oriented.[23]

Governance can also be more complicated and nuanced in hybrid ownership models, and in jurisdictions that regulate DE, hybrid ownership models introduce regulatory complexity. Furthermore, private ownership tends to increase financing costs and constrain the kinds of trade-offs between financial returns and public benefits that are possible under direct public ownership.

The negotiation of well-defined, outcomes oriented, principled contracts between the public and private parties under hybrid ownership and delivery models is essential to achieving the risk transfer and public benefits sought by the public sector.

6.2.1 Municipal Ownership with Long-Term Service Contracts

There are many examples of municipal DE systems that secure services from the private sector without transferring ownership or control of the municipally owned DE systems. These services can include design, construction, operations, maintenance and may even include financing support.

Service providers possess the industry-specific knowledge thermal energy utilities require. Outsourcing these services can thus help reduce demand on municipal organizational capacity or capital. These long-term services contracts can enable municipal owners to transfer some of the design, construction and operational risk to the service provider while retaining municipal ownership and control.

6.2.2 Public-Private Partnerships

Public-private partnerships can take the form of joint ventures (shared public and private ownership) or split asset models, where private companies control some assets and public companies control the remaining assets, with contracts governing the relationships among assets and owners. For example, both Oslo and Stockholm have large DE systems which are joint ventures between the municipalities and private investors or companies.

6.2.3 Split Asset Ownership

Split asset ownership allows municipalities to retain control over specific assets (such as wastewater systems), while enabling access to thermal resources. Split asset ownership may also facilitate the use of municipal authority to mandate connection to a municipally owned DE distribution system [24.] The municipality can then contract with a third party for the supply of energy to the distribution system.

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[23] Under this model, the public sector may define requirements for GHG outcomes but be agnostic to the technical solutions delivered by the private sector to achieve those outcomes.

[24] Where municipalities have the jurisdictional authority to mandate connection to a municipally owned utility.

Under a split-asset configuration, energy systems can also share energy across defined ownership demarcation points, with metered energy pass-through ensuring accurate accounting and clear ownership separation. Split asset ownership can be public-to-public, or public-to-private. Examples of the split asset model include:

- Metro Vancouver, which owns an existing waste-to-energy facility (WTEF), is building heat recovery and transmission infrastructure to sell heat from the WTEF under a long-term supply contract to a private DE company in Vancouver (River District Energy).
- The joint low-carbon heating plant developed by the privately owned Corix Utilities to serve both the Simon Fraser University (SFU) academic campus DES (existing) and an adjacent neighbourhood DES owned by Corix, in Burnaby, BC.
- The planned effluent heat recovery system at the GE Booth Wastewater Treatment Plant that will provide waste heat to the Enwave-owned Lakeview District Energy System in Mississauga.

6.3 100% Private Ownership

Privately-owned DE utilities are more common in markets with little or no economic regulation of private DE systems. Private owners can include dedicated DE utilities, gas and electric utilities, and property developers (e.g., large master-planned developments with DE systems).

Some private systems emerged out of previously publicly-owned systems (e.g., the Enwave district heating system in downtown Toronto). Others have emerged in response to unique commercial opportunities to provide competitive energy services through economies of scale and efficiency.

Regardless of how they came about, most private systems serve primarily commercial interests: competitive rates, reliability, and investor profits. Private systems can evolve in response to policies and incentives such as new building standards, carbon pricing or other environmental regulations. This is the case for some new private DE systems in large master planned communities facing higher environmental standards or expectations. These systems are commercial responses to new policies and may not be exclusively focused on achieving public benefit. However, in most cases, local climate policies have created investment opportunities for the private sector to deliver public benefits in the form of reduced GHG emissions.

6.4 Strategic Partnerships

Strategic partnerships involve full private ownership with significant municipal involvement and are designed to help municipalities meet policy goals through strategic collaboration instead of taking an ownership position.

For example, in exchange for securing public benefits (such as GHG reductions), a municipality may provide support to a private DE utility such as:

- Providing access to land, resources, and infrastructure (possibly on favourable terms);
- Contributing land or infrastructure paid for by the municipality on favourable terms;
- Committing to connect municipal buildings or to include connection requirements as a condition in the sale of municipal land to developers;

- Committing to align policies to encourage connection to DE (e.g., high performance development standards, accelerated permitting processes for developments connecting to DE; property tax rebates for buildings connected to DE);
- Coordinating installation of municipal and DE infrastructure;
- Accelerating permitting process for DE projects; or
- Providing property tax rebates for DE systems (where private DE systems are required to pay property taxes) or for properties that connect to approved DE systems.

Private systems may be incentivized to work with municipalities on strategic partnerships in order to protect their existing assets or to secure and de-risk new investment opportunities.

An example of a strategic partnership is the Joint Development Agreement (JDA) between Enwave and the City of Toronto. Under the agreement, Enwave has a preferential development right to participate in any potential district energy project that the City has an interest in. These preferential development rights may also include access to City sewers and other low-carbon energy sources. The process for developing a DE project under the JDA is outlined in Table 5.

Table 5: City of Toronto / Enwave JDA - Project Development Stages and Gates

Stage / Gate	Description / Decision
Stage 1	-Determine if a development opportunity exists.
Gate	- Review and approval (by City and Enwave Project Coordinators) to proceed to stage 2. - Approval of budget and resources for stage 2.
Stage 2	-Prepare preliminary design, develop the project business case and obtain letters of intent from potential energy customers.
Gate	-Approval for project development by City Council and Enwave Board.
Stage 3	- Create project specific partnership agreement. - Sign energy service agreements with customers. - Complete detailed design, tendering and construction.
Gate	-Commissioning and hand-over.
Stage 4	-Operation.

7 WRTEU OWNERSHIP CONSIDERATIONS

Reshape facilitated a WRTEU Ownership Models workshop with the TUSC in June 2025 to seek input on ownership objectives and to identify criteria for evaluating and shortlisting potential ownership models for the WRTEU. This section summarizes the feedback received, and based on the outcomes from the workshop, proposes a model for an evolutionary ownership framework for the development of the WRTEU.

7.1 WRTEU Core Objectives

The four core objectives of the WRTEU are focused on emission reductions, economic development, resilience, and financial sustainability. These objectives are based on prior work led by WRCE and feedback provided by the TUSC over the course of Reshape's engagement.

The core objectives of the WRTEU are:

- Leverage local, low-carbon thermal energy sources to provide low-carbon thermal energy services to new and existing buildings, at both the building and district scale, to achieve *TransformWR* goals.
- Create local jobs in a low-carbon economy, monetize local resources, keep energy dollars in the community, and create new utility business models.
- Deliver safe and reliable energy, and increase community resilience and energy security, by offsetting increasing demands on the electricity system and optimizing the electrification of heating.
- Leverage opportunities for efficiency, economies of scale, low-cost financing and grants to deliver affordable low-carbon energy in a financially sustainable manner.

Based on feedback from the TUSC, the ownership and governance of the regional thermal energy utility should prioritize:

- Representation for the entire region.
- Collaboration on long-term, region-wide energy transition planning.
- Pursuit of DE opportunities in high-density areas of Cambridge, Kitchener and Waterloo.
- Pursuit of building-scale opportunities in lower density urban areas and rural townships.
- Flexibility, scaling and partnership opportunities.
- Transparent, accountable and fair governance that provides benefits to WRTEU customers and owners.

7.2 WRTEU Ownership Model Evaluation

While there was general agreement on the WRTEU objectives and ownership priorities for the WRTEU listed above, TUSC feedback from the ownership models evaluation process at the Ownership Models workshop did not point to a single preferred model among all TUSC members. However, there was a consensus that some form of public ownership is necessary to achieve the WRTEU objectives.

TUSC members favoured hybrid public ownership models that enable some risk transfer while retaining a high degree of public ownership and control. Preferred ownership models identified by the TUSC included:

- Municipal ownership through a municipal services corporation
- Municipal ownership with private sector service contracts
- Municipal ownership with split assets
- Municipal majority joint venture

8 PROPOSED WRTEU OWNERSHIP AND GOVERNANCE FRAMEWORK

Rather than propose a single owner and ownership model for the WRTEU at this early stage of thermal energy utility development in Waterloo region, Reshape proposes that the TUSC members pursue discrete projects under the form of ownership and governance best suited to the needs of the individual project at the beginning of its lifecycle.

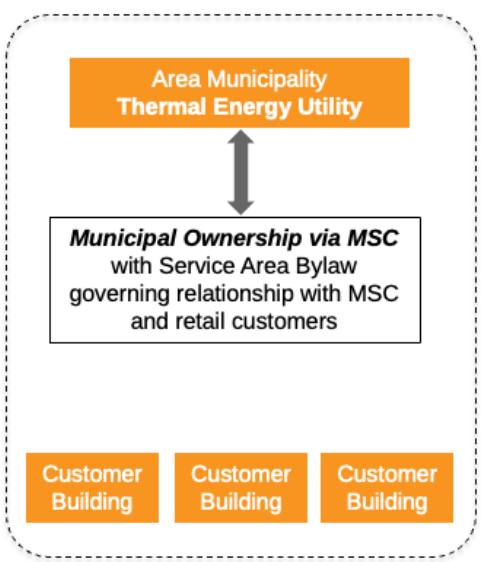
Based on the feedback from the Ownership Models workshop, it appears likely that direct or indirect municipal ownership and hybrid ownership models will prevail, which could provide a strong foundation for collaboration and scaling of services between the separate thermal energy utilities across the region.

This section provides ***one potential framework*** or vision for how separate utilities could collaborate to achieve the objectives of the WRTEU. This framework is intended to be a starting point for further discussion between the TUSC members and not a final recommendation on WRTEU ownership.

The proposed framework is based on local ownership supported by region-wide planning and contractual agreements between different parties (municipalities/municipal utilities and private sector service providers) for access to resources, provision of services, and delivery of customer contracts.

The proposed framework and evolution towards a network of interconnected thermal energy utilities forming a WRTEU is illustrated in Figures 3 through 7. This framework is focused on DE services, however opportunities for collaboration on building-scale projects may also evolve from this model.

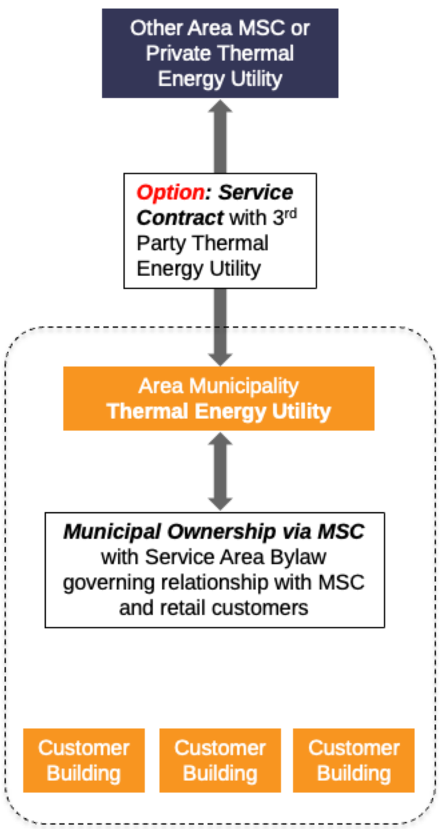
Figure 2: Establish Municipal Thermal Energy Utility



In Figure 2, a district energy utility owned by an area municipality is established as a municipal services corporation, on the strength of a specific project business case (potentially supported by a mandatory connection bylaw that is enabled through municipal ownership).

Thermal Energy Utility
Thermal Energy Utility
Thermal Energy Utility
Contract or Legal Framework
Energy Resource Owner
Contracting Parties

Figure 3: Option for Municipal Thermal Utility Contract with Service Provider

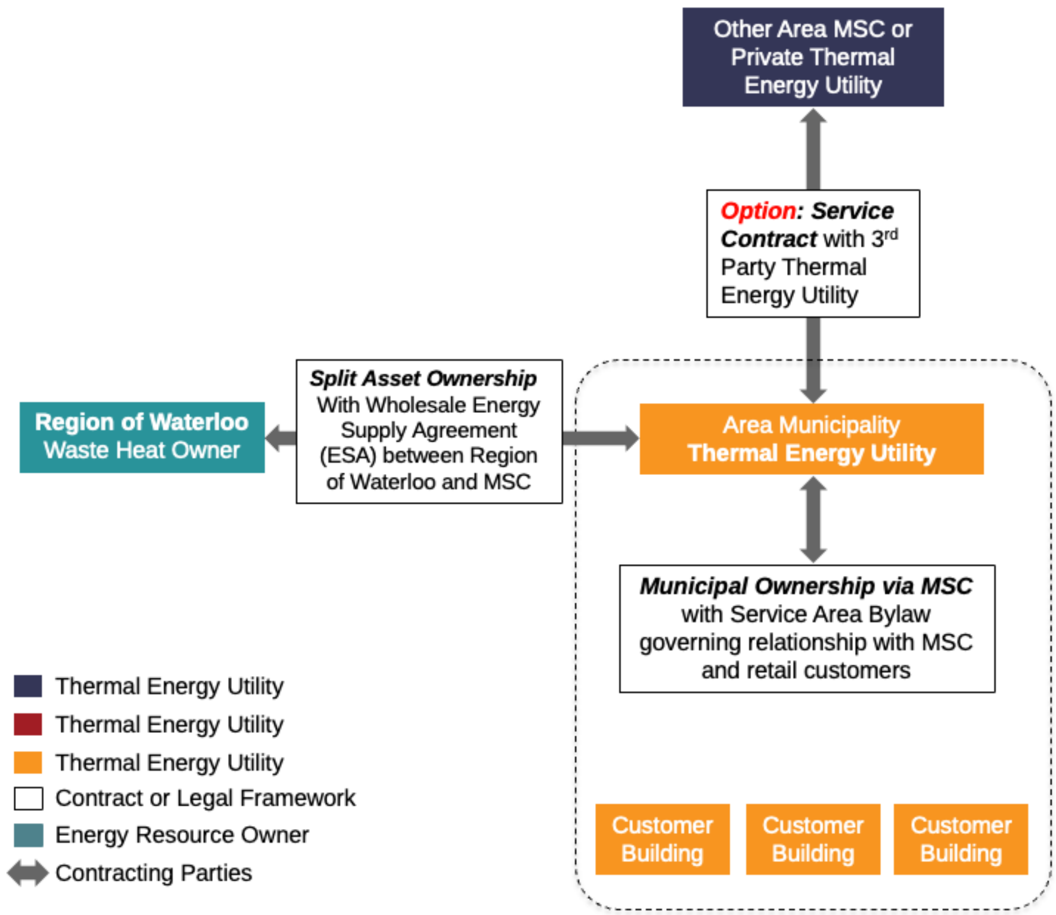


In Figure 3, optionally, the area municipality MSC contracts with a third party service provider for the delivery and operation of the system.

This third party could be a private DE utility, or another MSC (owned by a different area municipality).

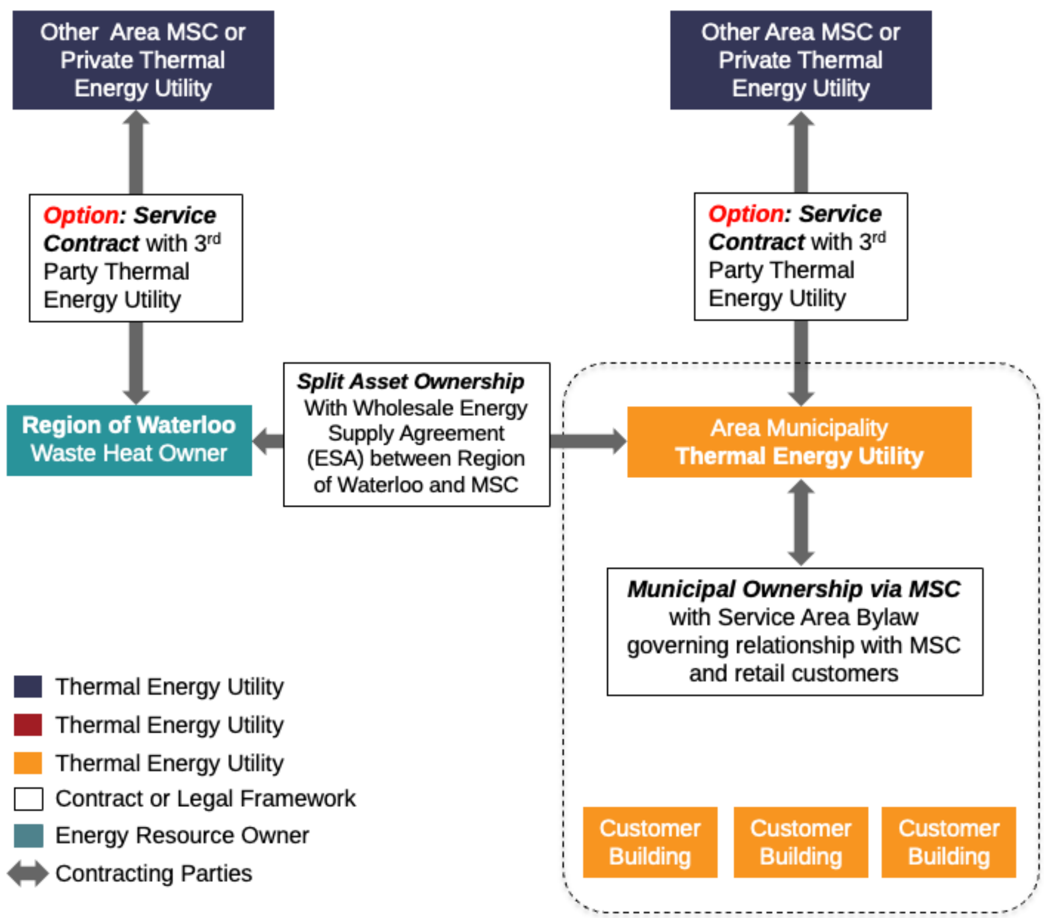
In Figure 4, the Region of Waterloo and the Area Municipality MSC enter into a thermal energy supply and purchase agreement to provide low carbon heat to the Area Municipality MSC. The Region of Waterloo continues to own the waste heat resource and may elect to own the heat recovery infrastructure that interfaces with the Region's wastewater system and/or is located on Region-owned property. This results in a split-asset ownership model between the Region of Waterloo and the Area Municipality MSC.

Figure 4: Region of Waterloo Supplies Waste Heat to Area Municipality MSC



In Figure 5, optionally, the Region of Waterloo contracts with a service provider for the delivery and operation of the Region-owned heat recovery infrastructure

Figure 5: Optional Region of Waterloo Contract for Delivery and Operation of Wastewater Heat Recovery System



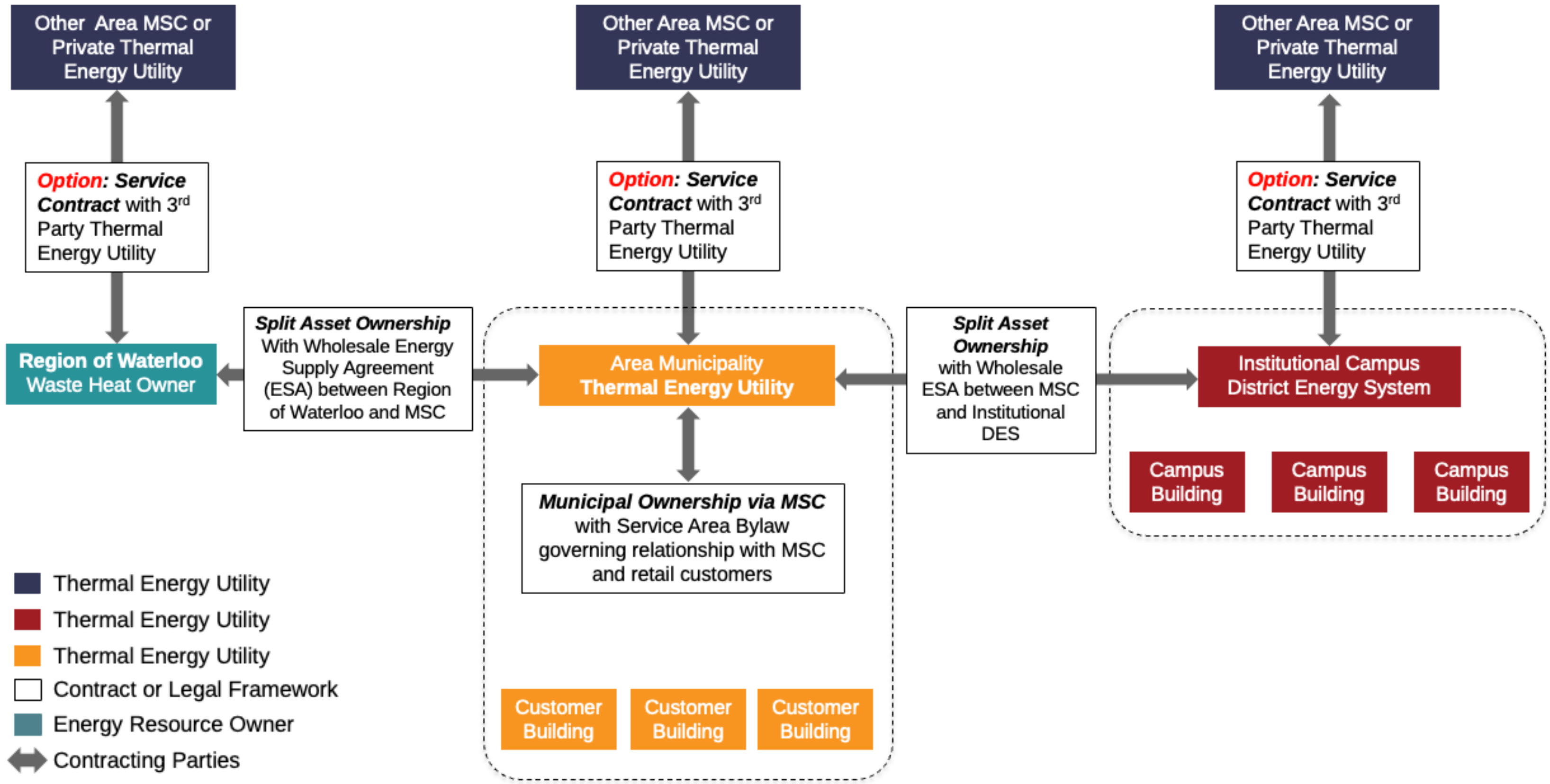
Finally, in Figure 6, the Area Municipality MSC delivers low-carbon thermal energy from the Region's wastewater system to an institutional DES under a thermal energy supply and purchase agreement. This results in a split-asset ownership model between the Institutional DES owner and the Area Municipality MSC.

Separately, the owner of the Institutional DES may contract with a third party DE service provider for the design and construction or renewal of its campus DES under a long-term service contract (e.g., a steam-to-hot water conversion of the University of Waterloo DES, or construction of a new DES at Wilfrid Laurier University).

In Figures 5 and 6, it may be possible for the Area Municipality MSC to be the 3rd party service provider to the Region of Waterloo and the Institutional DES owner.

While this is not shown in the figures, the first Area Municipality MSC could potentially act as a contracted service provider to a subsequent MSC owned by a different Area Municipality. This would leverage the experience and capacity of the first MSC to deliver the system on behalf of the second MSC, while facilitating local governance of the second MSC, and potentially enabling a mandatory connection requirement in the second MSC service area.

Figure 6: Interconnection of Institutional Campus DES under Split Asset Ownership



8.1.1 Utility Interfaces and Interoperability Considerations

Under the framework proposed, contractually defined relationships between different parties may lead to a network of physically separate but interconnected thermal energy utilities that provide thermal services across Waterloo Region.

Typically, physically connected systems will be hydraulically separated using heat exchangers. The heat exchangers protect one system from contamination or breaks in the other system and allow systems with different operating temperatures and pressures to share energy. In some cases, heat pumps may also be required at the interface between two systems, to transfer heat from the lower temperature network to the higher temperature network.

In addition to providing the physical benefits above, the heat exchangers provide a clear demarcation point for ownership of system assets that can be documented in energy sale and purchase agreements between parties.

While the systems may be physically separate, alleviating physical interoperability concerns, developing or adopting standardized thermal energy utility terminology such as “energy transfer station”; policies, such as DES service area bylaws; and procedures, such as approvals processes accessing municipally owned waste heat resources, will support organizational interoperability.

8.2 Evolution of the WRTEU

Once established, the relationships between the separate parties providing thermal energy services in Waterloo Region can evolve over time. For example, a split asset model initially may evolve into a consolidated utility in the long term, or a joint venture with the amalgamation of each party’s assets.

Evolution of ownership may be driven by changes in provincial legislation (e.g. economic regulation of thermal energy), to obtain better debt financing on a larger pool of common assets, or a desire to streamline operations. History provides many examples of utility consolidation in the electricity sector, and the district heating sector.

8.2.1 Historical Example: Utility Consolidation in the Electricity Sector

The electricity sector in Ontario provides an example of the evolution of utility ownership over time. In the early twentieth century, Ontario’s creation of the Hydro-Electric Power Commission of Ontario (HEPCO) under the Power Commission Act of 1907 enabled municipalities to establish local hydro commissions to distribute electricity at cost. Kitchener (then Berlin) and Wilmot each formed their own municipal utilities within this framework, operating independently for decades as part of Ontario’s power system.

By the late 1990s, provincial reforms transformed the electricity sector. The Energy Competition Act and the Electricity Act of 1998 required municipal utilities to incorporate. In response, the Kitchener Public Utilities Commission (Kitchener Hydro) and Wilmot Hydro merged to create Kitchener-Wilmot Hydro Inc., jointly owned by the City of Kitchener and the Township of Wilmot through Kitchener Power Corporation.

In 2022, this process of regional integration advanced further when Kitchener-Wilmot Hydro Inc. merged with Waterloo North Hydro Inc., which served Waterloo, Woolwich, and Wellesley. The new entity, Enova Power Corp., became a municipally owned distributor serving the entire Waterloo Region, combining local ownership with greater scale, financial strength, and capacity for innovation.

This evolution, from local commissions to municipal service corporations to a regionally integrated distributor, illustrates how public utilities have adapted to policy and market conditions while maintaining community ownership. It also offers a clear precedent for how thermal energy utilities in the Waterloo Region may evolve through shared governance, regional coordination, and consolidation to enhance efficiency and long-term resilience. Consolidation allows utilities to access capital for grid modernization and new power plants and enables companies to share expertise in new and evolving technologies.[25,26, 27]

8.2.2 Historical Consolidation of Thermal Energy Utilities

The United States has a long history of thermal energy utility consolidation, with many district heating systems initially established as combined heat and power systems by electric utilities changing ownership over time with the evolution of the electricity sector.

Today, although many of the district energy systems that were first established by local electric utilities are no longer in operation, others have been consolidated under the ownership of a handful of large investors, including Vicinity Energy, Cordia (formerly Clearway Community Energy) and CenTrio, who together own more than 20 systems across the United States[22].

Some recent acquisitions in the district energy sector have been driven by the need for capital investment to modernize aging infrastructure and to transition to lower-carbon energy sources.[28]

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[25] *Tuttle, D. P., et. al., "The History and Evolution of the U.S. Electricity Industry," White Paper UTEI/2016-05-2, 2016, available at http://energy.utexas.edu/ the-full-cost-of-electricity-fce/*

[26] https://www.energyplanets.org/utilities-accelerate-asset-acquisitions/

[27] *Summary of District Heating Systems in the United States, 1877-2020,* Pierce, M.A., University of Rochester (2022)

[28] https://www.vicinityenergy.us/press-releases/vicinity-energy-launches-as-largest-district-energy-provider-in-north-america/

9 RECOMMENDED NEXT STEPS

The ownership framework described in Section 8 allows for the continued development of in-progress projects, such as the Downtown Kitchener DES, while maintaining flexibility for utility scaling and partnerships in the future. The model also may also leverage the capacity developed by the "first" thermal energy utility in Waterloo Region to provide services to subsequent thermal energy utilities in the region.

Based on the framework outlined in Section 8, Reshape recommends the following next steps.

9.1 Continue to Develop In-Progress Projects

Continue to advance the feasibility and business case studies for the identified district energy opportunities in Waterloo Region, prioritizing those that have strong project champions and the greatest load certainty (e.g., through customer commitments, or mandatory connection mechanisms).

9.2 Develop Area-based Thermal Energy Transition Plans for Waterloo Region

Concurrent with the development of ongoing projects, it is recommended that area-based thermal energy transition plans (including both low-carbon district energy and building-scale energy retrofits) are developed for Waterloo region to identify and prioritize subsequent thermal energy utility investment opportunities. Development of area-based thermal energy transition plans (area-based plans) should include the participation of the subject municipality or township, the local electric and gas utilities, and the Region of Waterloo, as well as institutional building owners and residents.

A region-wide organization such as WRCE could potentially support the development of area-based plans in Waterloo region by acting as a region-wide resource for planning data, coordination and expertise (developing standardized scopes of work and supporting procurement of consulting services) and convening stakeholders.

The completion of area-based plans should lead to the identification of high-priority, low-carbon thermal energy projects that can be developed under different ownership models, depending on the location, scope and scale of the project.

For new development areas, the land use plans should include requirements for low-carbon thermal energy in buildings to support subsequent policies such as mandatory connection bylaws for district energy systems.

Once local thermal energy utilities have been established, they may take a bigger role in the project development process, however initially this role may be filled by the municipalities themselves. This process is illustrated in Table 6.

9.2.1 Complete Feasibility Studies for High-Priority Projects

Based on the outcomes of the area-based planning process, complete additional due diligence on high-priority projects, including:

- Technical feasibility studies to confirm the preferred technical approach, including low-carbon energy resources, building retrofit strategies and network types (for district energy opportunities). This stage should involve lifecycle cost evaluation of different project concepts to identify a preferred technical option.
- Once a preferred technical approach has been selected, complete additional design as required to refine capital cost estimates, and to inform the development of a project business case.
- Develop a project business case, including proposed ownership model, financial plan (including connection fees and rates), strategy or policy to secure customer connections, and any proposed service contracts for project delivery.

9.2.2 Project Approvals

Project approvals may be required following the completion of feasibility studies and business case to approve resource allocation, capital investment, and project implementation under utility governance.

Depending on the proposed ownership model for a specific project, investment-level project approvals may be at the municipal level (e.g., for the formation of a new thermal energy utility MSC or the creation of the DE by-law), the region level (e.g., for a split asset project that involves the use of effluent waste heat), or the board of an existing MSC.

Project approvals may also include permission from municipal councils or agencies for building permits and resource use, such as effluent waste heat.

9.2.3 Project Delivery

The various thermal energy utility projects within the regional thermal energy utility are designed, built, financed, operated and maintained under a range of ownership and project delivery models, selected on a case-by-case basis to suit the needs of individual projects.

9.2.4 Utility Consolidation

A fifth column could be added to Table 6 for a subsequent phase of consolidation of individual projects or utilities into the WRTEU. Once established, the separate thermal utilities / projects may gradually consolidate to enable region-wide utility planning, administrative and operational efficiencies, increased access to capital and greater sharing of expertise.

Table 6: Long-term Process for Region-wide Thermal Energy Transition

Phase	Development of Area-based Transition Plans	Project Development	Project Approvals	Project Delivery and Operation
Objectives	Prepare thermal energy transition plans for geographical areas: • Opportunity screening and categorization • Prioritize projects • Develop phasing plan For new development areas, land use plans should include requirements for low-carbon thermal energy.	Completion of: • Feasibility study • Preliminary design • Project business case and rates Confirm strategy to secure utility customers.	Secure the necessary approvals to establish a new thermal energy utility or project from: • Area Municipality or Township • Local Thermal Energy Utility Board of Directors • Region of Waterloo (if applicable)	Design, build, finance, operate and maintain the thermal energy utility project.
Phase Lead	**Region-wide Organization (such as WRCE)**	**Local Municipality or Utility**	**Local Municipality or Utility**	**Local Municipality or Utility**
Participants	• Area Municipalities and Townships • Region of Waterloo • Local Electric Utilities • Local Gas Utilities • Large Institutions • Local Thermal Utilities[29]	• Area municipality • Potential customers / target buildings or new developments • Local electric and gas utilities	• Region of Waterloo (if applicable) • Area Municipality or Township	• Region of Waterloo (if applicable) • 3rd party utility service provider (if applicable)

[29] Once established

10 CONCLUSION

Progress towards a Waterloo Region Thermal Energy Utility (WRTEU) may be central to achieving the scale of decarbonization required to meet the region's climate commitments. As of 2022, community-wide emissions have fallen only 12% from 2010 levels, while Waterloo Region has committed to reducing emissions by 30% by 2030 and 80% by 2050. Since buildings contribute roughly 45% of total emissions, transforming thermal energy systems represents a great challenge and a significant investment opportunity.

In its initial phase, the WRTEU would function as a regional coordinating and delivery platform for low-carbon heating and cooling solutions. The WRTEU could facilitate the identification and development of projects, many structured as Municipal Services Corporations (MSCs), that leverage municipal policy tools such as mandatory connection bylaws and high-performance development standards. Through this model, municipalities would retain ownership and oversight while gaining the commercial flexibility to secure financing and services from the private sector, form partnerships, and finance large-scale infrastructure without affecting their borrowing capacity.

The success of the WRTEU will rely on strong collaboration among key regional stakeholders. The Region of Waterloo controls access to low-carbon resources such as wastewater heat, treated effluent, and geothermal energy. Municipalities, in turn, hold the policy levers through planning authority, building standards, and connection bylaws, that can enable or require low-carbon thermal energy systems. Local gas and electric utilities bring expertise in utility management, customer relationships, billing systems, and corporate infrastructure that can support WRTEU operations, while maintaining service quality and reliability. Coordinated action across these stakeholders ensures that thermal energy projects are feasible, integrated, and aligned with both community needs and long-term climate objectives.

Over time, the WRTEU may expand its scope to integrate individual municipal utilities and MSCs under a unified regional framework. Such consolidation would be pursued collaboratively, where integration demonstrates clear public benefit, enhancing operational efficiency, improving service reliability, and realizing economies of scale in planning, financing, and delivery.

By coordinating investment, standardizing delivery, and aligning public and private sectors within a single, region-wide framework, the WRTEU can accelerate progress from incremental change to intentional transformation. In doing so, Waterloo Region can collectively advance toward its climate targets as an integrated energy ecosystem, setting a precedent for community-scale decarbonization, collaboration, and regional climate leadership.

11 REPORT SUBMISSION

RESHAPE INFRASTRUCTURE STRATEGIES

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Principal

Revision History

Revision #	Date	Status	Revision Description	Author
0	2025.10.04	Draft	Draft for WRCE review	SMW
1	2025.10.30	Draft	Draft for WRCE review	JAAG/SMW
2	2025.11.05	Draft	Draft for TUSC review	SMW
3	2026.01.21	Final		SMW

Filename: RPT P846 WRTEU Final Report R3 2026.01.21.docx

APPENDIX: CRITERIA FOR BUILDING A STRATEGIC IMPLEMENTATION NETWORK

Purpose of the Implementation Network

The Strategic Implementation Network (SIN) is a roster of qualified resources established to support the planning, design, and delivery of Waterloo Region Thermal Energy Utility (WRTEU) projects. The SIN is intended to provide WRTEU with access to specialized technical, legal, financial, and operational expertise required for project development and implementation. The primary objectives of the Strategic Implementation Network are to:

- Connect WRTEU to pre-vetted, qualified, and specialized advisory, technical, and delivery partners,
- Support coordinated decision-making that balances policy, financial, and technical considerations,
- Foster long-term regional capacity to manage, operate, and expand district energy systems and building-scale thermal systems, and
- Reduce procurement processing times through pre-vetted expertise already in the network.

Network Development Strategy

The Strategic Implementation Network can be developed as a structured expansion of the TUSC. This approach preserves the existing governance structure while introducing new members.

Table 7: Strategic Implementation Network – Development Process

Stage	Strategic Action	Key Outputs
Mapping Existing Capacity	Identify expertise, roles, and institutional representation already embedded in TUSC	Baseline inventory of TUSC member organizations and service providers, and their capabilities.
Gap Analysis	Determine areas where support is required, such as agreement negotiation, rate design, detailed design, construction management	Needs assessment
Partnership and Procurement Framework	Establish a process for selecting consultants and technical partners to address identified gaps	Prequalification and evaluation framework

Composition of the Network

The Strategic Implementation Network (SIN) is a group of organizations and experts with skill sets and expertise that are aligned to the development and delivery of a thermal energy utility. Its composition will ensure that project implementation benefits from strategic oversight and industry best practices.

Current WRTEU Skills (Existing):

- Thermal Utility Steering Committee (TUSC): regional and local municipal staff, utilities, academia, and key advisors.

Expanded WRTEU Capacity through the SIN:

- **Geospatial and Data Systems:** GIS-based energy mapping, area-based thermal energy transition planning, utility corridor routing, and asset visualization.
- **Building Energy Modeling and Integration:** modeling building-level demand, connection feasibility, and retrofit pathways.
- **Energy System Engineering:** system design, cost estimation, and integration of low-carbon technologies.
- **Financial Analysis and Utility Rate Design:** thermal utility business planning, tariff design, and capital structuring.
- **Policy and Governance:** alignment of Regional and municipal policies with provincial legislation.
- **Electricity and Gas Systems Coordination:** coordination with Enova Power, Enbridge Gas, and IESO initiatives.
- **Agreement Negotiation:** specialized support for the negotiation of thermal energy utility agreements with private sector service providers.

Criteria for Selecting Members of the Strategic Implementation Network

Selection of SIN members will be guided by level of expertise and alignment with WRTEU objectives.

Core Selection Criteria

Criterion	Description	Evidence / Evaluation Method
Technical Expertise and Experience	Demonstrated proficiency and project experience in district energy, utility planning, or related infrastructure within Ontario or comparable jurisdictions.	Portfolio of similar projects; client references; resumes of key staff.
Understanding of Local and Regulatory Context	Familiarity with municipal governance under the *Municipal Act of 2001*, OEB regulatory processes, local utility structures, and regional climate-energy policies.	Description of prior Ontario or municipal utility projects; regulatory engagement experience.
Innovative and Integrated Approach	Ability to deliver creative, data-driven, and technically integrated solutions that align with the region’s decarbonization, resilience, and growth goals.	Methodology statement; demonstration of innovative tools or modeling capabilities.

Financial and Value Proposition	Competitive and transparent fee structure demonstrating value-for-money while maintaining quality and innovation.	Detailed cost proposal; cost breakdown by task or deliverable.
Risk Management and Compliance	Adherence to procurement requirements, professional licensing, insurance, and safety standards.	Proof of compliance and insurance; health and safety documentation.

Additional Considerations

- **Regional Alignment:** Preference will be given to firms already active in Waterloo Region with demonstrated familiarity with local conditions.
- **Knowledge Transfer:** Members should be willing to build WRTEU staff capacity through training, documentation, and mentorship.
- **Scalability:** Ability to adapt scope and participation as WRTEU moves from planning to implementation and operation.