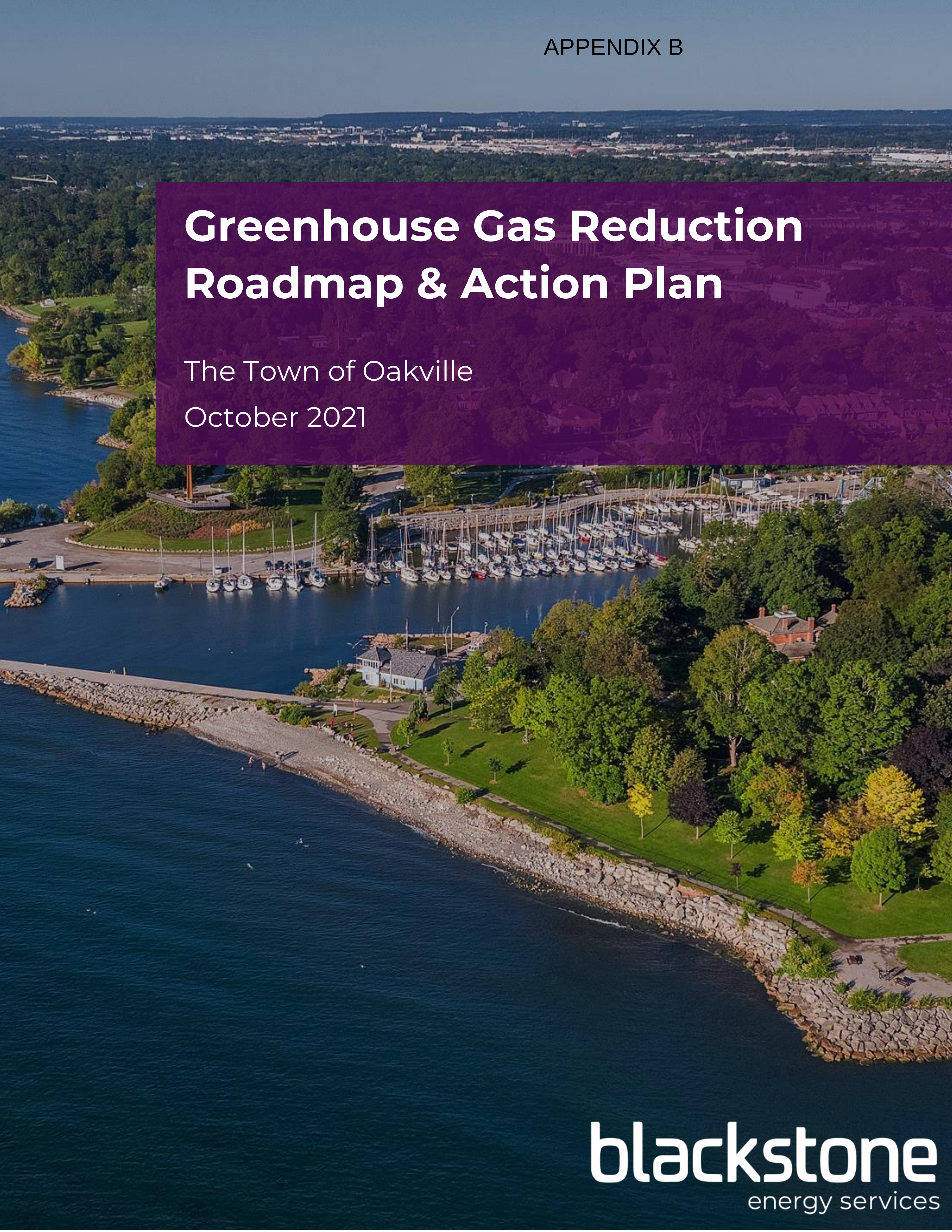
APPENDIX B

Greenhouse Gas Reduction Roadmap & Action Plan

The Town of Oakville

October 2021



blackstone energy services

Introduction

The transition toward the decarbonization of your facilities and services is an opportunity for The Town of Oakville (The Town) to be a part of the growing activity around climate action initiatives. The Town has made significant strides in its sustainability standing and is on a path to significant and important actions that mitigate and prepare for the impacts of climate change. The Town's Greenhouse Gas Reduction Roadmap & Action Plan (GRRAP) includes corporate facilities and sets short-term and long-term strategies for greenhouse gas (GHG) footprint targets. It recognizes The Town's overarching sustainability goal of achieving 80% GHGs reduction from 2014 level and energy portfolio resiliency by 2050.

Compared to a baseline year of 2014, The Town has committed to:

- Reduce its GHG emissions by 20% by 2030 from 2014 level
- Achieve 80% reduction by 2050 from 2014 level

This GRRAP aims to provide strategic direction and options required to reduce emissions at The Town over the next 30 years. In order to reach its GHG emission targets, The Town's GRRAP must be reflected in its vision, planning, and financial strategies. The Town policies and plans may include those listed below which may need to be adapted to fully realize their goals:

- Municipal Master Plan
- Parking Master Plan
- Sustainability Action Plan
- Energy Management
- Five Year Strategic Plan
- Sustainability Policy

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Glossary of Terms

Word	Abbreviation	Meaning
Air Handing Unit	AHU	A device used to regulate and circulate air as part of a heating, ventilating, and air-conditioning system.
Baseline Year		A benchmark that is used as a foundation for measuring or comparing current and past values.
British Thermal Units	BTU	A standard unit of the heat content of fuels or energy sources.
Building Automation System	BAS	The automatic centralized control of a building's heating, ventilation and air conditioning, lighting, and other systems.
Business as Usual	BAU	Scenario if no actions are taken to mitigate or change.
Canada Green Building Council	CaGBC	The Town of Oakville certifies a Zero Carbon Building Standard that could be used as a guide for carbon-free construction and operations.
Carbon Dioxide	CO_2	A greenhouse gas that results, in part, from the combustion of fossil fuels.
Coefficient of Performance	COP	A ratio of useful heating or cooling provided to work is required.
Carbon Reduction Roadmap	GRRAP	Provides an in-depth look at a facility's baseline, current, and forecasted Scope 1, 2 and 3 GHG emissions relative to their targets, and provides reduction strategies.
Direct Expansion	DX	A system that uses the vapour-compression refrigeration cycle to efficiently cool a building.
Environment and Climate Change Canada	ECCC	Informs Canadians about protecting and conserving natural heritage and ensuring a clean, safe, and sustainable environment for present and future generations.
Electric Vehicle	EV	A vehicle that uses one or more electric motors for propulsion
Energy Conservation & Demand Management	ECDM	The installation of measures, or implementation of practices, to improve energy efficiency. This is a requirement of O. Reg. 507/18: Broader Public Sector: Energy Conservation and Demand Management Plans (ECDM).
Energy Storage		Typically refers to the energy stored by the battery.
Energy Usage Intensity	EUI	The amount of energy consumed relative to a building's physical size, typically measured in equivalent kWh per square foot.
Engineering, Procurement and Construction	EPC	Engineering, procurement, and construction of infrastructure projects.
Electrification		The conversion of fossil fuel-based technologies to electric alternatives.
Equivalent Carbon Dioxide	CO_2e	Measurement of greenhouse gas emissions, relative to carbon dioxide.
Equivalent kilo-watt hours	ekWh	A standard unit of energy consumption that is used to compare energy sources.
GHG Protocol		The recognized international standards used in the measurement and quantification of greenhouse gases – The Scope 1 Standard, the Scope 2 Standard, and the Scope 3 Standard.
Greenhouse Gas	GHG	A gas that contributes to the greenhouse effect by absorbing infrared radiation, e.g., carbon dioxide and chlorofluorocarbons.
Global Warming Potential	GWP	A measure of how much heat is trapped in the atmosphere by a greenhouse gas up to a specific time horizon, relative to carbon dioxide.

Global Reporting Initiative	GRI	The GRI is an international independent standards organization that helps businesses, governments and other organizations understand and communicate their impacts on issues such as climate change, human rights, and corruption.
Heating, Ventilation and Air Conditioning +Lighting	HVAC+L	A system that provides heating, cooling, ventilation, and lighting to a building.
Hourly Ontario Electricity Price	HOEP	The wholesale price of electricity as determined in the real-time market administered by the IESO.
Independent Electricity System Operator	IESO	Crown corporation responsible for operating the electricity market in the province of Ontario.
The Town of Oakville Energy Efficiency Project	EEP	The Town of Oakville's program on improving energy efficiency and promoting energy conservation.
Leadership in Energy and Environmental Design	LEED	A green building certification program that is administered by the CaGBC.
Long Term Energy Plan	LTEP	Ontario's plan that outlines the province's energy demand, supply, and commitments.
Metric Tonnes	t	A unit of measurement of mass.
Mega Tonnes	MT	A unit of measurement of mass (1 MT = 1,000,000 t).
Photovoltaic	PV	The conversion of light into electricity using semiconducting materials.
Renewable Energy	RE	Generation of energy produced from sources that do not deplete.
Renewable Natural Gas	RNG	Biogas that is captured from decomposing organic waste.
Scope 1		Direct emissions from sources owned or controlled by the municipality.
Scope 2		Indirect emissions from the consumption of purchased energy generated upstream from the municipality.
Scope 3		Indirect emissions (not included in Scope 2) that occur in the value chain of the municipality including both upstream and downstream emissions, like waste, transport, food, and procurement.
Space Optimization	SO	Maximizing the effective use of the built environment.
Natural Gas/Traditional Natural Gas	TNG	Natural gas is a naturally occurring hydrocarbon gas, or fossil fuel, mixture consisting primarily of methane.
Power Purchase Agreement	PPA	A contract between two parties, one which generates electricity (the seller) and one which purchases electricity (the buyer) for an agreed cost (including maintenance) over a defined time where typically the source of electricity generation is from a renewable power generation system.
Variable Refrigerant Flow	VRF	A system that varies the *flow* of *refrigerant* to indoor units based on demand.
Zero Carbon Building	ZCB	A highly energy-efficient building that is fully powered from on-site and/or off-site renewable energy sources and carbon offsets resulting in an annual net-zero carbon footprint.

1. Executive Summary

The Town has committed to achieving an 80% GHGs reduction from 2014 levels by 2050. The path and transition to 80% reduction by 2050 will be impacted by strategic planning, technology, implementation timelines, government incentives, utility rate structures, grid emissions and societal impacts. It is recommended that The Town prepares and follows a strategy as envisioned through this GRRAP, performs annual inventory of energy and GHGs, regularly assesses their progress, adapts to achieve, and identifies new programs that could help The Town reach 80% reduction from 2014 level by 2050.

Note that when The Town is mentioned in this report, we are referring to the corporate facilities, fleets, and transit assets. Private assets are not included.

There are **four key pillars** on the journey to achieving 80% GHGs reduction from 2014 level:

- **Pillar 1: Energy Conservation & Demand Management (ECDM)** – The Town has a documented ECDM strategy with estimated costs, benefits, and timelines. Pillar 1 supports the implementation and continued commitment to energy conservation, reduced waste, and optimum energy and GHG use intensities.
- **Pillar 2: Space Optimization (SO) & Zero Carbon Buildings (ZCB)** – Addresses how to minimize emissions from buildings by optimizing the use of existing building space and reducing emissions from renovations and new facilities through high-performance design standards and operations.
- **Pillar 3: Facility Electrification** – Focused on converting existing fossil fuel-based technologies to low carbon, electric, alternatives.
- **Pillar 4: Renewable Energy (RE) Generation** – On- and off-site renewable energy generation can support The Town's net-zero carbon targets. For The Town, renewable generation is focused on the installation of rooftop solar photovoltaics, carport solar photovoltaics, solar heated air/water, and geo-exchange technologies (i.e., inter-seasonal ground energy storage).

To achieve an 80% GHGs reduction from 2014 level, it is recommended that The Town commits to implementing the strategies outlined in the GRRAP to support each of the four pillars.

Under Pillar 1, The Town should continue to create a culture of ECDM. The Town's existing ECDM program has created a foundation for improvements to minimize energy use. ECDM technologies – including lighting, ventilation controls and upgraded building automation systems – have proven to be cost-effective mechanisms for The Town. Also, the ECDM Plan provides a short-term overview of projects, their estimated costs, and benefits. The Town should continue to fund ECDM to minimize energy usage and should review the ECDM plan on a five-year renewal schedule.

Under Pillar 2, it is recommended that The Town commits to undertaking a space use optimization study to further assess how to maximize the efficiency of existing spaces. For new buildings, The Town should commit that all new buildings and major renovations will be built to (at minimum) zero carbon standards. To build to these higher standards will cost more than building to the Ontario Building Code (approximately 4%-16% depending on the systems used). However, zero-carbon buildings have lower operational costs, are more comfortable and cost-effective over their lifespans. Blackstone also recommends that The Town develops their own high-performance standards tailored to their portfolio archetypes and include elements of existing standards/guidelines (such as LEED, Passive House, Toronto Green Standards) as a checklist for best practices sustainability and high-performance measures.

Under Pillar 3, The Town commits to the electrification of fleet and facility HVAC equipment. Internal combustion fleet vehicles should be replaced with electric vehicles. When asset renewals are considered, facility equipment should be evaluated from a life cycle cost and carbon perspective. Installing electric systems may be more expensive and operating costs may increase, though against increasingly more expensive carbon fees due to fossil fuels. These are budget considerations The Town should assess with the knowledge that the sooner the investment is made, the lower the carbon output of The Town's operations. Under Pillar 4, it is recommended that The Town installs the maximum amount of solar photovoltaics (both rooftop and carport) and geothermal systems its municipality can support to provide renewable energy. The onsite renewable potential was assessed to determine the feasibility of renewable energy projects and identify archetypes best suited for installation at The Town. Note also that a renewable energy systems (RES) report has been prepared and submitted for The Town that provides further details about RES opportunities.

The graph below depicts the combination of four scenarios, as well as the addition of aggressive renewable systems installations as recommended in the RE report. By executing all these initiatives, The Town will achieve their GHG emission reduction target which is 20% GHG emissions reduction by 2030 from 2014 levels and GHG emissions reduction of 80% by 2050 from 2014 levels, as shown in Figure 1.

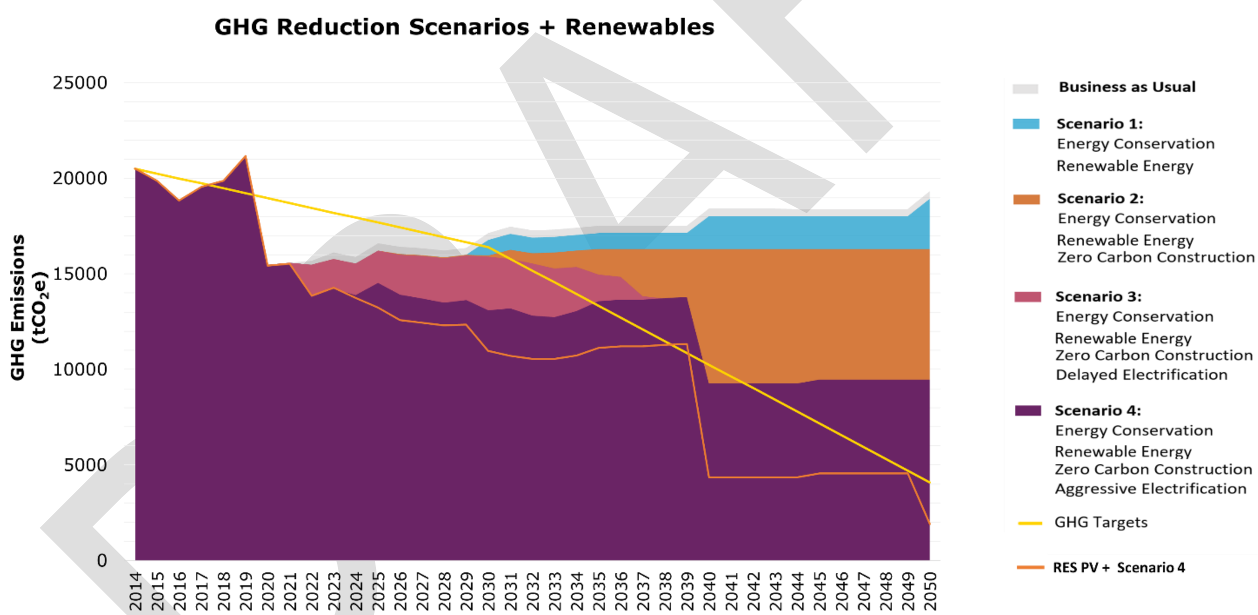


Figure 1. *GHG Reduction Scenarios + Renewables – Path to Achieve GHG Reduction Target*

2. Recommendations

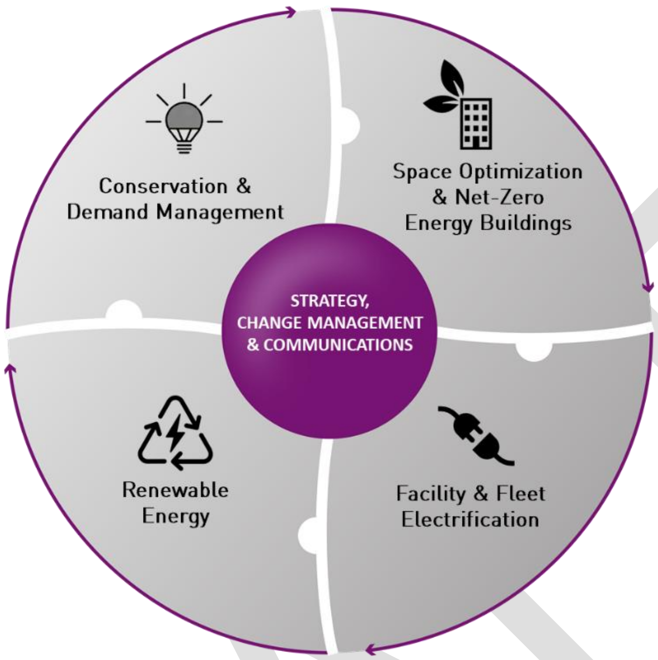


Figure 2. *Strategy, Change Management & Communications Wheel*

It is recommended that The Town moves ahead with the following actions items listed below, under all four pillars, to support the GRRAP.

Pillar 1. Energy Conservation & Demand Management

- At five-year intervals, update ECDM Plan and maintain a commitment to energy management programs (as part of O. Reg. 507/18).
- Ensure budget allocation to support the implementation of best practice ECDM standards.
- Identify opportunities for energy conservation and deep energy retrofits in alignment with deferred maintenance priorities.
- Review the state of building envelope items and facility condition reports regularly.

Pillar 2. Space Optimization & Net-Zero Carbon Buildings

- Develop design and construction standards to drive high-performance indices and ensure Net-Zero Carbon as the minimum standard for new builds and major renovations.
- Develop space use policies to minimize underused space and maximize the space utilization rate within corporate facilities.
- Develop a master plan that has space optimization as a guiding principle.
- Allocate budget for conducting space use audits and implementing space optimization measures.

Pillar 3. Facility & Fleet Electrification

- Commit to the electrification of facility equipment. Explore alternatives for fossil fuels for cooking equipment.
- Implement a Green Fleet Strategy to replace the corporate fleet with electric vehicles.
- Ensure parking lots have the infrastructure to support solar panels, electric vehicles, and geo-loops, and enhance the infrastructure for vehicle-to-grid in existing buildings.

Pillar 4. Renewable Energy

- Install maximum amount of solar photovoltaics, both rooftop and carport, and geothermal as the municipality will allow.

General Sustainability Initiatives

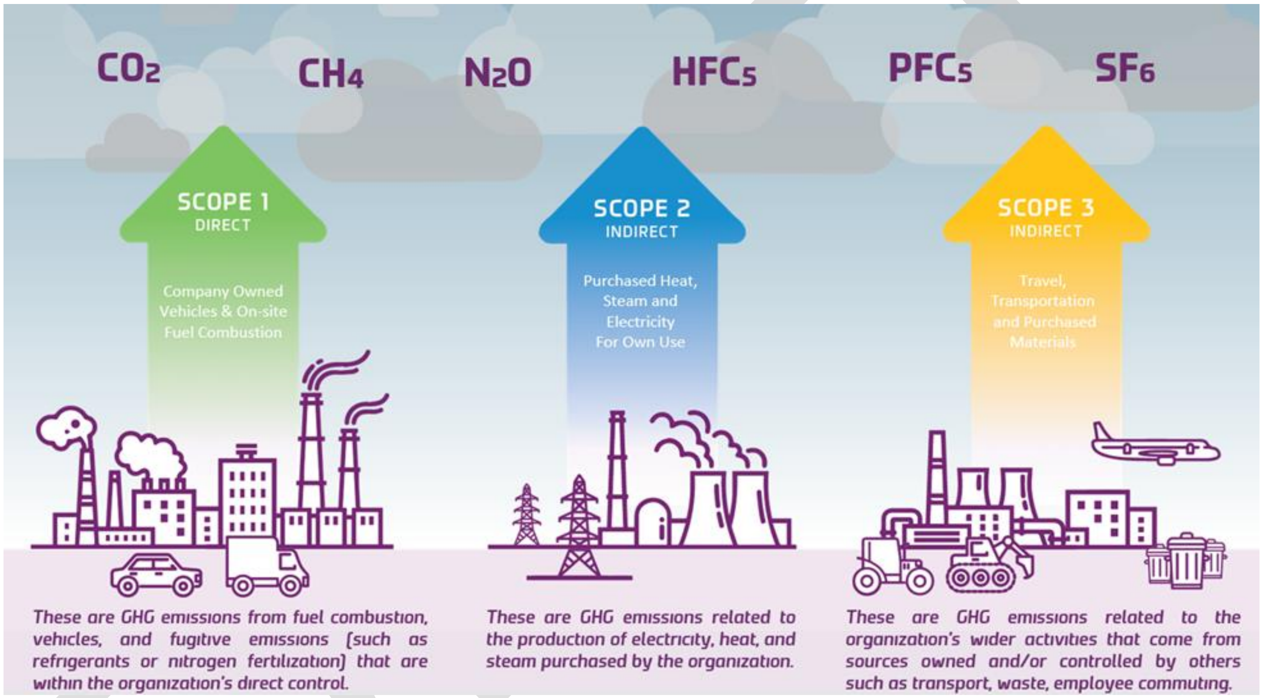
It is recommended that The Town continues to support a low carbon future and promotes sustainability at a municipality level.

- Continue to monitor and achieve alignment between the sustainability plan and The Town's GHG reduction targets.
- Ban single-use plastics within corporate facilities.
- Limit food waste generation.
- Strengthen awareness programs about energy and waste management for employees, staff, and residents.
- Expand sustainable transportation options for The Town's community.

3. The Town of Oakville's GHG Footprint

3.1. Scope of Emissions

The Town's GRRAP quantifies GHG emissions by source, outlines the scenarios for emission reduction and provides The Town with a roadmap to reach its reduction targets. GHG emissions are accounted for according to the GHG Protocol Standard, which is the global standardized framework to measure and manage greenhouse gas (GHG) emissions from private and public sector operations. GHG emissions considered for the GRRAP are categorized by three types of emissions: Scope 1, Scope 2, and Scope 3, although due to the complex nature of a spread out and multiple stakeholder corporation, scope 3 emissions are excluded from this report. Therefore, for the following sections, only scope 1 and 2 emissions are discussed, calculated, and addressed.



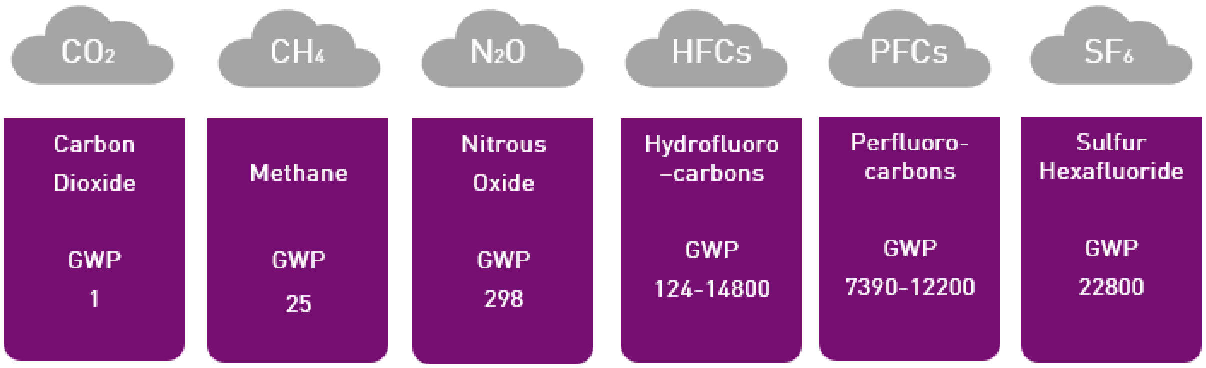
Source: GHG Protocol[1]

Figure 3. GHG Emissions and Scopes

GHG emissions released from The Town's operations may include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Each gas has a global warming potential (GWP) that is expressed in terms of CO_2 equivalent or CO_2e. The GWP of GHGs is a measure of how much heat a greenhouse gas traps in the atmosphere. The GRRAP accounted for emissions from Scope 1, and 2 calculated the GWP relative to tonnes of carbon dioxide equivalent (tCO_2e). For example, for every tonne of methane released, about 25 tonnes of equivalent CO_2 is released as the GWP for methane is 25. Each GHG must be converted to equivalent CO_2 for calculations and reporting.

[1] Greenhouse Gas Protocol: http://ghgprotocol.org/about-us

The global warming potentials (GWP) associated with these six common GHGs are depicted in Figure 4 below.



Source: National Inventory Report 1990 –2019: Greenhouse Gas Sources and Sinks in Canada

Figure 4. *Common Greenhouse Gases and Respective Global Warming Potentials*

The Scope boundaries, activities that were included in the GHG emissions calculations for The Town, were selected based on the availability of data and discussions with the Facilities and Construction Management office and are summarized in Table 1 below.

Table 1. *GHG Emission Scopes & Sources*

Scope of Emissions	Definition	Source of Emission
Scope 1	Direct emissions from sources owned or controlled by The Town	• Natural Gas • Refrigerants • Diesel • Gasoline
Scope 2	Indirect emissions from the consumption of purchased energy generated upstream from The Town	• Purchased electricity

Stationary sources such as oil (#1-4), natural gas, the use of refrigerants and organic fertilizers were all considered in the GHG emissions calculations for Scope 1 emissions. Scope 2 GHG emissions in The Town are solely generated from purchased electricity. The share of The Town's GHG emissions in 2020 is illustrated in Figure 5.

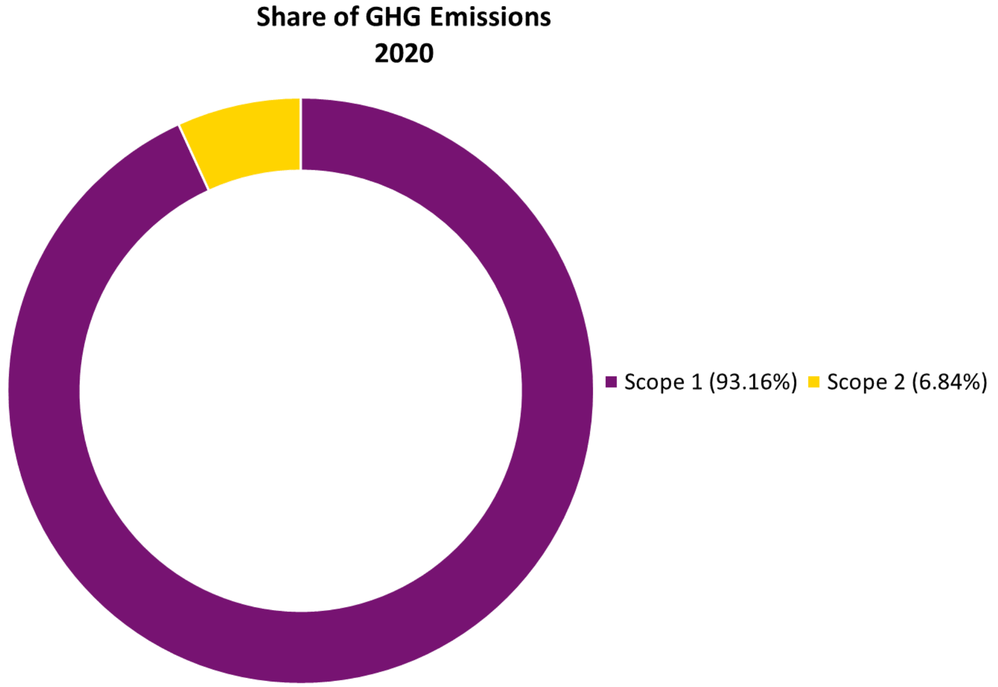


***Figure 5**. 2020 Share of Emissions for The Town*

The emissions were calculated for building archetypes including Community Centers, Operations and Admins, Arenas, and Other (streetlights, parks, parking lots) – and mainly addresses Scope 1 and Scope 2 emissions which are directly under The Town's operational control given they are driven by energy use and facility management. Scope 3 emissions are dependant on human and social behaviour and can best be addressed by awareness and policy implementation across the corporation and community. Scope 3 emissions are dealt with briefly in Section 9.

3.2. GHG Emissions Baseline

To set appropriate, ambitious yet achievable emissions reductions targets, and to set dates by which to achieve those targets, a baseline year of emissions must be set as a benchmark to measure the progress of the GRRAP. The Town's official baseline year has been selected to be 2014 and The Town has confirmed the baseline year of 2014, as established in its Sustainability Action Plan. **It is Blackstone's recommendation to switch the baseline year to 2015 as that is the first year that coal-fired electricity has been phased out**. Coal-fired electricity has a much higher GHG emissions factor making any GHG reductions in 2015 and forward unrelated to conservation or GHG mitigation measures. Any electricity-saving projects before 2015 would require GHG emissions factor adjustments for any cumulative sum accounting.

The emission reduction targets for The Town are absolute numbers (versus an intensity-based value such as energy units/capita) as a percentage of The Town's emissions compared to the baseline year of 2014. Absolute GHG reduction targets are increasingly more common in municipal and large portfolio operations and are considered best practice (intensity-based targets tend to be used in manufacturing/production-based operations). The following table summarizes the GHG emissions in the baseline year and the resulting absolute targets set by The Town (in metric tonnes of carbon dioxide equivalent – tCO_2e).

Table 2. *Baseline, Current and Target Emissions for The Town*

GHG Emissions (tCO_2e)	2014 (Baseline)	2020 (Current levels)	2030 (20% reduction from baseline)	2050 (80% reduction from baseline)
Scope 1	19,300	14,427	15,440	3,860
Scope 2	1,206	1,059	965	241
TOTAL	**20,506**	**15,486**	**16,404**	**4,101**

EF and Quantification Method Source: National Inventory Report 1990 –2019: Greenhouse Gas Sources and Sinks in Canada

3.3. Historic Emission Trends

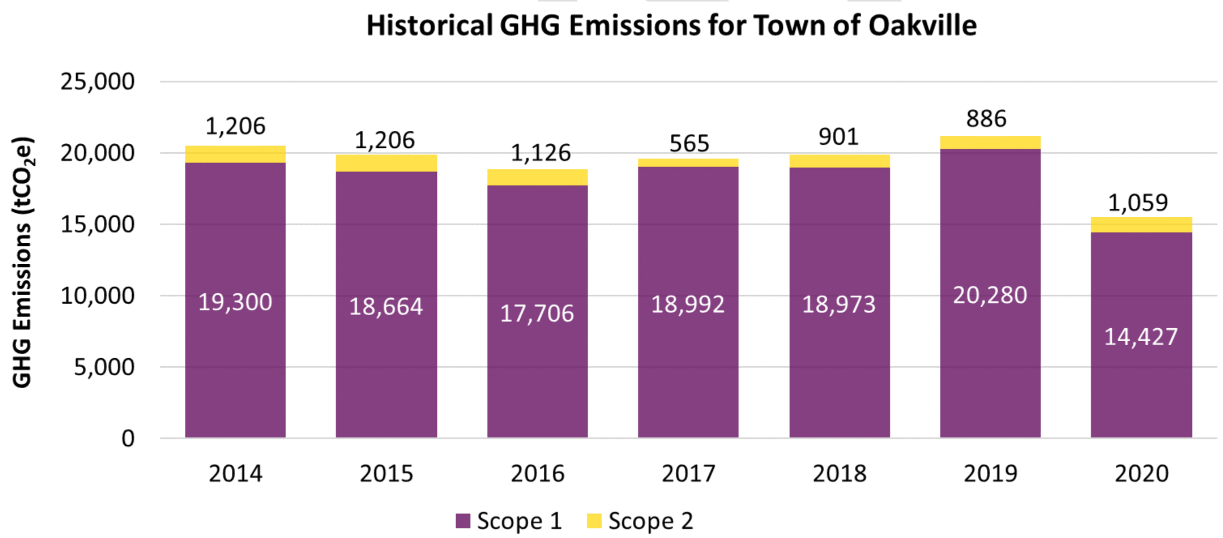


Figure 6. *Historical Emissions Trends for The Town*

Figure 6 above shows the annual GHG emission trends from the baseline year of 2014 through to 2020. The trends in the GHG emissions are broken down further between community Centers, Operations and Admins, and Arena's buildings. Factors affecting the GHG trends are explained on the following page by archetype.

3.3.1. Community Centers

The Community Centers archetypes – including Central Libraries, Community Centers and Performing Art Centers – were responsible for almost 21.62% of The Town's total GHG emissions in 2020. Scope 1 emissions peaked in 2014 at 3,738 tCO_2e, although it decreased in 2020 reaching 2,955 tCO_2e. Scope 2 emissions had a peak in 2014 at 478 tCO_2e. While there has been a significant reduction in emissions in 2017, they still stand on the high side in 2020 at 394 tCO_2e. Though not fully quantified, the impact of COVID-19 likely had some impact on the energy used in many of these facilities during 2020. The influence of municipality growth (in both population and physical size) on GHG emissions is further explored in Section 3.5.

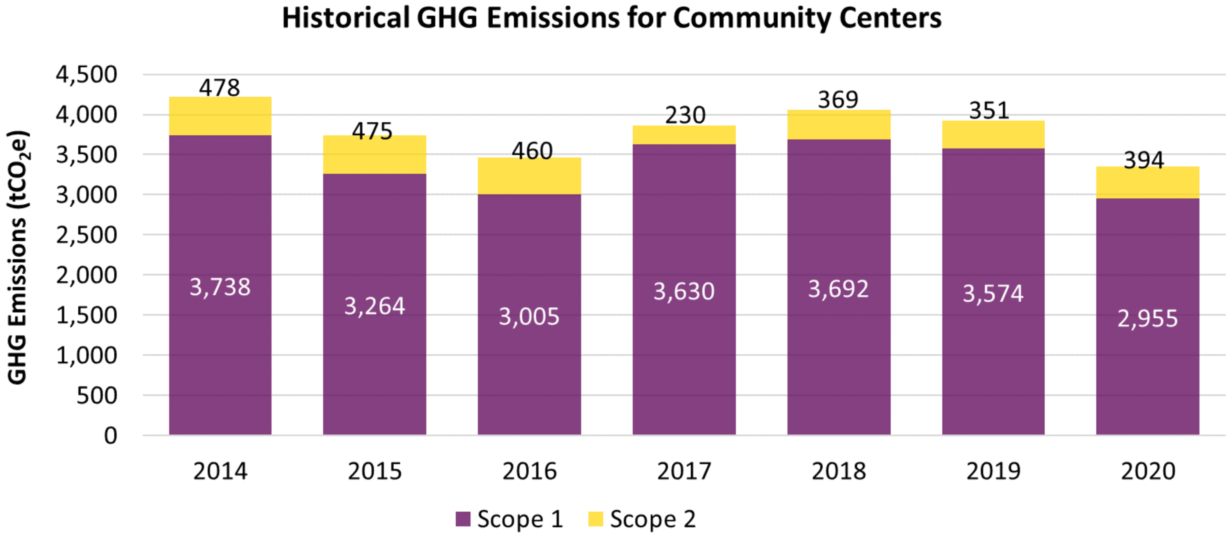


Figure 7. *Historic Emissions Trends for Community Centers*

3.3.2. Operations and Admins

Operations and Admins archetypes – including Town Halls, Transit Facilities, and Operations Centers – account for 71.65% of The Town's overall emissions. Scope 1 emissions increased to their peak in 2019 at 15,619 tCO_2e. However, Scope 1 emissions decreased largely by 2020. Scope 2 emissions experienced a rise in the same year, standing at the high end after 2015 with 425 tCO_2e. As with Community Centres above, the impact of COVID-19 is likely showing up as a part of reduced GHG loads.

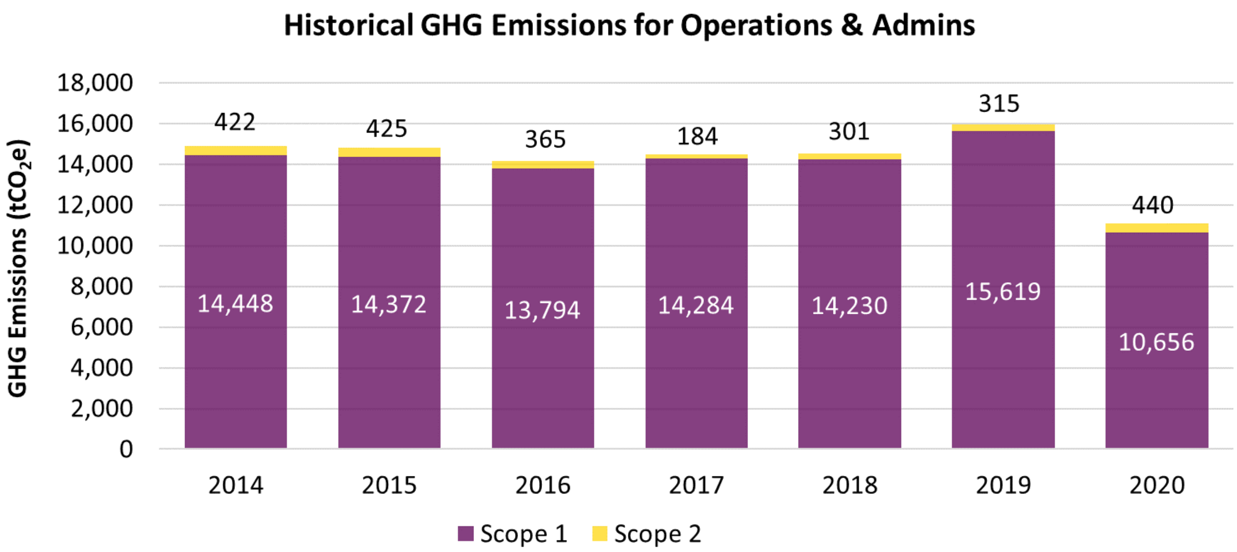


Figure 8. Historic Emissions Trends for the Operations and Admins

3.3.3. Arenas

Arenas' archetypes – including Sports Complexes and Arenas – account for 6.66% of The Town's overall emissions. The Scope 1 emissions have a significant drop in 2020. The Scope 2 emissions increased in 2018 and 2019, even though they got reduced over the first three years of the period and it has been increased again in 2020 at 223 tCO_2e. Again, COVID-19 may have had some effect on the GHG levels in 2020. Less than 1% of The Town's total GHG emissions is attributed to Others including parking garage, meters, splashpads and outdoor washrooms.

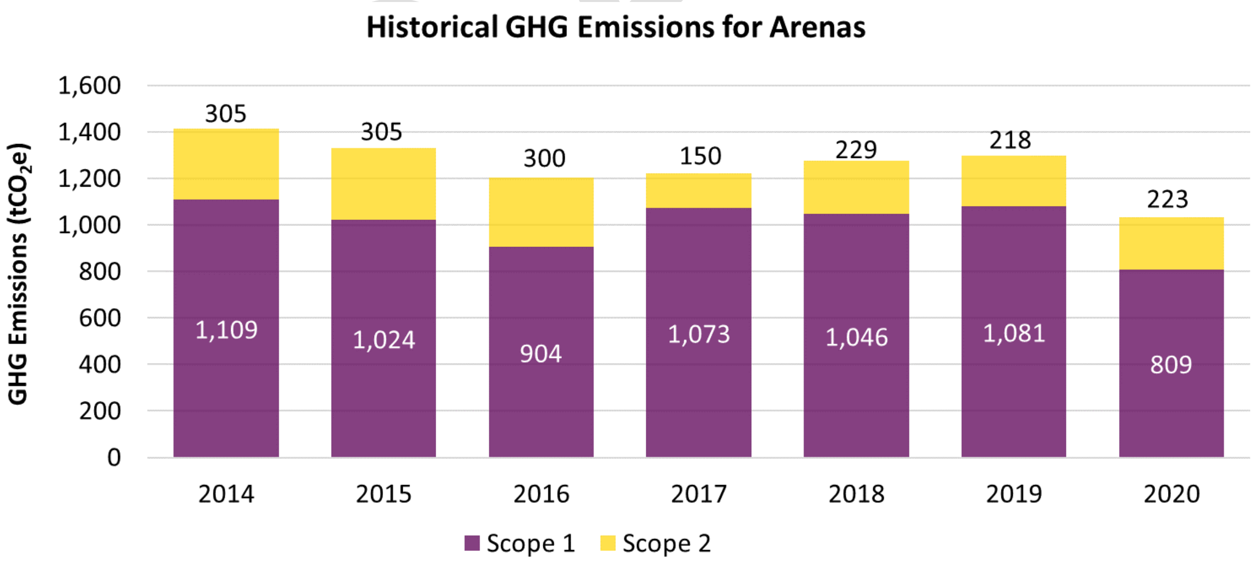


Figure 9. Historic Emissions Trends for the Arenas

3.4. The Town of Oakville GHG 2020 Inventory

The Town's 2020 GHG footprint includes Scope 1 & 2 emissions. The breakdown of emissions by Scope is similar year over year. The highest contributors to The Town's GHG emissions are Diesel and natural gas (Scope 1), and electricity (Scope 2). Figure 10 below illustrates the share of various GHG sources for all Scope 1 & 2 combined for the year 2020, aggregated for all buildings and facilities – Community Centers, Operations and Admins and Arenas. Figure 10 below shows Diesel with 42.8% is the largest contributor of The Town's total emissions. For this reason, diesel has been broken down into diesel transit and diesel fleet to give a better view of their contributions separately.

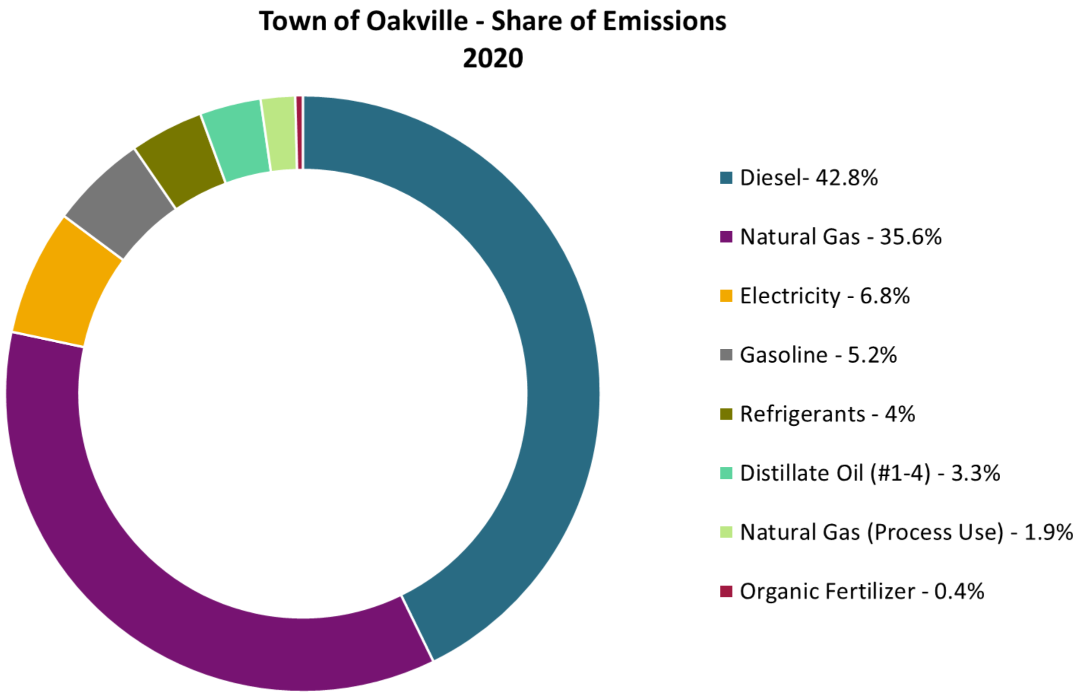


Figure 10. *Share of Various GHG Sources for Scope 1&2 in 2020*

Scope 1 represents most of the total corporate GHG emissions, which are primarily from diesel and natural gas as shown in Figure 11. Of The Town's scope 1 emissions 11.12% are produced by diesel fleet and 34.79% by diesel transit which represents ~46% of the total scope 1 emissions. Emissions reductions strategies, including electrification, that target the use of natural gas and diesel will result in the most significant decreases in Scope 1 emissions.

Only about 8% of Ontario's total power generated from natural gas plans which results in relatively clean electricity grid at 40 g CO_2e.

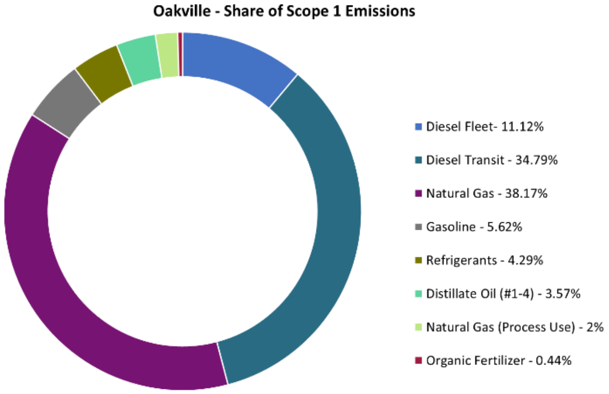


Figure 11. *2020 Scope 1 Emissions and Sources*

3.5. Growth

In 2014, The Town's total size of corporate facilities-Community Centers, Operations and Admins, and Arenas was 2,078,734 sq. ft (please note that this total square footage includes some buildings which have been reportedly sold or have no energy data). This real estate size stayed stable by 2018 and there is a modest increase by 2019 to 2,083,273 sq. ft. The annual growth trends are summarized in the graph below.

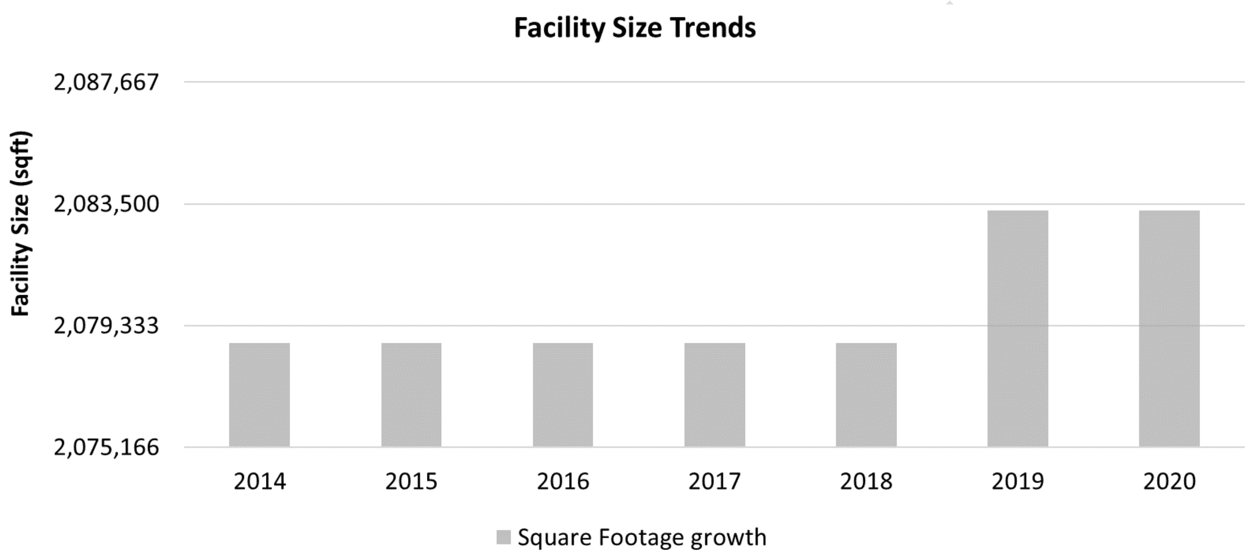


Figure 12. *Historic Growth Trends*

When analyzing data from the baseline year-to-date and forecasting trends to estimate The Town's expected facility size growth by 2022, 2030 and 2050, there is only one important factor to consider, the increase in corporate facilities' square footage. Every day The Town will need more facilities for the residents and expansions will be added to existing buildings, and new facilities will be constructed to provide residents' demands. As this factor increases, it is expected that total GHG emissions will increase as well.

For Scope 1 and 2 emissions, it is assumed that electricity and natural gas consumed per square foot is constant (2020 level). As square footage increases, the emissions rise proportionally though neglecting (directly) any energy conservation measures in any specific building.

3.5.1. The Town of Oakville Growth

Scope 1 and 2 emissions for the years 2014 to 2020 are modelled against the increase in square footage. Historically, increases in emissions and square footage follow an almost linear growth pattern. The scope 1 emissions had a moderate reduction in 2016 and then a small increase over 2017 and 2018. However, by 2019 there was a facility growth of 4,539 sq ft which resulted in a growth of scope 1 emissions at 1,307 tCO_2e.

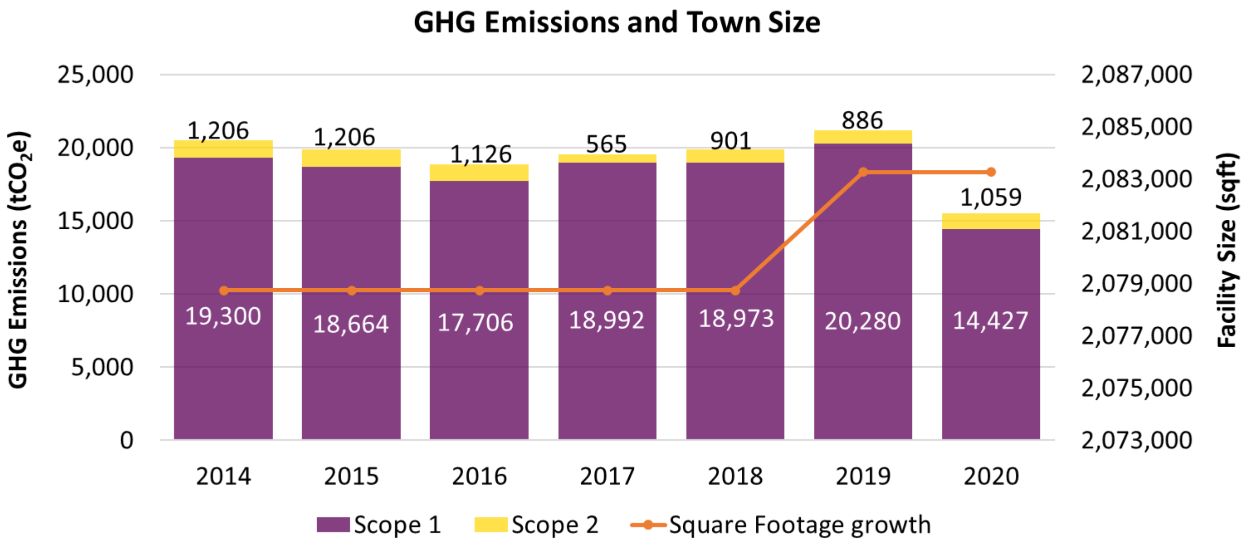


Figure 13. *Historic GHG Emissions Relative to The Town Size*

3.6. Business as Usual (BAU) Emission Forecast

The following assumptions were considered to model The Town's forecasted emissions. Growth assumptions are based on Blackstone's experience and Statistics Canada.

Table 3. *Growth Assumptions for The Town*

Annual Growth Assumptions	Community Centers	Operations and Admins	Arenas
Facility Growth (sq. ft)	5% every 10 Years		

Figure 14 below demonstrates the business as usual (BAU) increase in The Town's total forecasted GHG emissions compared to The Town's target emissions level. It is expected that, by 2030, The Town's total emissions will be 17,138 tCO_2e, which is ~733 tCO_2e above its target for that year. Keeping with this trend, The Town's total emissions will be 19,321 tCO_2e in 2050 if no conservation or GHG mitigation strategies are implemented, this amount will be 15,220 tCO_2e above the GHG target of 2050. These findings are further explained in the graph below.

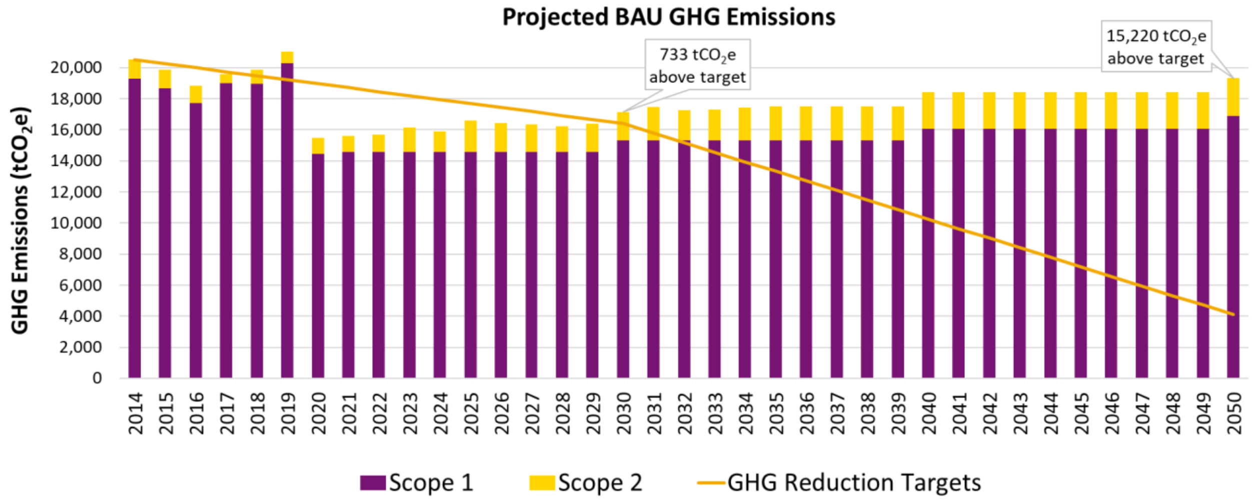


Figure 14. *Projected Business as Usual GHG Emissions*

4. Pillars of Carbon Reduction Roadmap

To reach The Town's reduction carbon target, the following factors were analyzed in conjunction with a study of their HVAC+L infrastructure, utility portfolio, projected facility size growth and the potential for renewable energy generation. To meet its 2030 and 2050 GHG emissions targets, The Town's GRRAP will be centred around the following four pillars, as previously mentioned:

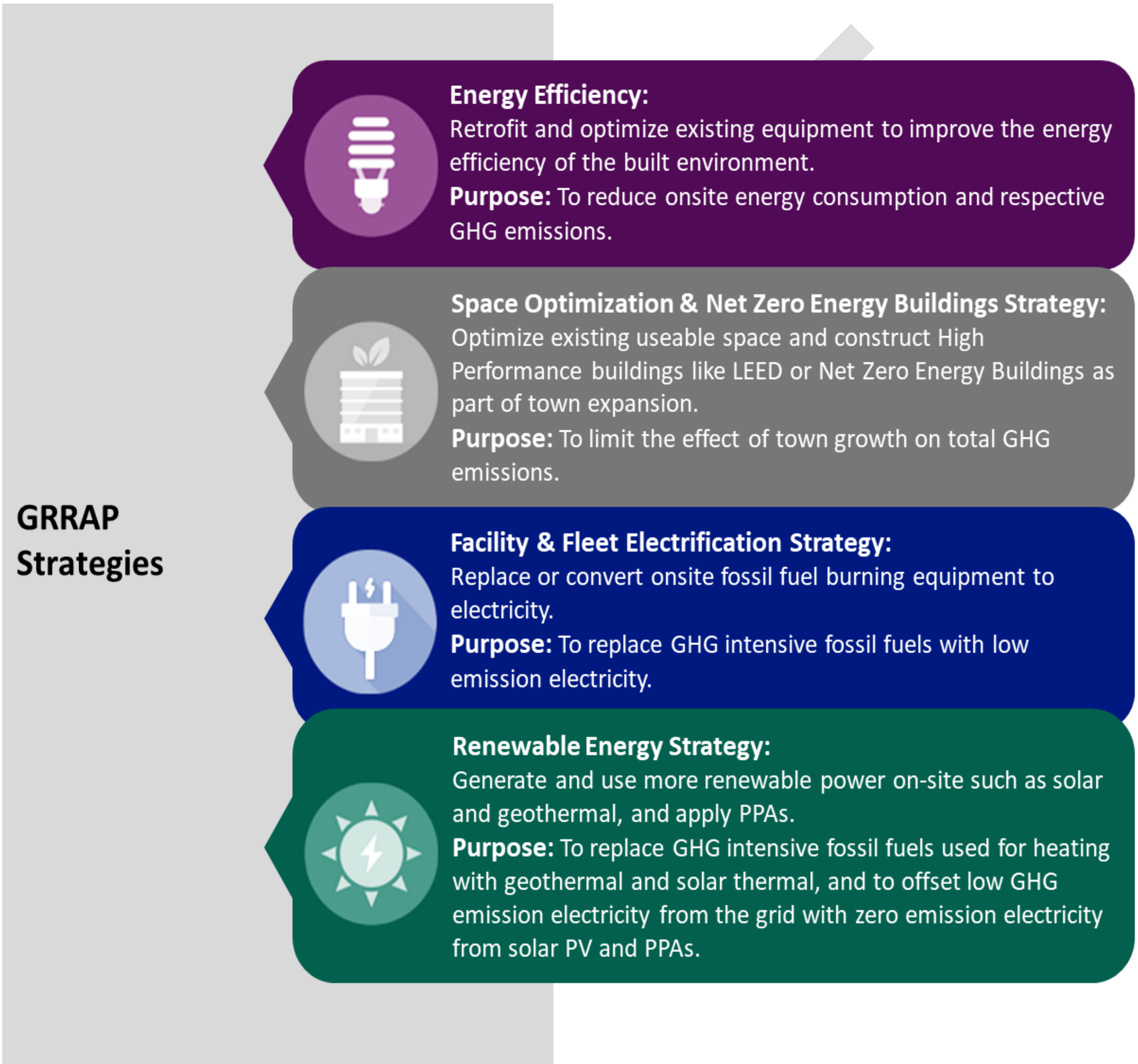


Figure 15. *GHG Reduction Pillars for the GRRAP*

4.1. Pillar 1: Energy Conservation & Demand Management

Energy Conservation and Demand Management (ECDM) refers to The Town's ongoing commitment to energy management and the improvement of Town-wide energy efficiency. ECDM measures reduce Scope 1 and Scope 2 emissions through facility upgrades, energy efficiency improvements and renewable energy projects. The estimated savings and GHG reductions associated with the implementation of the ECDM, and measures and renewable energy generation planned from 2022 to 2028 are summarized in the table below. Note, the table below does not include the renewable energy systems recommended by the RE report.

Table 4. *Estimated Annual Savings from Pillar 1 Initiatives*

ECDM Summary	2022 - 2024	2025-2028	
Total Investment in Conservation	$9,757,773	$2,329,801	**$12,087,574**
Electricity Savings (kWh)	5,636,456	0	**5,636,456**
Electricity Cost Savings	$799,192	$0	**$799,192**
Gas Savings (m3)	140,176	166,645	**306,821**
Gas Cost Savings	$40,214	$53,466	**$93,680**
Total Utility Savings ($)	**$839,406**	**$53,466**	**$892,872**
GHG Reduction (tCO_2e)	**554.11**	**314.96**	**869.07**

The Town should continue to be committed to creating a culture of ECDM and should update the ECDM Plan on a five-year renewal timeframe. To implement all measures identified in the EDCM Pillar, The Town would need to invest $12,087,574 over 6 years. Once completed, the ECDM measures will save electricity and natural gas and reduce GHG emissions by 869.07 tCO_2e annually. The detailed list of measures covered under the ECDM Pillar can be found in Appendix 2.

4.2. Pillar 2: Space Use Optimization & Zero Carbon Buildings

The built environment is a crucial element in The Town – community and corporately. As such, it is important for their spaces such as community centers, parking, parks, libraries, Town halls, etc., to be well maintained, efficient, resilient, and have the flexibility to support new municipal demands. Space use optimization and zero-carbon building designs provide opportunities for The Town to meet the needs of its community while remaining in alignment with their GHG emission reduction targets.

4.2.1. Space Use Optimization

Space utilization analysis is a tool that can help The Town uncover which areas in the buildings are underused, why they are underused, and how to best move forward to improve space utilization. For example, space utilization will point out when and where HVAC systems are being operated for spaces that are not fully occupied and too large for the number of people using the space.

Space utilization audits provide a data-centred assessment of the condition of building stock and the state of deferred maintenance. This is coupled with insights on how relocating certain activities could better centralize multiple facilities. It can also help with the development of a capital allocation plan to achieve desired improvements.

Space utilization audits provide insights into wasted space and outline how rethinking existing assets can achieve cost-savings goals previously thought to be out of reach. Municipalities have spaces that are designated for " more general use" (rooms that can be used for multiple municipal purposes such as community Centers) and other spaces that are considered "owned-space" (parking, libraries, Arenas, central depots). A space utilization audit would identify the potential positive and negative impacts, as well as barriers, to The Town implementing a policy to release "owned" spaces for general assignment.

Indoor space mapping, combined with real-time occupancy and schedule monitoring, determines how existing spaces can be better utilized. Space-sensing technology, combined with building automation systems (BAS), can support energy-saving lighting and HVAC optimization, further reducing total GHG emissions.

Space use optimization is a preventive measure against building new spaces. By maximizing the use of the existing built environment and underutilized spaces, and using technology and data analysis, space utilization can give municipalities useful information to avoid unnecessary new construction projects. It is a useful tool to evaluate if expansion requirements can be met by effective utilization of existing spaces, avoiding the significant costs associated with new construction and operations and maintenance required for the new space. Proper space utilization combined with high-performance design standards will promote correct sizing and operation leading to consistent and repeatable energy/GHG reductions.

Case Study 1: Space Optimization – Compatible Technology

Cloud computing, artificial intelligence analytics and internet-connected sensors allow BAS to continually re-adjust temperatures. These adjustments are based on real-time data from occupancy and humidity sensors, commands from individual users via mobile or desktop applications, exterior temperature readings and predictions based on historical patterns of user behaviour, and time-of-use energy pricing policies in Ontario[2]. Smart heating, ventilation and air conditioning controls can limit energy consumption in unoccupied building zones, detect and diagnose faults and help reduce HVAC usage during times of peak energy demand.

As an example, the setup and functions of GE Current's smart office system are demonstrated below.

Figure 16. *GE Smart Office System*

[2] GE Current: How to build an intelligent office
https://www.currentbyge.com/ideas/how-to-build-an-intelligent-office

Case Study 1: Space Optimization – Compatible Technology

Integrating smart office technology in operations has many advantages:

- Space availability and booking are dynamically adjusted based on occupancy and proximity.
- Hoteling or desking opportunities are created for remote workers, enabling effective use of underutilized space.
- Tracking equipment and furniture use can be implemented to improve logistics, facility operations and resource management.
- HVAC and lighting can automatically adjust to room occupancy.
- Up to ~20% annual utility cost savings can be achieved across typical office environments[3].
- Networked lighting control and BAS create energy management strategies that:
    - Enable facilities to never forget to flip the switch when leaving a room
    - Empower users to personalize their lighting and temperature controls
    - Set up facilities that coordinate lighting, heating, and cooling for optimum operational efficiency

[3] Brasington, 2019: Smart Buildings – Innovation in Space Utilization
https://www.cleantech.com/smart-buildings-innovation-in-space-utilization/

4.2.2. Zero Carbon Buildings

The design, and operation of new and renovated spaces can have a significant impact on total GHG emissions for a long time. Environmental performance measures that promote sustainable new and retrofit development have a significant impact on the energy, GHG and comfort characteristics. Buildings in the corporate portfolio tend to be retained for long lives meaning a structure built today will still be in use past 2050 – designs now will impact carbon loads in a time when low to zero carbon buildings will be the norm and carbon fees could be very high relative to the cost of the actual fuel itself. Low to zero carbon building (L-ZEB) designs will help The Town to reduce its carbon presence now and continue to keep GHG levels low as the building ages.

There are several existing L-ZEB standards and guidelines The Town can refer to and tailor to their own needs and circumstances. A dominant concept is to define absolute performance metrics for new builds and renovations. This refers to defining fixed energy and GHG performance as units/m^2, such as kWh/m^2 and kg CO_2/m^2. Selecting these performance indices with The Town's GHG goals for 2030 and beyond will guide new developments and renovations to assist in meeting the targets without compromising the path.

For example, the Toronto Green Standards, British Columbia Step Program and Canadian Green Building Council (CaGBC) – all with best practices standards, have been shown to drive high-performance construction without causing insurmountable incremental costs while yielding reduced life cycle energy and carbon costs. These typically reference the current Building Code requirements and are updated at the same time the Codes are. In the case of The Town, we recommend setting design standards that surpass the requirements of the current Ontario Building Code (OBC) including the Supplementary Bulletin 10 before the Code is updated to allow for planning cycles and permitting. For example, The Town could pursue zero carbon building standards for new builds as an upper-tier design target.

These standards differ slightly but are all focused on designing high-performance buildings that can be augmented (or in some cases, totally) by renewable energy sources. The more energy-efficient a building is constructed to be, the less energy is required to power the building which also means any renewable energy will have a more significant impact.

With high-performance design goals, the architectural/engineering teams would be required to pursue L-ZEB concepts from the beginning. For example, by considering solar panel location, shading and designs with surfaces at a specific angle to optimize the solar access. Other considerations such as roof gardens or green walls would enhance these buildings with carbon sequestration and rain surge mitigation by green space. Location and orientation of the building on the site considering natural ventilation and daylighting can be addressed as an energy-saving concept early in the design process. In general, the standards should promote passive design features along with high-performance design elements in the envelope to keep energy and GHG levels to their lowest possible.

Benefits of an L-ZEB design/renovation are:

1. Reduced energy and carbon costs
2. Improved thermal autonomy
3. Improved resilience against extreme weather events.
4. Improved and consistent thermal control
5. Attention to and use of daylighting
6. Improved ventilation efficacy
7. Improved and consistent comfort levels

8. More consideration for the impact on the surrounding environment – exterior lighting, bird impacts, water retention, heat island, public transportation

Blackstone recommends that The Town develop their own high-performance standards tailored to their portfolio archetypes and include elements of best practices standards/guidelines (such as TGS, BC Step, CaGBC and LEED).

The New Buildings Institute studied the cost and savings from the construction and operation of ZCB. In the study, costs were separated into two categories: 1) the incremental costs for energy conservation measures and 2) the costs for the purchase and installation of renewable energy systems. By increasing energy efficiency, the number of renewable energy systems (and therefore the cost) will be reduced. The Institute also extended the framework to retrofits and refurbishment of existing buildings to net-zero carbon by considering the design strategies listed in Figure 17 below.

***Figure 17**. Design Considerations for High Performance Buildings*

The average construction cost of office space in Ontario is an estimated $300 per square foot (sq. ft), compared to the average cost of a LEED building in Ontario, which was found to be ~$295/sq. ft. A ZCB is estimated to add approximately 13% to the cost premium of LEED buildings. The differences in cost for The Town expansion are estimated in Table 5 below.

Table 5. Capital Cost Considerations for Zero Carbon Buildings

Construction Type	$ / sq. ft		Example Facility Expansion in 2028	Estimated Total Cost (2028 $)
	2018 $	2028 $		
Building Code	$270	$315	100,000 sq. ft	$31,500,000
LEED Gold Construction	$295	$339		$33,900,146
ZCB Construction	$320	$368		$36,800,000

Although construction of a ZCB comes with a cost premium of 13%, there are long-term financial savings in building the Zero Carbon Standard. A typical ZCB has an annual utility and maintenance cost savings of approximately 26% when compared with a LEED construction project[4]. This is shown in Table 6 below.

Table 6. Comparing LEED & Zero Carbon Buildings

	LEED Construction	Zero Carbon Buildings	Savings
Addition to Community Centers (sq. ft)	100,000	100,000	-
Estimated Construction Costs ($/sq. ft)	$295	$320	-
Estimated Construction Costs	$29,500,000	$32,000,000	-$2,500,000
Annual Natural Gas and Electricity Utility Cost ($/sq. ft)	$1.49	$0.97	26%
Estimated Annual Utility Expense	$148,532	$96,546	$51,986
Simple Payback (Years)	-	-	48
Simple Payback with Utility Rate Escalation (Years)	-	-	34

Investing an additional $2,500,000 to construct a ZCB would generate an annual utility cost saving of $51,986 and would result in a 48-year payback based on additional construction costs and at current utility rates. However, when accounting for the escalation of utility rates, the payback for a ZCB goes down to 34 years.

Consideration must also be given to the cost of carbon and how it will increase over the next 9 years. In all cases, we recommend a life cycle cost analysis be followed that includes the cost of carbon and best estimates for the cost of utilities. The comparison timeframe should be 15 years minimum. Note that current photovoltaic warranties are 25 – 30 years with an 80% of nameplate at end of the warranty. This timeline should be used when PV is being considered for electrification planning.

[4] Canada Green Building Council & WSP, 2019: Making the Case for Building to Zero Carbon.

Case Study 2: Zero Carbon Buildings

Completed in Fall 2018, "evolv1" is a three-story, 110,000 sq. ft commercial multi-tenant office building and one of 16 participants in CaGBC's Zero Carbon Building pilot program.

Figure 18. *Evolv1 in Waterloo, ON*

Building highlights:

- Modelled as zero carbon balance for future operations.
- Incorporated a highly efficient energy and ventilation system to meet a defined threshold for thermal energy intensity.
- Designed onsite renewable energy systems capable of providing a minimum of five percent of building energy consumption.

The building's design includes elements aimed at maximizing its energy efficiency and producing more energy than it consumes:

- High-performance building envelope.
- Geo-exchange/variable refrigerant flow (VRF) HVAC system.
- Triple pane glazing.
- Solar wall for preheated ventilation.
- Combination of a carport and roof-mounted photovoltaics producing 700kw of electricity for the grid.
- Three-story green wall to improve indoor air quality.

Estimated construction cost:

$318/sq. ft (without interior fit-out)

4.3. Pillar 3: Facility & Fleet Electrification

To meet The Town's 2050 GHG emission target, they must transition away from fossil fuel-based energy consumption and move towards low-carbon alternatives. Total facility and fleet electrification would entail the complete conversion of onsite equipment, including natural gas-fired boilers and HVAC equipment, natural gas cooking equipment, as well as fleet gasoline and diesel vehicles.

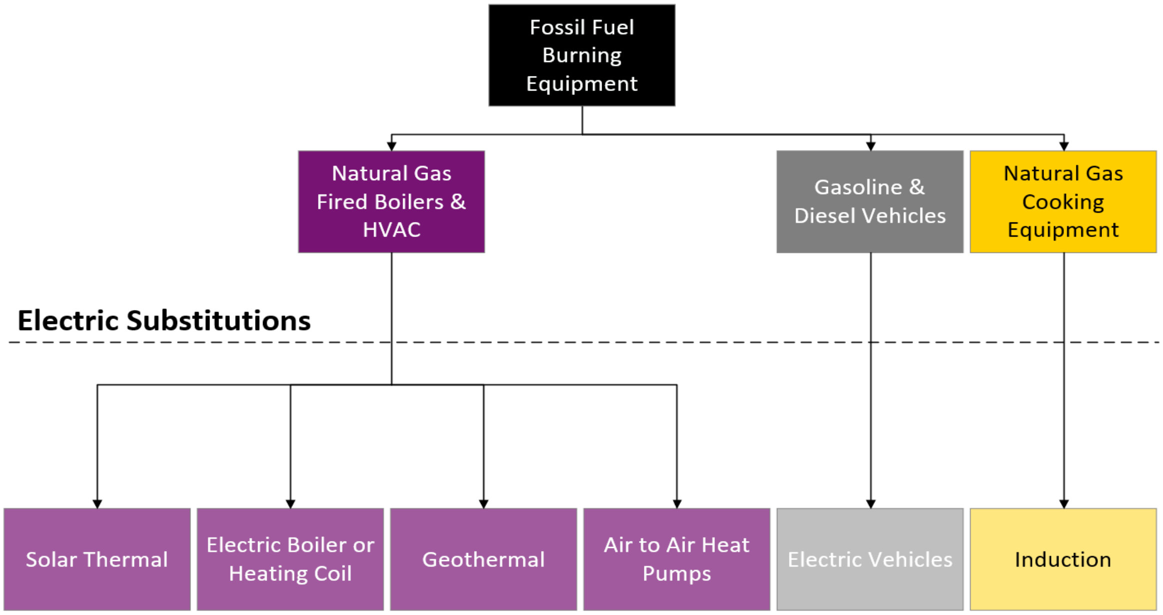


Figure 19. *Electric Equivalents for Traditional Equipment*

When comparing natural gas and electric systems, electric systems produce fewer CO_2e emissions per kWh consumed. Comparatively, 1 kWh of electricity would emit 40g of CO_2e while 1 equivalent kWh (ekWh) of natural gas would emit 179 g of CO_2e (note that some databases will show slightly different factors depending on the source) The carbon content of various fuels converted to equivalent kWh is represented in Figure 20.

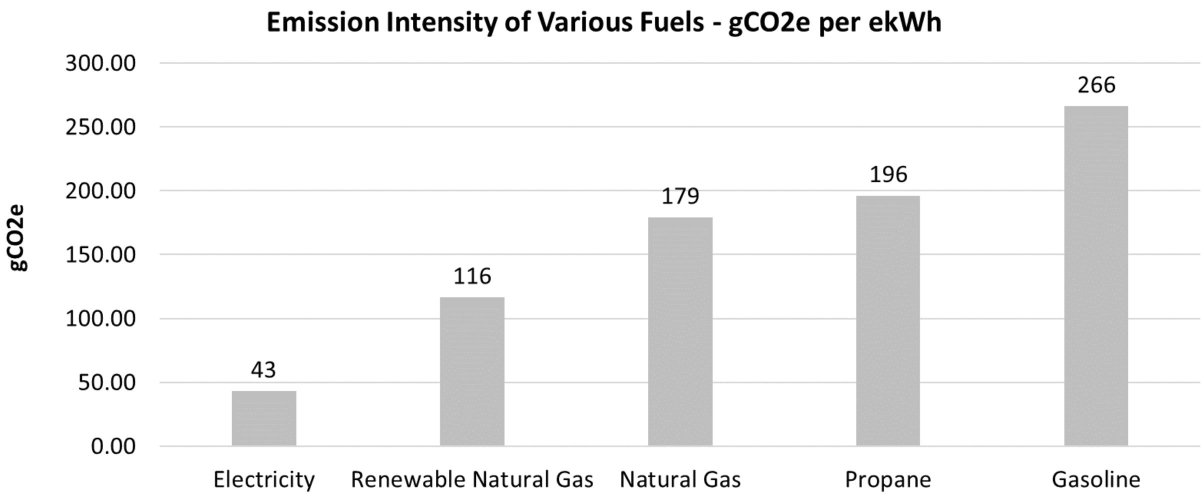


Figure 20. *Emissions Intensity of various Fuels for Equivalent Energy Output*

Source: National Inventory Report: Greenhouse Gas Sources and Sinks in Canada.

Based on the timeline and rate of electrification, two actions were developed: aggressive action electrification and delayed action electrification. We understand The Town is considering the purchase of some electric buses to supplement the transit fleet. This has not been taken into account though we encourage the switch to non-diesel transit whenever possible. The net carbon accounting will include the difference between the electric emissions and diesel for the year.

Under the aggressive and delayed actions, it is expected that The Town will fully implement the projects needed under Pillars 1, 2 and 4.

The actions were based on the expected asset end of life characteristics using ASHRAE standards (see Table 8) and applied to The Town's equipment list. For example, as each natural gas-fired air handling unit (AHU) approaches the end of life, the GRRAP considered the cost and carbon reduction associated with replacing it with an electric equivalent or high-efficiency natural gas replacement. Depending on the current age of the equipment, it may be replaced approximately two times with similar natural gas equipment before being replaced with low carbon electric equivalents, as shown in Table 7.

Table 7. *Sample Replacement Schedule for Fossil Fuel Equipment*

Facility	Initial Installation Date	Estimated Replacement Schedule		
Community Centers	1999	2020	2035	2050
Potential Fuel Source →	Natural Gas	Natural Gas	Natural Gas	Electric

As part of Pillar 3, replacing equipment at the end of its life expectancy creates a decision point for The Town to assess whether the equipment should be replaced with electric equivalents or conventional natural gas systems. Under the aggressive action, The Town will replace fossil fuel burning equipment at the *first* end-of-life replacement cycle and with an electric equivalent. Under the delayed action, it will defer electrification and convert equipment at the *final* end-of-life replacement cycle before 2050. In all cases, energy conservation measures should be pursued so that replacement equipment is "right-sized" according to efficient operations, further improving the energy/GHG performance over the life of the equipment.

The following table shows the life expectancy of equipment and the last date of potential installation for fossil fuel burning equipment.

Table 8. Fossil Fuel Burning Equipment Expected Life Table

Fossil Fuel Burning Equipment	Expected Life (Years)[5]	Last Date of Potential Installation / Replacement
Boiler	20	2030
Make-up Air Unit / Air Handling Unit – Interior Installation	25	2025
Make-up Air Unit / Air Handling Unit – Exterior Installation	15	2035
Cars / Trucks	10	2040
Cooking Equipment	15	2035

**Expected Life - ASHRAE Equipment Life Expectancy Chart*

Under the aggressive and delayed actions, The Town will increase its electrification efforts and reduce its GHG emissions from natural gas-based equipment. The sooner The Town invests in electric systems, the quicker it will reduce emissions and be on track to achieve GHG reduction goals. The following chart depicts the potential replacement (under each action) for fossil fuel-burning equipment during the process of electrification (based on currently available technologies). The types of equipment that make up these measures are boilers, MAUs and AHUs.

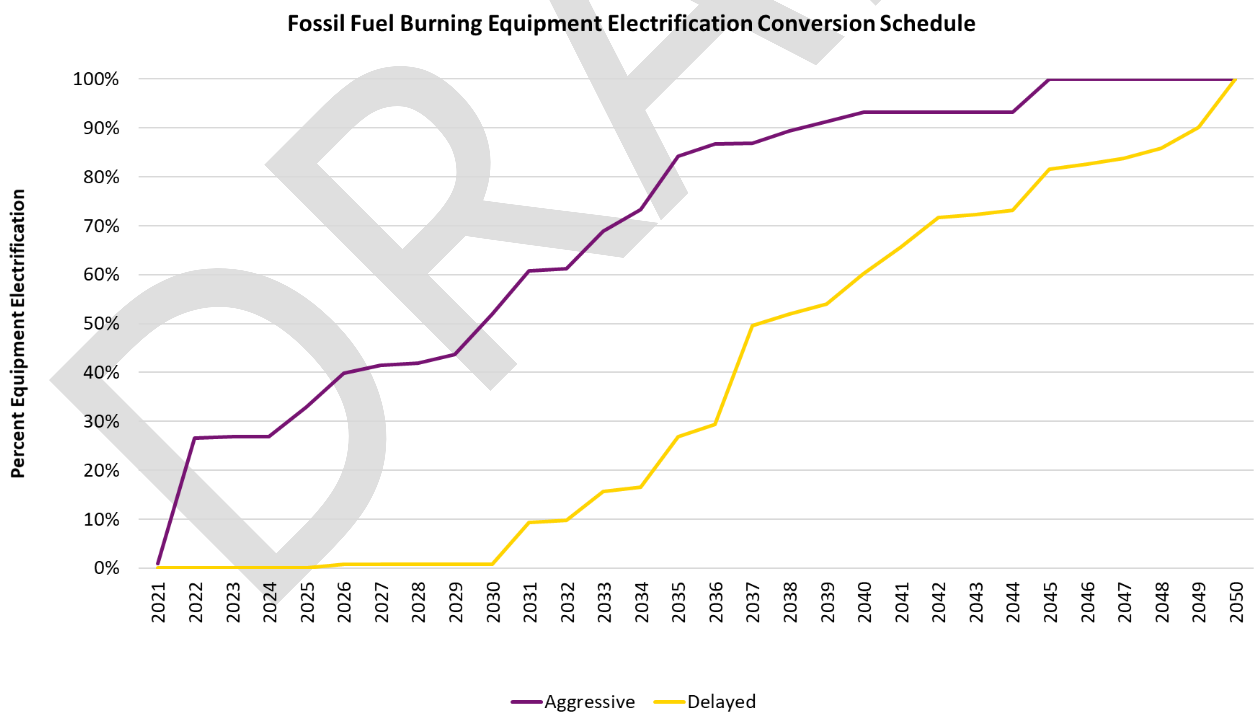


Figure 21. *Equipment Electrification Conversion Schedule*

[5] ASHRAE Equipment Life Expectancy Chart

4.4. Pillar 4: Renewable Energy Generation

Solar photovoltaic (PV) is a proven, low-maintenance and cost-effective form of renewable energy. High-level estimates indicate The Town could install 1,094 kW of carport systems and produce 1.71 million kWh of renewable power per year, rooftop systems also could produce 2.53 million kWh/yr. with 2,204 kW installation. This estimate is based on the information available during the period of this study and the actual number could vary depending on multiple factors such as changes to the master plan, connection capacity, and parking plans.

Carports provide a great opportunity to produce renewable power when space constraints on a building are a concern. Carport solar PV systems are a highly visual symbol of The Town's commitment to sustainability and portray them as actively looking for low carbon solutions. The steel structures (or canopies) required to hold the solar panels typically make carport PV systems about twice as expensive to install as rooftop PV systems.

The limiting factor for renewable energy generation is the space requirement per kilowatt (kW) installed. Based on estimates of the rooftop solar potential for The Town, using current solar technology efficiency estimates and assuming the roof space can take the load, the existing facilities can accommodate about 1,040 kW of rooftop solar PV at an estimated cost of ~$1,850 per kW. Solar PV is typically net-metered to the local grid system. The amount produced would contribute to lowering The Town's Scope 2 emissions by reducing the amount of electricity it purchases from the grid. A more detailed renewable energy study has been completed which illustrates how low carbon solutions could be implemented across the corporate portfolio. The estimates here are a snapshot of the opportunities within The Town. See the more detailed report for concepts with more information regarding areas, costs, and performance.

PV technologies being applied more often are the building integrated and building applied photovoltaics more available (BIPV and BAPV). Case Study 3 in the following pages elaborates on the BIPV and BAPV systems, their space and cost considerations.

Other forms of solar technology – hot water and heated air, are not as popular due to the current low cost of natural gas. However, when the cost of carbon is included over the next 9 years, these technologies might be feasible for The Town and should be considered. The following table illustrates the potential for solar hot water systems at some selected sites. These sites were chosen based on solar access and estimated solar energy contribution capacity. These systems were estimated based on contributing ~20% of the annual natural loads, which is a common metric for commercial hot water loads. The solar fraction amount of hot water that can be supplied by solar energy, was assumed at 20% annually. The tonnes avoided per year are based on all current hot water loads being supplied by natural gas heaters. The technology used to estimate the performance is the vacuum tube with storage tanks and circulating a water/propylene glycol mixture.

Table 9. Estimated opportunities for solar hot water at select sites.

Archetype	Site	2019 m3	Est DHW, m3	Target SDHW, m3/yr.	GHG saved tonnes/ yr.	Proposed Solar water est. cost	$/yr. Saved	$/ tonne
Community Center	Glen Abbey	353,953	70,791	14,158	268	$154,000	$4,247	$576
Community Center	Iroquois Ridge	311,548	62,310	12,462	236	$143,000	$3,739	$607
Community Center	Queen Elizabeth Park and Community Centre	218,849	43,770	8,754	165	$110,000	$2,626	$665
Community Center	River Oaks	218,048	43,610	8,722	165	$110,000	$2,617	$667
Community Center	Trafalgar Park Community Centre	167,431	33,486	6,697	127	$99,000	$2,009	$782
Operations and admins	Fire Station #3	24,521	4,904	981	19	$44,000	$294	$2,374
Operations and admins	Transit Facility	537,745	53,775	10,755	203	$132,000	$3,226	$649
Arenas	Joshua Creek Arena	165,526	33,105	6,621	125	$99,000	$1,986	$791
Arenas	Maple Grove Arena	31,583	6,317	1,263	24	$46,200	$379	$1,935
Arenas	16 Mile Sports	349,377	41,925	8,385	158	$107,800	$2,516	$680
Operations and admins	North Operations	62,403	7,488	1,498	28	$107,800	$449	$3,808
	Total	**2,440,984**	**401,481**	**80,296**	**1,518**	**$1,152,800**	**$24,088**	**$759**

Another solar heating system that has been in use for over 35 years is Solar wall technology. This is an aspirated wall with perforations on the surface of a metal wall attached to the outside wall which is heated up by the sun then draws air in and then into an air duct connected to the pre-heat section of a rooftop unit. This concept pre-heats outside air before it has to be warmed up by a natural gas (typically) coil inside the rooftop unit. Recognizing that only a fraction of the required air in a building is drawn from the outside, these systems are estimated at ~7% of the estimated ventilation loads.

Table 10. *Performance for solar pre-heated air at select sites.*

Archetype	Site	Est Air preheat, m3	GHG saved, tonnes	Est wall area sq. ft	Solar wall cfm	Estimated solar wall cost
Community Center	Glen Abbey	24,777	468	4,955	11,893	$297,000
Community Center	Iroquois Ridge	-	-	-	-	$-
Community Center	Queen Elizabeth Park and Community Centre	15,319	290	3,064	7,353	$198,000
Community Center	River Oaks	15,263	288	3,053	7,326	$187,000
Community Center	Trafalgar Park Community Centre	-	-	-	-	$-
Operations and admins	Fire Station #3	-	-	-	-	$-
Operations and admins	Transit Facility	37,642	711	7,528	18,068	$473,000
Arenas	Joshua Creek Arena	-	-	-	-	$-
Arenas	Maple Grove Arena	-	-	-	-	$-
Arenas	16 Mile Sports	24,456	462	4,891	11,739	$297,000
Operations and admins	North Operations	4,368	83	874	2,097	$66,000
Totals		**121,825**	**2,302**	**24,365**	**58,476**	**1,518,000**

Both of these solar heating concepts have been in use (in Ontario) for over 40 years. They have not been as popular over the last 10 years due to the low price of natural gas. Now, with the cost of carbon to be taken into account, they should be reconsidered for any renovations and new buildings where hot water and/or air pre-heat is required. The following table illustrates the estimated benefit due to reduced natural gas use for these solutions. Though these are high-level estimates and assuming the systems can be installed, savings on the order of $3 million over the next ~9 years can be predicted on an installed cost of ~$3 million of both solar water and air pre-heating. This implies paybacks on the order of 12-15 years for solar heating (also assuming natural gas commodity prices do not increase significantly over the next 9 years).

Table 11. Estimated carbon saved and carbon costs avoided from solar heat systems, 2022 – 2030

Archetype	Site	Solar Hot Water; 2022-2030		Solar Air pre-heat; 2022-2030	
		Tonnes	$	Tonnes	$
Community Center	Glen Abbey	2,408	$26,491	4,215	$509,957
Community Center	Iroquois Ridge	2,120	$23,317	-	$ -
Community Center	Queen Elizabeth Park and Community Centre	1,489	$16,380	2,606	$315,306
Community Center	River Oaks	1,484	$16,320	2,596	$314,152
Community Center	Trafalgar Park Community Centre	1,139	$12,531	-	$-
Operations and admins	Fire Station #3	167	$1,835	-	$-
Operations and admins	Transit Facility	1,829	$20,123	6,403	$774,754
Arenas	Joshua Creek Arena	1,126	$12,389	-	$-
Arenas	Maple Grove Arena	215	$2,364	-	$-
Arenas	16 Mile Sports	1,426	$15,689	4,160	$503,364
Operations and admins	North Operations	255	$2,802	743	$89,907
	Totals	**13,658**	**$150,241**	**20,723**	**$2,507,440**

The table above illustrates the impact carbon costs will have on natural gas use for heating. Avoiding these costs using solar energy where feasible will assist The Town in meeting their 2030 and beyond GHG reduction goals and should be reviewed in more detail.

Case Study 3: Building Integrated and Building Applied Photovoltaics (BIPV and BAPV)

Recent PV technology improvements are making building integrated and building applied photovoltaics more available (BIPV and BAPV). The difference between the two is that BIPV is when the PV is a part of the building such as embedded into the windows or forms the actual envelope, whereas BAPV is when the PV system is mounted onto the building such as the roof or vertical racking onto a wall.

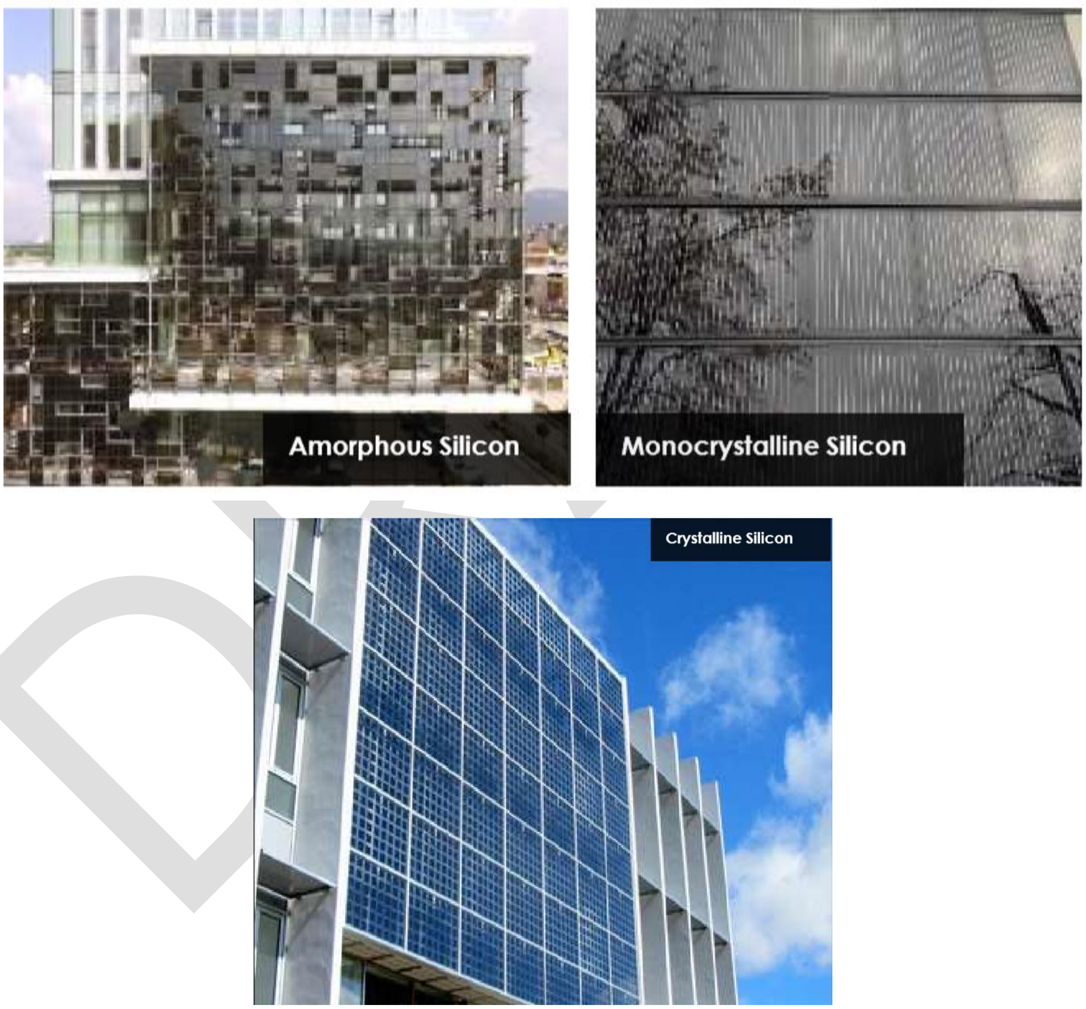


Figure 22. *Examples of BIPV & BAPV*

Case Study 3: Building Integrated and Building Applied Photovoltaics (BIPV and BAPV)

Some examples of BIPV – the PV modules are a part of the envelope. These can be customized with a range of transparencies and limited colours. The lower left image shows crystalline modules; the right is amorphous.

BIPV applications are typically considered from the start of a new building as the architect is generally the lead to make sure the “look”, style and appropriate design teams are involved – i.e., structural, electrical. If an envelope BIPV system is being considered, the existing wall will be removed and the new BIPV envelope installed. Other examples of BIPV are the skylight and window style of BIPV, which will require a structural survey as well and best coordinated with a design team to ensure compatibility with the building style and envelope integrity.

An alternate version is the building applied PV or BAPV. In this case, the PV array is mounted onto the structure. A fixed or ballasted PV array on a roof is an example of this arrangement and is very common. Wall-mounted PV can be hung onto the wall using a racking system or used as an awning over windows to provide some shading as well as power.

Figure 23. *Examples for mounting of BIPV & BAPV*

Case Study 3: Building Integrated and Building Applied Photovoltaics (BIPV and BAPV)

BIPV and BAPV Considerations

BIPV systems are used as cladding or window units. The design possibilities are in keeping with the envelope designs available. There are curtain walls, skylights, canopy, ventilated facades, and floors. They are usually constructed as sandwiched PV between the glass so can be a substitute for conventional architectural glass. They offer energy production, lighting (depending on transparency), infra-red and UV filters, acoustic and thermal characteristics.

The PV module is either amorphous or crystalline cells. Amorphous can be supplied in a variety of shapes, sizes, colours, and transmission from 0% to 30%. These have a consistent colour across the complete face of the glass. Due to the transparency the power ranges from ~57 W/m^2 at 0% to about 28 W/m^2 at 30%.

Crystalline silicon PV can also be customized but is usually configured as square to rectangular shapes. These look more like conventional PV modules with cells spread across the face. This also means they always let some light through even at high cell densities. They range from ~15% to 38% transparency. The power is dependant on the cell density.

Production Potential

The graphs below illustrate a sample output for an amorphous array, 100 m^2, 5.7 kW, 0% transmission, 4,000 kWh/yr. and a crystalline array, 100 m^2, 3.5 kW, 15% transmission, 2,756 kWh/yr., both mounted on a vertical wall, facing due south.

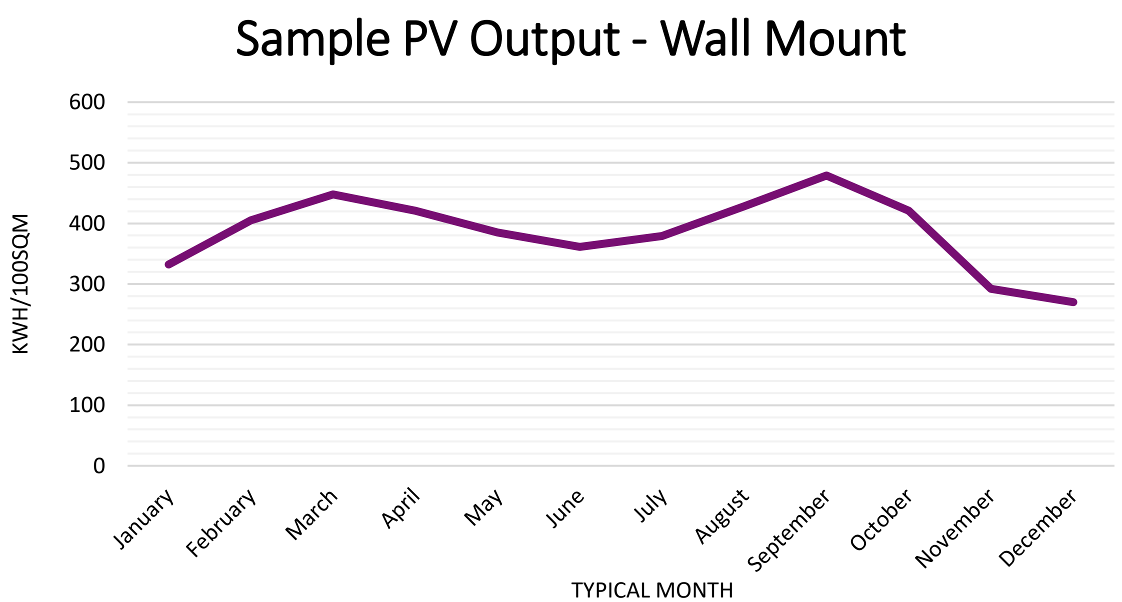


Figure 24. *Sample amorphous wall 100m2 BIPV at 0% transmission, 5.7 kW, 4,000 kWh/yr.*

Case Study 3: Building Integrated and Building Applied Photovoltaics (BIPV and BAPV)

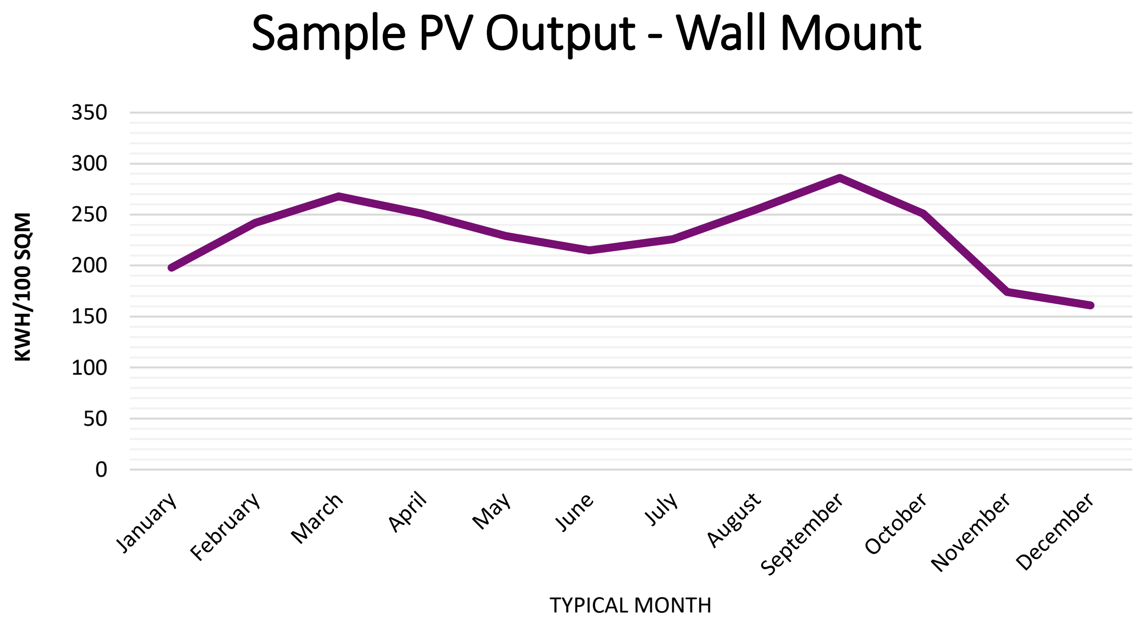


Figure 25. *Sample crystalline wall 100m2 BIPV at 15% transmission, 3.5 kW, 2,756 kWh/yr.*

Cost Considerations

Of the BIPV applications, a fully integrated PV envelope will be more expensive due to the structural elements required to complete the wall. Though a sample has been shown above for 100 m^2, most BIPV systems are at or above 1,000m^2 before the benefits of scale are available. An estimated cost for a full BIPV wall can be expected to be between $1 million and $1.5 million depending on the fastening system.

A wall-mounted BAPV can be expected to cost about half of a BIPV but is more dependent on the structural integrity of the existing wall.

As for any PV system, the connection must be evaluated before deciding to go forward with an installation. This is done early in the design process in coordination with the local distribution company.

4.5. General Sustainability Initiatives

The four pillars will reduce Scope 1 and 2 emissions that result from the energy used by The Town facilities and fleets. To reduce Scope 3 emissions, which is excluded from this study, from air travel, mileage reimbursements, waste and purchased paper, The Town will need to support general sustainability initiatives that typically require staff and resident engagement.

The Town should ensure that all municipal policies are aligned with the GRRAP and the goal of encouraging a low carbon future. For example, banning single-use plastics and continue initiatives to limit food waste. The Town has a well-developed waste management program called 'Towards Zero Waste Procedure' aside from other sustainable plans that have contributed to a reduction in their GHG emission footprint and increased awareness of sustainability issues. The Town should also expand sustainable transportation options for urban transportation – such as EVs, hybrid and electric buses, bikes, and electric bikes – to ensure that low carbon modes of transportation are a part of its carbon reduction future. We are aware that The Town is purchasing electric buses and this direction should be promoted to reduce the significant GHG contributions from diesel engines.

4.6 Sustainability Indicators

Climate change is recognized as a risk for financial and sustainability modelling. Markets and society are increasingly aware of the costs and risks of climate change and the results of inaction to mitigate the effects. Establishing a strategy will help with managing the risks associated with environmental, societal and governance dimensions for The Town. This GRRAP is a part of the strategic planning and combines with their sustainability plans and efforts to align with current programs that are being used as benchmarks for acknowledging the efforts. The UN Sustainable Development Goals (SDG) are another recognized platform for this. Elements of this GRRAP support the UN SDG categories that relate to clean energy, resiliency, and action.

Figure 26. *UN Sustainable Development Goals*

5. GHG Emissions Reduction Scenarios

For The Town to meet its emission reduction targets, it must implement programs to support the four GRRAP pillars. Based on the combinations in which the GRRAP pillars are implemented, four scenarios for The Town to advance towards 80% GHG reduction from 2014 level, are presented.

5.1. Scenario 1: Energy Conservation and Renewables Only

Under this scenario, The Town implements Pillars 1 and 4 – Energy Conservation and Demand Management, and Renewable Energy Generation. Efforts under this scenario are minimal and do not deviate from BAU operations considerably, although Blackstone recommends solar domestic hot water and air solar systems be further investigated for reduced natural gas in the HVAC systems. With consideration of these measures, the GHG emission reduction target for 2030 can be achieved but the corporate GHG emissions reduction target by 2050 will not be achieved. The assumptions made under this scenario apply to three different time periods that are outlined below.

Between 2022 and 2024, The Town will:

- Implement all electricity and natural gas conservation (ECDM) measures.
- Invest in Rooftop and Carport Solar energy and promote the use of heat pumps if applicable.
- Develop high-performance design standards.
- Implement a measurement & verification (M&V) plan.

Between 2025 and 2035, The Town will:

- Continue to implement electricity and natural gas conservation (ECDM) measures.
- Update The Town's ECDM plan.
- Conduct annual M&V reporting.
- Continue to invest in Rooftop and Carport Solar and heat pumps.
- Invest in solar domestic hot water and solar air systems.

Between 2036 and 2050, The Town will:

- Update The Town's ECDM Plan regularly.
- Investigate and implement RE technology as they evolve.

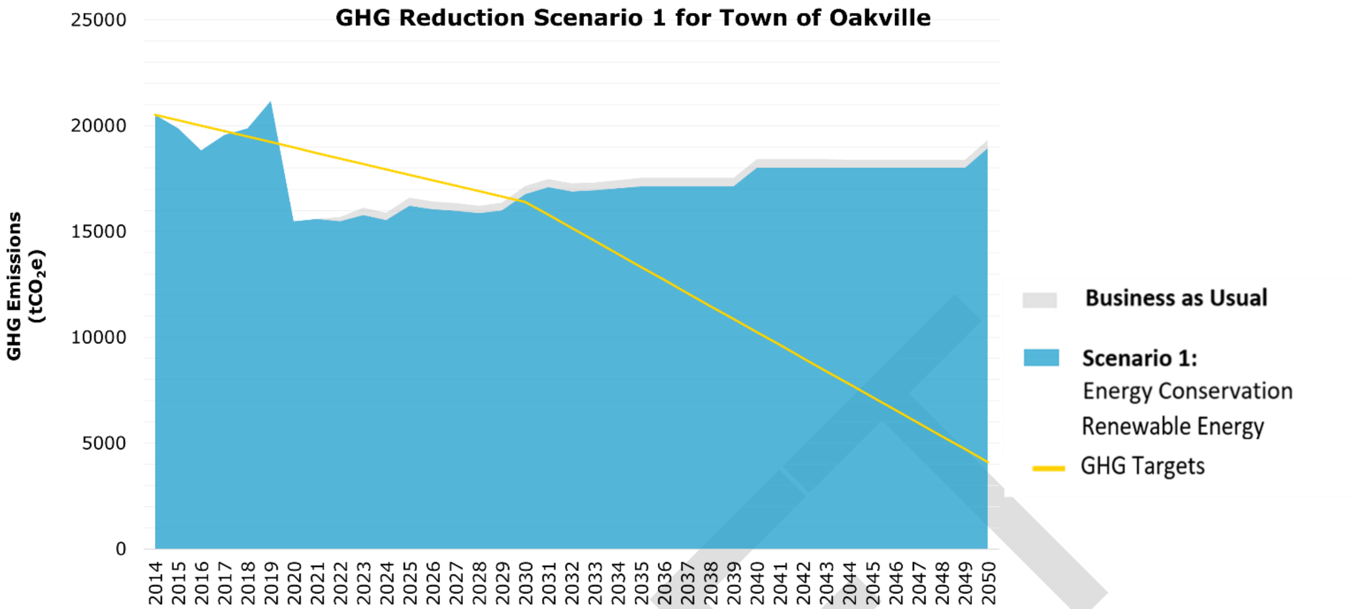


Figure 27. *GHG Reduction Scenario 1 for The Town*

5.2. Scenario 2: Energy Conservation, Renewables and Zero Carbon Buildings

Under this scenario, The Town will implement Pillars 1, 2 and 4 – Energy Conservation and Demand Management, Space Use Optimization & Zero Carbon Buildings, and Renewable Energy Generation. The Town will undertake all efforts from Scenario 1 and additional efforts to manage its space use and the built environment. This scenario eliminates the rise in future GHG emissions resulting from expansion, but the corporate GHG emissions reduction target for 2050 will not be achieved. The assumptions made under this scenario apply to three different time periods that are outlined below.

Between 2022 and 2025, The Town will, in addition to Scenario 1:

- Conduct space utilization audits to ensure a 90% space utilization rate and optimize HVAC use for those spaces according to actual loads.
- Consider electrification of HVAC replacements.
- Construct Zero Carbon Buildings for planned expansion.

Between 2026 and 2035, The Town will, in addition to Scenario 1:

- Invest in solar domestic hot water and solar air systems
- Update high-performance design standards.

Between 2036 and 2050, The Town will, in addition to Scenario 1:

- Update The Town's ECDM Plan with more aggressive reduction planning for high-performance building designs.

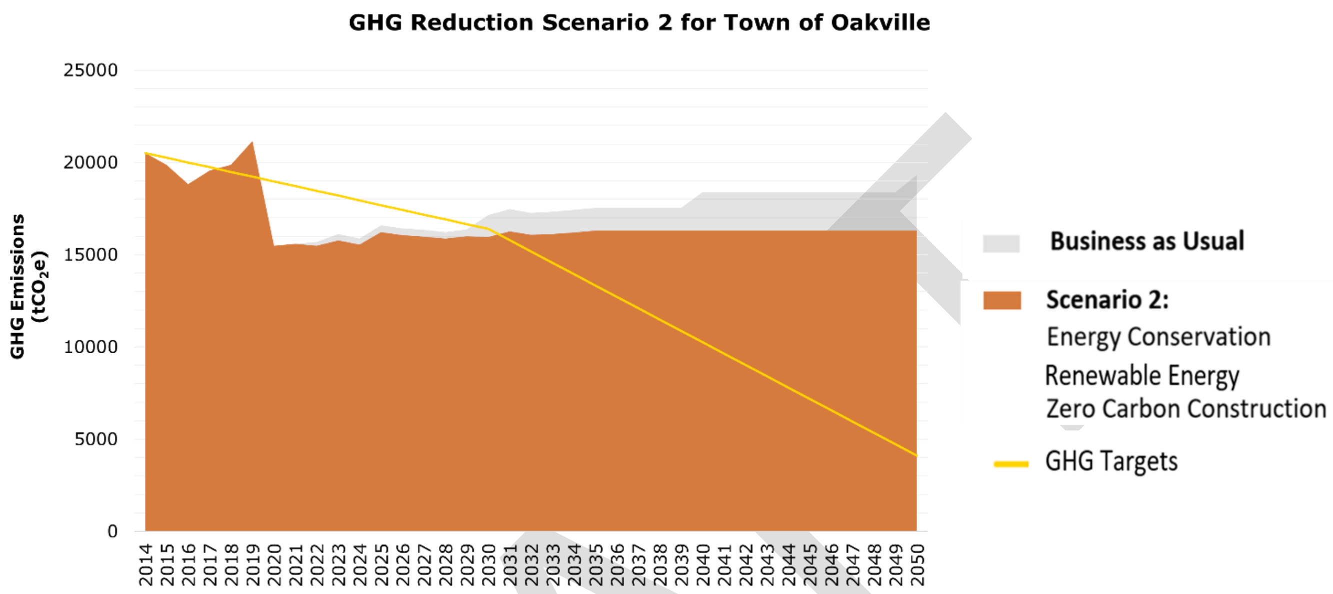


Figure 28. *GHG Reduction Scenario 2 for The Town*

5.3. Scenario 3: Energy Conservation, Renewables, Zero Carbon Buildings and Delayed Electrification

Under this scenario, The Town will implement Pillars 1, 2, 3 and 4 – Energy Conservation and Demand Management, Space Use Optimization & Zero Carbon Buildings, Electrification, and Renewable Energy Generation. The Town will undertake all efforts from Scenario 2 and the delayed action for electrifying its natural gas-based equipment. This scenario effectively reduces Scope 1 GHG emissions resulting from natural-gas use and accelerates them towards its GHG reduction target. However, it still does not reach the corporate 2050 GHG emissions reduction target. The assumptions made under this scenario apply to three different time periods that are outlined below.

Between 2022 and 2025, The Town will, in addition to Scenario 2:

- Electrify 0% of natural gas-based HVAC equipment.

Between 2026 and 2035, The Town will, in addition to Scenario 2:

- Electrify 27% of natural gas-based HVAC equipment.

Between 2036 and 2050, The Town will, in addition to Scenario 2:

- Electrify 73% of the remaining natural gas-based equipment.

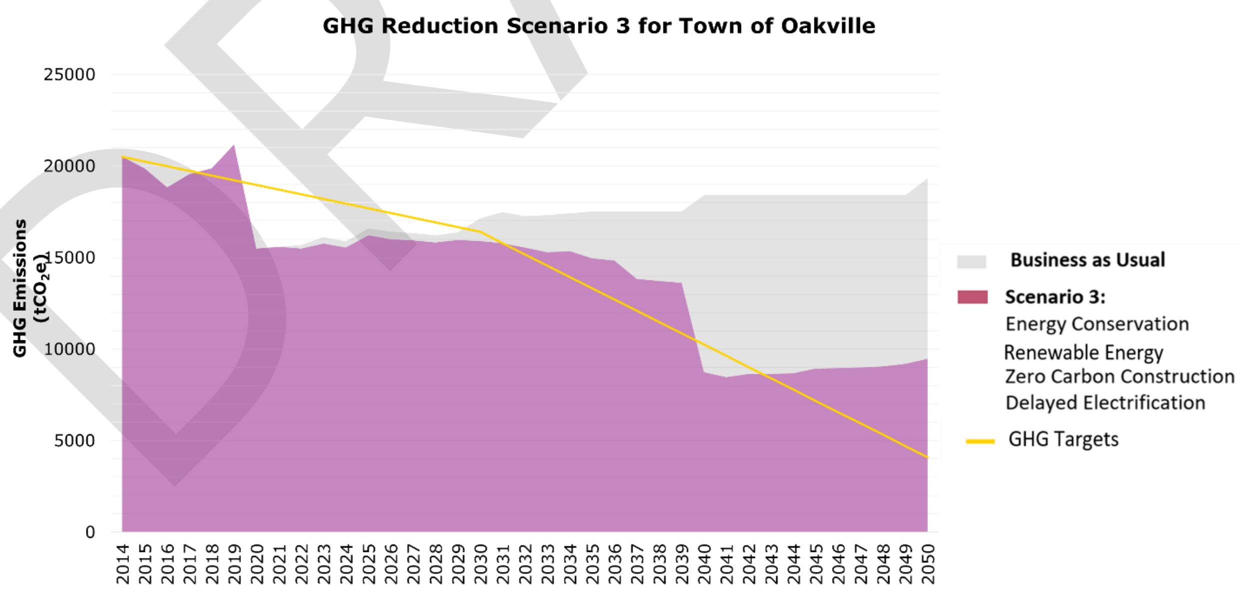


Figure 29. GHG Reduction Scenario 3 for The Town

5.4. Scenario 4: Energy Conservation, Renewables, Zero Carbon Buildings and Aggressive Electrification

Under this scenario, The Town implements Pillars 1, 2, 3 and 4 – Energy Conservation and Demand Management, Space Use Optimization & Zero Carbon Buildings, Electrification, and Renewable Energy Generation. The Town undertakes all efforts from Scenario 2 and the aggressive action for electrifying its natural gas-based equipment. This scenario drastically reduces Scope 1 GHG emissions resulting from natural-gas use and provides the maximum GHG reduction, but still falls short of the 2050 GHG emissions reduction target. The assumptions made under this scenario apply to three different time periods that are outlined below.

Between 2022 and 2025, The Town will, in addition to Scenario 3:

- Electrify 32% of natural gas-based HVAC equipment.

Between 2026 and 2035, The Town will, in addition to scenario 3:

- Electrify 51% of the remaining natural gas-based equipment.

Between 2036 and 2050, The Town will:

- Electrify 17% of the remaining natural gas-based equipment.

The graph below depicts four scenarios for advancing towards 80% GHG reduction from 2014 level, by depicting the GHG emissions under each scenario and the business as usual (BAU) scenario.

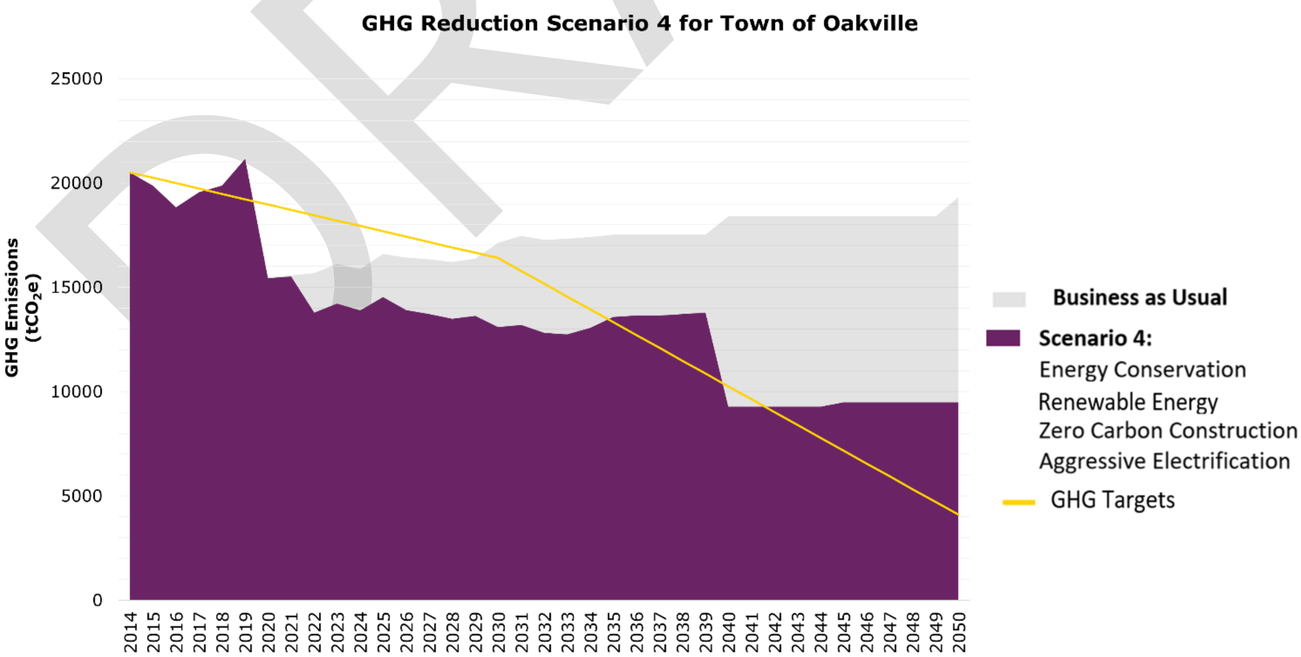


Figure 30. *GHG Reduction Scenario 4 for The Town*

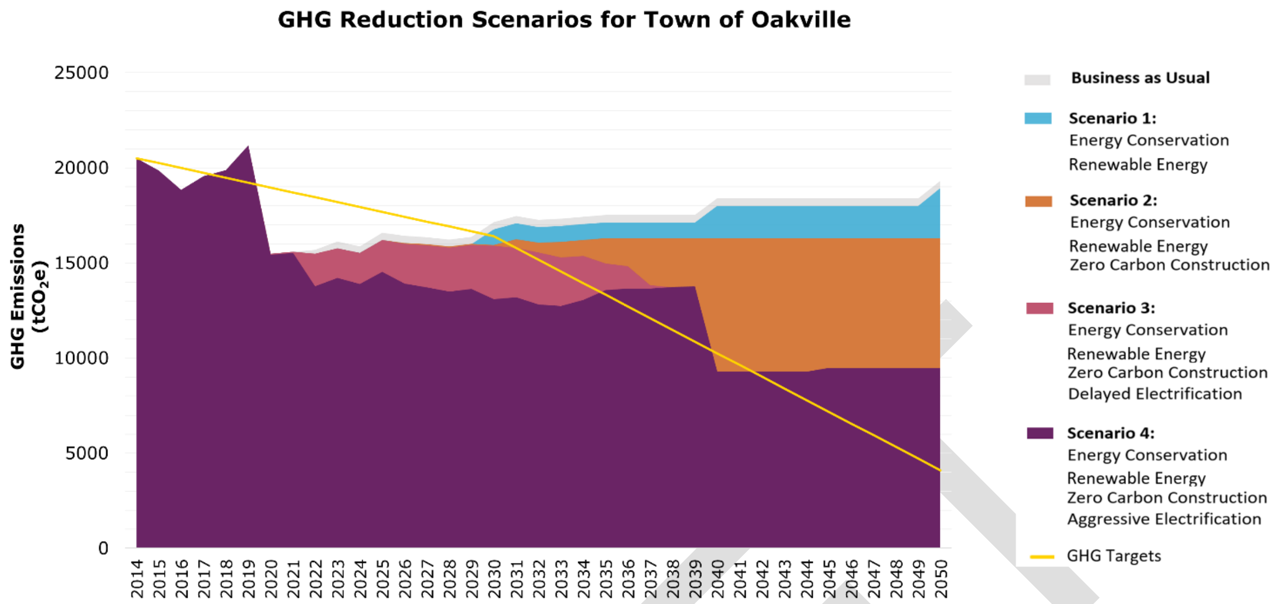


Figure 31. *GHG Reductions Scenarios for The Town*

Natural gas consumption accounts for the largest share of The Town's Scope 1 and 2 GHG emissions. However, after only electrification is implemented, the share of emissions would get redistributed. This is demonstrated in Figure 32.

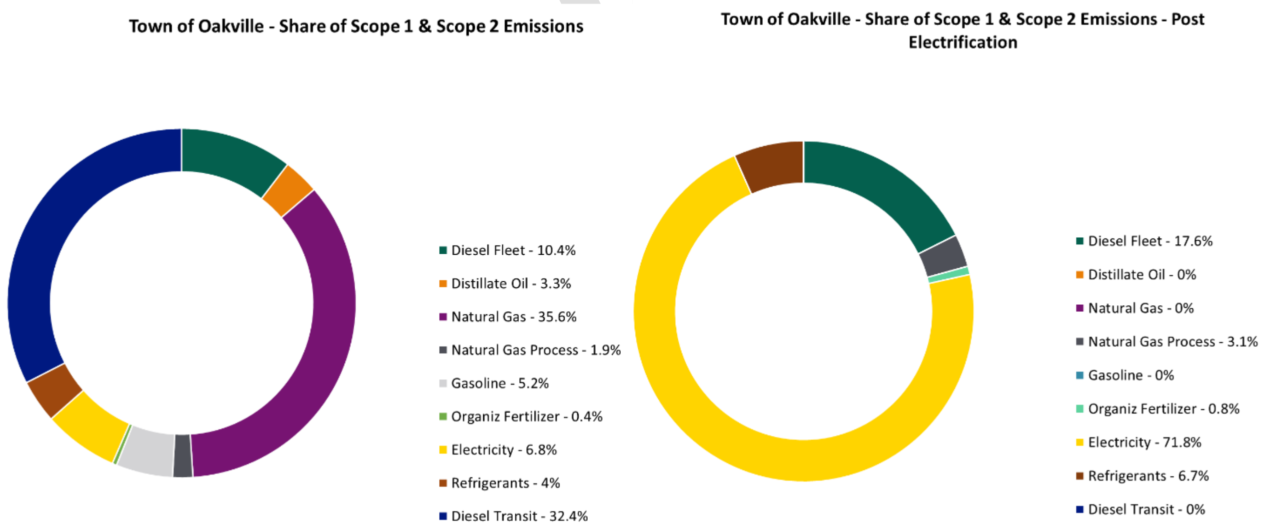


Figure 32. *Effect of Electrification on Scope 1 & 2 Emissions*

Figure 31 shows aggressive electrification but still will not be meeting the 2050 target. The Ontario electricity grid is removing nuclear power generation, which will cause an increase in GHG emissions between 2022 and 2030. Therefore, Blackstone recommends applying solar PV panels to reduce the electricity supplied by the grid. The RE Report recommends these measures in detail. Figure 33 shows the GHG emissions profile with the Solar PV panels as suggested in the RE report.

Figure 33 shows that with the implementation of all four (4) Scenarios and intense renewable measures implementation, the corporate GHG emissions reduction target in 2050 will be achieved.

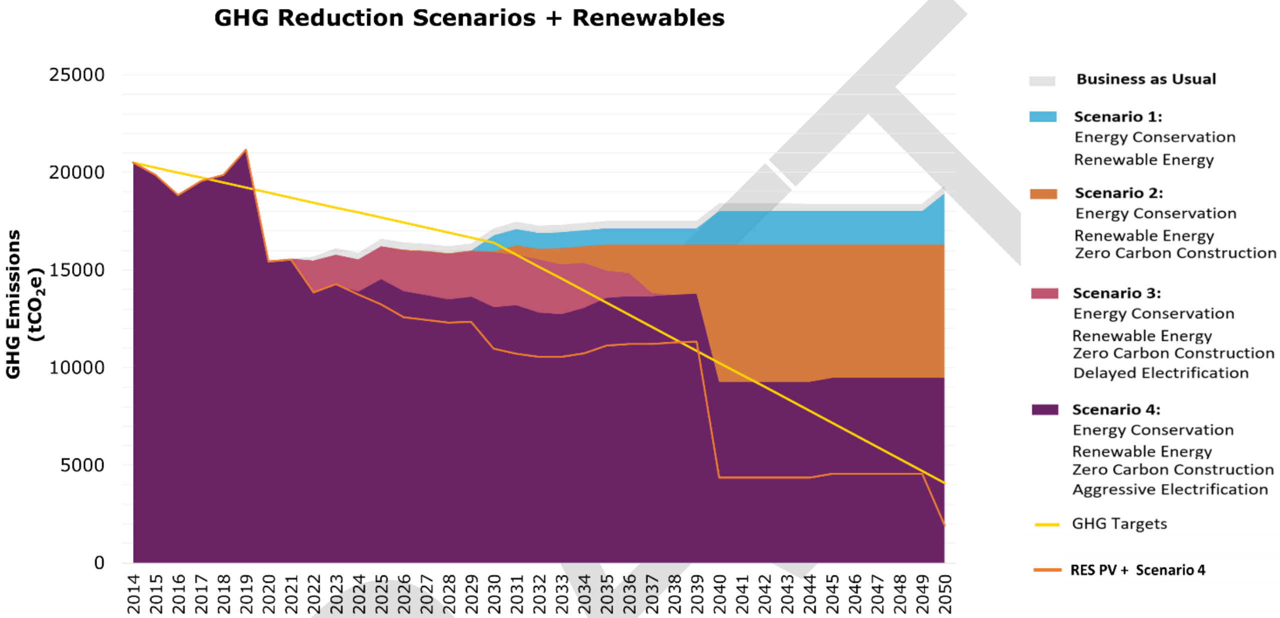


Figure 33. *GHG Reduction Scenarios + Renewables – Path to Achieve GHG Reduction Target*

6. Net-Zero Gap

An analysis of The Town's future GHG emissions from 2019 to 2050 suggests there is a high chance of achieving the interim target of 2030, however, more aggressive measures are required in order to meet the 2050 target. The "gap" between The Town's GHG emissions and its 2050 target is defined as the "Net-Zero Gap.

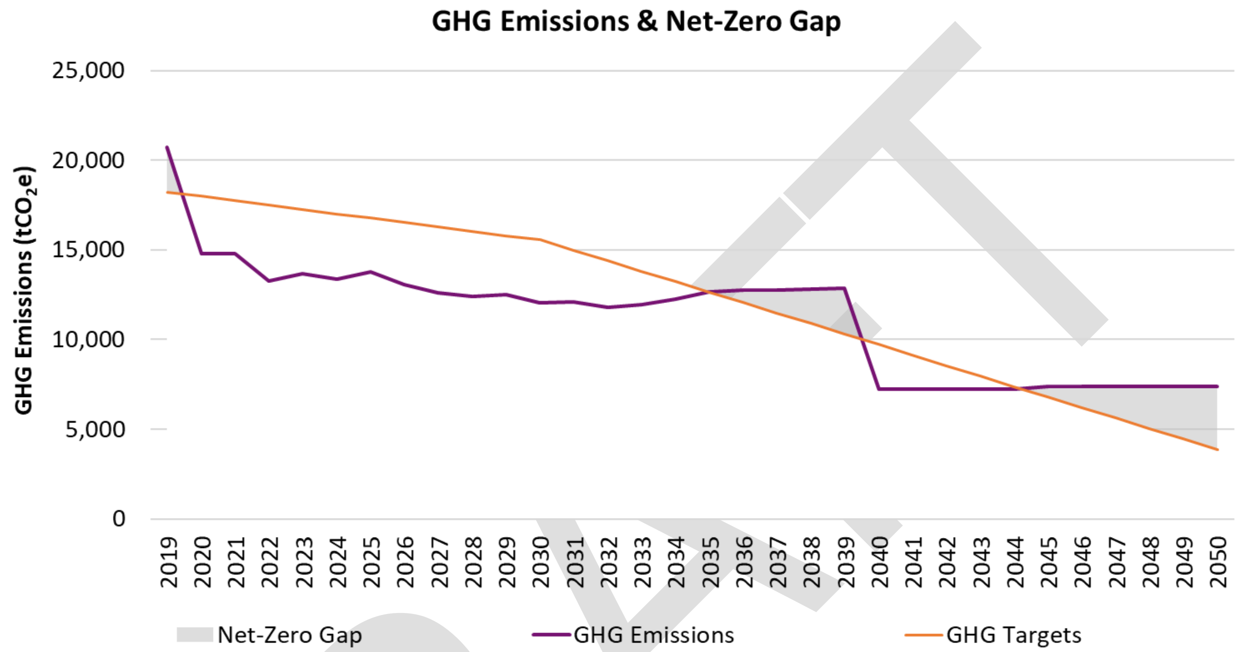


Figure 34. *The Net-Zero Gap Based on The Town's GHG Reduction Plan*

The Town's 2050 GHG reduction goal is not currently in line with the Federal GHG emissions reduction plan which is Carbon neutrality by 2050. Figure 35 below shows the gap between The Town's GHG emissions and the Federal GHG reduction plan. There are significant gaps over the period for complete facility and fleet electrification that would still not be enough for The Town to become carbon neutral or achieve their GHG emission reduction target of 80% by 2050. In both Scenario 3 and 4, with current technology and based on the provincially projected electricity mix, The Town will be able to reduce emissions to more than 9,000 tCO_2e. To reduce emissions and achieve the goals, it is recommended that The Town converts fossil fuel burning equipment and vehicles to electric alternatives as soon as possible. This means the conversion of natural gas burning equipment (HVAC heating and hot water boilers, natural gas-fired rooftop units) as well as corporate fleet vehicles to grid-provided and/or onsite renewable electricity.

It is expected that the annual electricity consumption for The Town will be approximately 89 million kWh in 2050 with the implementation of aggressive electrification. Installing renewable power generation, with current technology could provide approximately 1.38 million kWh of electricity to The Town. The remaining 87 million kWh of electricity will be provided through the Ontario electrical grid which will account for ~70% of the total GHG emissions in 2050 at 7,501 tCO_2e. However, based on the recommendations from Blackstone in the RE Report, potential PV systems installation could create 88 million kWh by 2050 and reduce The Town's dependency on grid electricity.

The Net-Zero Gap also refers to the amount of energy The Town would have to produce using renewable energy, and/or the degree of decarbonization that Ontario's electrical grid would have to undergo, for The Town to achieve an 80% reduction from 2014 level.

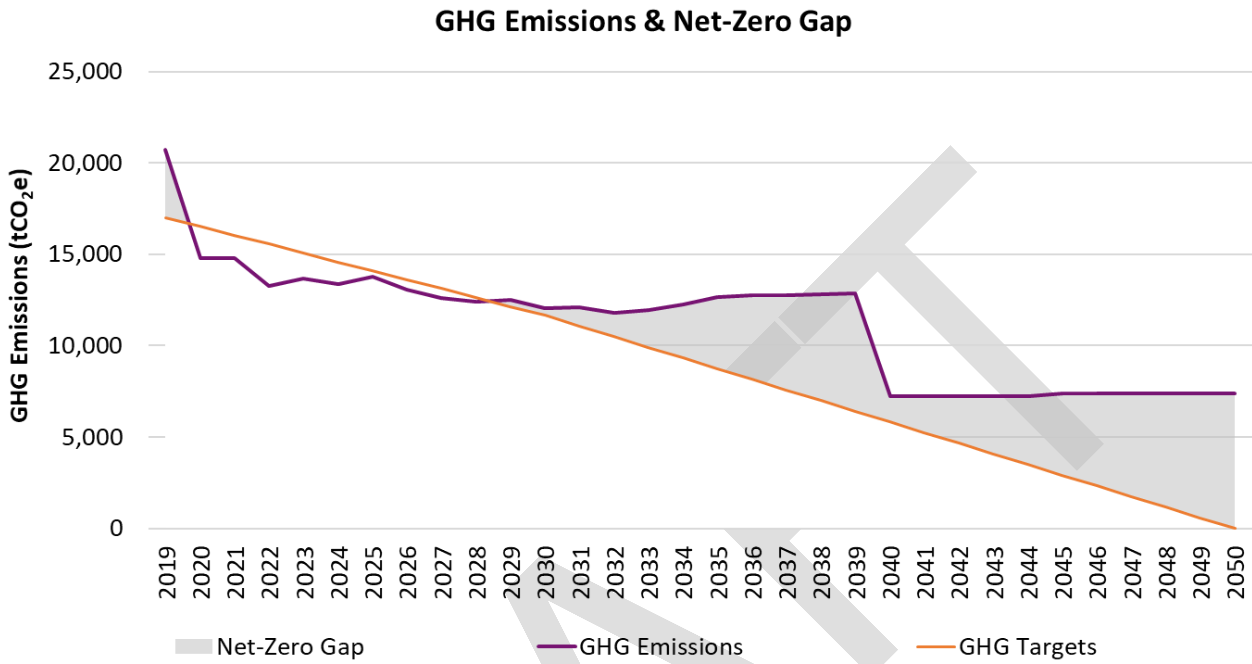


Figure 35. *The Net-Zero Gap Based on Federal GHG Reduction Plan*

The Net-Zero Gap will either increase or decrease depending on factors including corporate asset expansion, the adoption of high-performance building designs for both new and renovation projects, engagement by staff and the evolution and timely acceptance of low carbon solutions.

The Town's Net-Zero Gap could be addressed by emerging technologies and changes to the Ontario electrical grid. To address the Net-Zero Gap, consider the following options, which will each be explored in more detail below:

- Renewable Generation
- Grid Carbon Intensity
- Renewable Natural Gas
- Carbon Offsets
- New low carbon Technologies

6.1. Renewable Generation

In addition to renewable generation becoming more affordable, the energy density of renewable generation systems is increasing. Significant advancements are being made in the amount of electricity that is produced per square foot of renewable PV panel, which would increase the amount of electricity The Town can produce on its sites.

The Town may have the opportunity to produce renewable energy at an offsite location if the regulatory barriers to Virtual Net Metering are removed. The Town could then install renewable generation capacity offsite using increasingly common power purchase agreements. The renewable electricity produced would be fed into the grid and the renewable generation would be credited to The Town as an offset to balance the electricity is consumed (e.g., the increase due to electrification of HVAC).

Figure 36 below shows the Net-Zero gap when the renewable generation based on the RE Report being applied. The Town would easily meet a Net-Zero target by 2050 under this model.

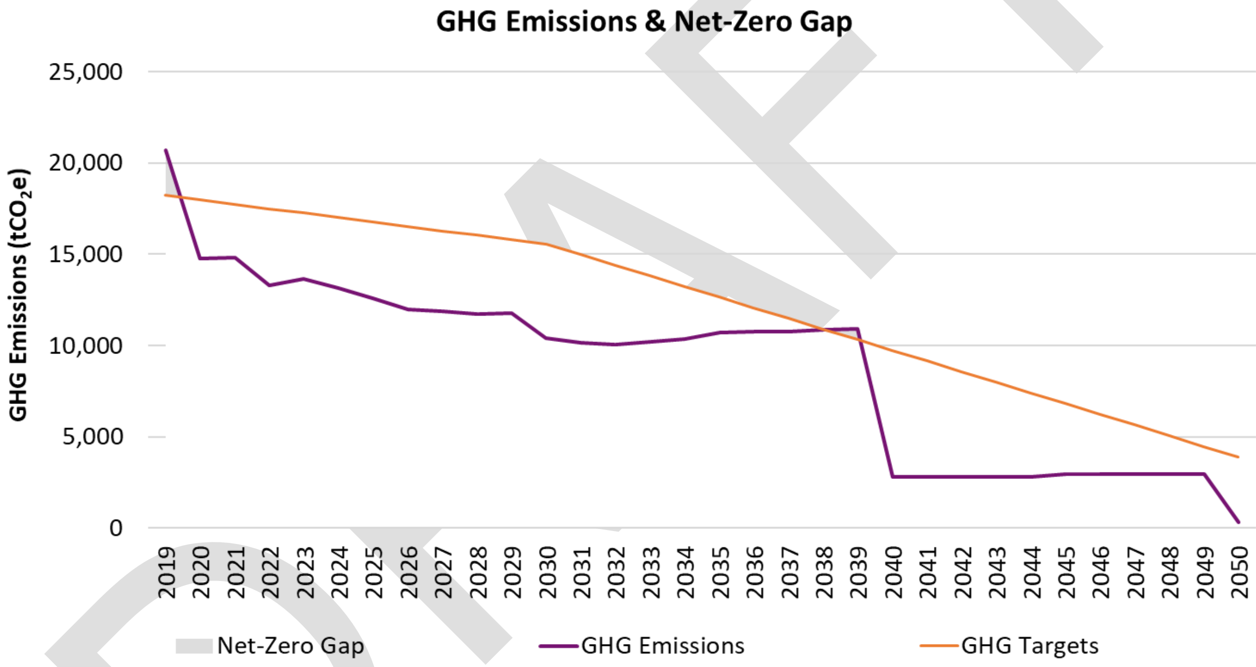


Figure 36. *The Net-Zero Gap Based on The Town GHG Target and RES PV + Scenario 4*

6.2. Grid Carbon Intensity

The existing carbon grid intensity determines the amount of carbon produced per electricity unit consumed. Since 2014, there have been significant reductions in carbon grid intensity because of the closing of coal plants. If carbon grid intensity is lowered, this would assist The Town in reaching its net-zero target. Grid carbon intensity is discussed further in Section 8.4. However, in upcoming years there would be an increase in carbon intensity due to refurbishment (in the near term) and possible phasing out of nuclear from the Ontario electricity grid.

6.3. Renewable Natural Gas

Renewable natural gas (RNG) is a low-carbon alternative to traditional natural gas (TNG). It is produced from biosources such as food waste, sewage, or other organic materials. RNG is currently expensive, about ten times more expensive than traditional natural gas, and is difficult to source in large quantities. However, in the future RNG will be more readily available. Several Ontario municipalities and major gas distribution companies are investing in RNG facilities. There is potential for the market to supply renewable natural gas through the existing distribution system, which would greatly impact the need for and cost of conversion to electrification. Lastly, as carbon taxes are increased, the price gap between RNG and TNG will be reduced.

6.4. Carbon Offsets

To address the Net-Zero Gap, The Town could buy carbon offsets. A carbon offset is a credit for GHG reduction that has been achieved by one party that can be purchased and used to offset the emissions of another party. Carbon offsets can range from $10 to $20 per tonne, depending on the location and type of offset. It is recommended that if The Town considers offsets, only those registered under The Gold Standard – the highest global standard for carbon offsets, be utilized. BESL is well versed in the capacity of carbon offset and commodity evaluators and could be consulted if this path is chosen for more details. At this time, we recommend following strategies that reduce energy and GHG using internal and grant/program funding.

6.5. New Technologies

There is of course an “unknown” factor when it comes to the availability and viability of future clean technologies. Energy technology trends suggest that the alternatives to create low-carbon electricity are improving, becoming more efficient and less expensive. However, is it difficult to predict the rate at which new technologies will make their way onto the market and which will be technically suitable to reduce the Net-Zero Gap. For example, air-source heat pumps can now maintain high-performance ratios (coefficient of performance >1.0) at outdoor temperatures below freezing which makes them candidates for HVAC replacements. Some examples of emerging technologies are discussed in Case Study 4, in the following pages.

6.6. Power Purchase Agreement (PPA)

To reduce the carbon intensity of the electricity provided by the grid, power purchase agreements (PPAs) can be applied between The Town as the buyer and a second party as the seller to provide offsite electricity generated by renewable power and will be shipped through the Ontario grid. This partnership is contracted to last for a set time, 15 – 20 years, with the power cost set for that time period. The Town is not responsible for the site. Currently, the type of arrangement called a virtual PPA), whereby the client can use the generated power to offset their loads is not available in Ontario. The concept is gaining traction across North America and is available in Alberta and Saskatchewan. Until that time – and it was being investigated about 5 years ago in Ontario, The Town should maintain awareness of any changes to the VPPA model.

Case Study 4: Emerging Technologies - Algae Cultivation

Photobioreactors

When it comes to organic processes that can be leveraged to tackle the problem of climate change, the carbon-sequestering capabilities of algae may be some of the most effective means that can be deployed. The U.S.-based company Hypergiant Industries uses a box-shaped machine for algae cultivation. This machine can soak up as much carbon from the atmosphere as an acre of trees[6].

Figure 37. *Bioreactor Concept by Hypergiant Industries*

Through the process of photosynthesis, the aquatic plant algae soak up carbon dioxide, water, and sunlight to produce energy. Hypergiant's Eos Bioreactor measures 3x3x7ft and is designed to be installed in urban environments, where it captures and sequesters carbon from the atmosphere and produces clean biofuels and other products like fertilizers, soaps, cosmetics, and even food. Artificial intelligence (AI) systems are used to monitor and manage airflow, amount of light, available CO_2, temperature, pH, and bio-density to ensure optimum conditions for maximum carbon sequestration.

The company is in the final stages of the production of a commercial device. Hypergiant says it aims to make the bioreactor designs available publicly in hopes that this will inspire others to come up with similar solutions. Hypergiant plans to share details about bringing the reactor to market sometime in 2020.

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[6] Hypergiant Industries Green R&D
https://www.hypergiant.com/green/
https://www.hypergiant.com/wp-content/uploads/2019/09/algae_is_the_new_green.pdf

Case Study 4: Emerging Technologies - Algae Cultivation

Bio Façades

Bio façades are reactive structures that use algae cultivation within glass-panelled facades to generate energy and provide shade to a working building. Unveiled in a pilot project at the International Building Exhibition (IBA) in Hamburg in 2013, the BIQ House uses about 100 bioreactors to cultivate algae[7]. The façade houses a unique architectural ecosystem where living organisms play a crucial role. The design was developed collaboratively by Strategic Science Consult of Germany (SSC), Colt International and ARUP.

Figure 38. *Bio Facade at the BIQ House*

The biomass and heat generated by the façade are transported by a closed-loop system to the building's energy management centre, where the biomass is harvested through floatation and the heat is utilized by a heat exchanger. As the system is fully integrated with the building services, the excess heat from the photobioreactors (PBR) can be used to help supply hot water or heat to the building or can be stored for later use.

The algae also work as dynamic shading and acoustic buffering systems that respond naturally to external changes. The more sunlight the system gets, the more the biomass grows and blocks off excess natural light. During peak daylight hours, this provides an organic and automatic shade, plus a noise reduction layer to protect interior spaces.

The notion of bio-architecture – or "growing structures" – has always been a green building ideal. The use of such technologies and building design concepts is growing and will likely continue to do so on a commercial scale in the years to come. As such, it is recommended that The Town stays vigilant in monitoring future developments in integrated biotechnology.

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[7] Solar Leaf Concept by ARUP
http://www.morethangreen.es/en/solarleaf-solar-leaf-algae-bio-reactive-facade/
https://99percentinvisible.org/article/architectural-ecosystems-bioreactors-generate-green-energy-shade-oxygen/

7. Financing Net-Zero

This section of the GRRAP outlines the required steps and financial implications of The Town meeting its 2030 and 2050 GHG targets under Scenarios 3 and 4, as the scenarios with the best GHG emission reduction potential. As part of each scenario, the idea of replacing fossil fuel equipment with electricity equipment is explored. The proposed measures require capital investment and may have utility cost implications or savings. It should be noted that converting from natural gas to electricity will increase operational costs.

7.1. Capital Costs Required

7.1.1. Scenario 4: Energy Conservation, Renewables, Zero Carbon Buildings and Aggressive Electrification

Under Scenario 4, the investment and associated costs include the following:

- The total investment cost for energy conservation, renewable energy projects and Renewable Energy Systems according to the RE report.
- The incremental investment cost for the construction of ZCB.
- The incremental investment cost for replacing traditional equipment with electric equivalents at the **first end-of-life replacement.**
- The increase in electricity cost is due to equipment electrification.

The cost estimates listed above also include utility cost escalation. This is illustrated in Figure 39. Note, in the following graphs the recommended solar systems based on the RE report have been considered in the calculations.

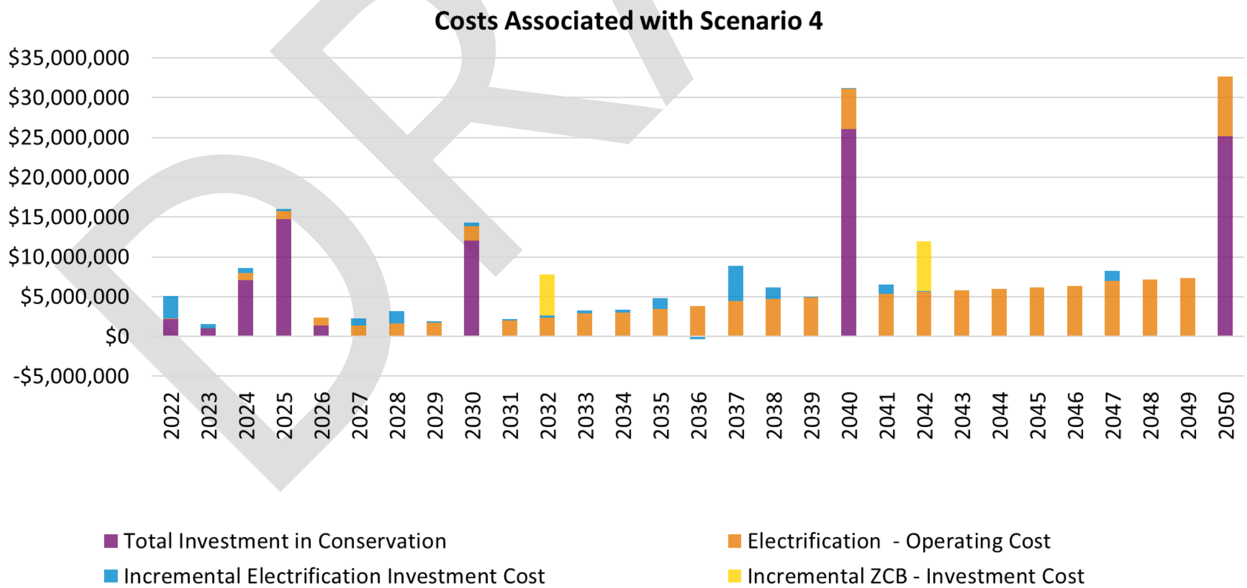


Figure 39. *Annual Costs Associated with Aggressive Electrification Scenario*

Table 12 below summarizes the cumulative total costs of all initiatives under Scenario 4 at the target milestone years between 2022 and 2050.

Table 12. Cumulative Costs Associated with Aggressive Electrification Scenario

Scenario 4 - Cumulative Costs	GHG Target Milestone Years		
	2022 - 2024	2025 - 2035	2036 - 2050
Total Investment in ECDM & Renewable Energy	$9,757,773	$27,050,321	$51,154,708
Incremental ZCB - Investment Cost	$0	$4,437,709	$5,354,607
Incremental Electrification Investment Cost	$3,961,138	$5,960,822	$8,292,448
Electrification - Operating Cost	$947,328	$20,380,080	$79,835,929
Total Cost	**$14,666,239**	**$57,828,932**	**$144,637,692**

7.1.2. Scenario 3: Energy Conservation, Renewables, Zero Carbon Buildings and Delayed Electrification

Under the Delayed scenario, The Town would invest in high-efficiency natural gas systems. Fossil fuel-burning equipment would be replaced at the last date of potential replacement and onsite conservation activities would continue. The annual investment and associated costs include the following:

- Total investment costs for energy conservation projects, renewable energy projects and building envelope upgrades.
- The incremental investment cost for the construction of ZCB.
- The incremental investment cost for replacing traditional equipment with electric equivalents at the **end-of-life replacement**.
- The increase in electricity cost is due to equipment electrification.

The cost estimates listed above also include utility cost escalation. This is illustrated in Figure 40.

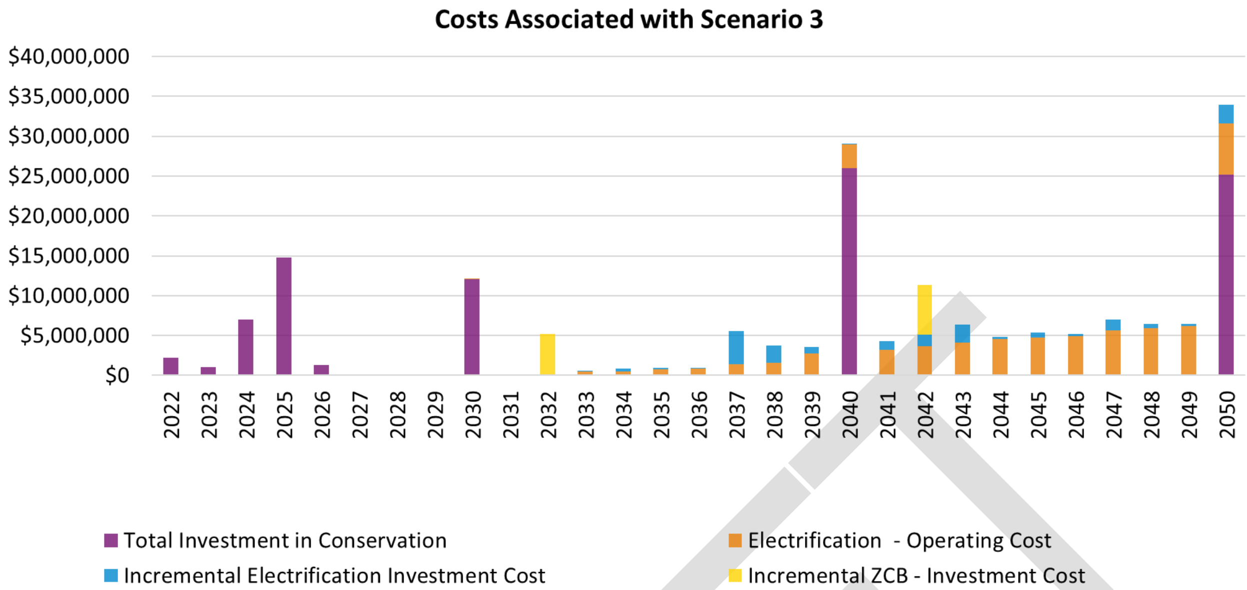


Figure 40. *Annual Costs Associated with Delayed Electrification Scenario*

The following table summarizes all initiatives under Scenario 3 for the period 2022 to 2050.

Table 13. *Cumulative Costs Associated with Delayed Electrification Scenario*

Scenario 3 - Cumulative Costs	GHG Target Milestone Years		
	2022 - 2024	2025 - 2035	2036 - 2050
Total Investment in ECDM & Renewable Energy	$9,757,773	$27,050,321	$51,154,708
Incremental ZCB - Investment Cost	$0	$4,437,709	$5,354,607
Incremental Electrification Investment Cost	$0	$645,267	$17,873,377
Electrification - Operating Cost	$0	$1,734,128	$54,065,762
Total Cost	**$9,757,773**	**$33,867,425**	**$128,448,454**

The decision of which of the four scenarios to choose for reaching 80% GHG reduction from 2014 level is dependent upon when The Town decides to replace fossil fuel-based technologies with low carbon alternatives. The sooner The Town switches, the faster emissions will be reduced. However, switching to electricity from natural gas, or from internal combustion vehicles to electric vehicles, requires a significant investment of capital and operational costs (except for electric vehicles which tend to have lower operating and maintenance costs). This will likely influence which scenario The Town chooses. The path to The Town's GHG reduction target can be financed through multiple approaches which are discussed in Section 7.2 below.

7.2. Investment Scenarios – Further Financial Details

7.2.1. Capital Investment Required

For The Town to meet its 2050 GHG target, it is vital to reduce and where possible, eliminate the consumption of natural gas and diesel. Hence, all GHG reduction scenarios prioritize conservation, high-performance designs, the implementation of renewable energy systems and ECDM measures. To develop plausible investment strategies for the implementation of these projects several factors must be considered. These include the current cost of technology, utility prices and incentives or funding avenues, which in some cases do not immediately provide a sound business case for facility electrification and ultimately carbon reduction.

Please keep in mind that all future systems designs should take into consideration the measures being planned to not design equipment based on past performance energy use. The new designs (and renovations) will have lower energy use and demand indices which means smaller systems. "Rightsizing" equipment to suit the actual design conditions (also taking into consideration that the weather patterns are changing) will help ensure energy/GHG reductions are met.

Table 14 below depicts financial details of the ECDM and RE measures only recommended in this report.

Table 15 below depicts financial details of all recommended initiatives required to be implemented for The Town to achieve the 2050 GHGs reduction target.

The details of all measures and recommended year of implementation are provided in Appendix 2.

Table 14. *Investment Costs and Benefits for ECDM & RE Program- Scenario 1*

Average Annual Savings ($)	Total Cost ($)	Simple Payback (years)	NPV	IRR
$8,594,052	$87,962,802	10.2	$325,531,769	8.58%

Table 15. *Investment Costs and Benefits for all Recommended Initiatives*

Average Annual Savings ($)	Total Cost ($)	Simple Payback (years)	NPV	IRR
$5,105,661	$217,132,863	42.5	-$237,029,110	-4.87%

The cumulative net cash flow for all recommended initiatives is illustrated in Figure 41.

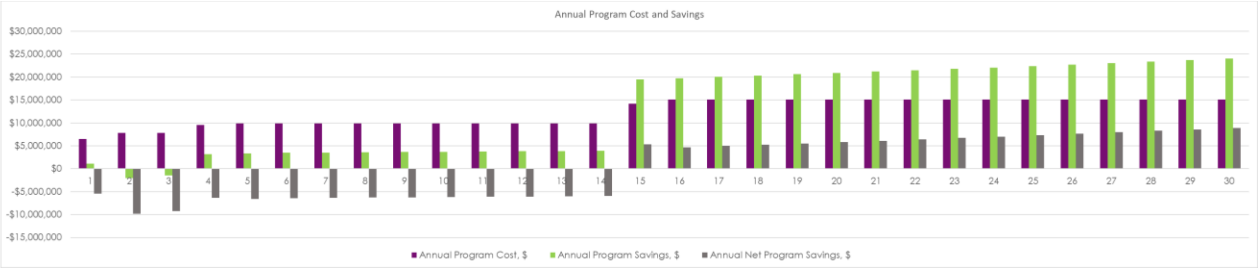


Figure 41. *Cumulative Net Cash Flow for all Recommended Initiatives*

7.2.2. Role of Deferred Maintenance

The above capital investment models shown in the previous section depict cash flows based on total project costs and do not account for cash injection like incentives from provincial and federal programs and The Town's capital budgets for deferred maintenance. At the moment, there are no incentives offered by the Federal and provincial governments on ECDM measures. The capital budget allocated for asset renewal for equipment directly targeted in the ECDM measures recommended in this report is approximately $44 million over the next 30 years. Hence, it is vital to consider deferred maintenance costs when considering ECDM and renewables programs. This effectively reduces the capital cost of projects from $87 million to approximately $43 million. The financial details on the incremental costs are shown below.

Table 16. *Deferred Maintenance & Recommended ECDM Measures for The Town*

Consolidated ECDM & Aggressive Renewables					
Measure	Average Annual Savings ($)	Total Cost ($)	Simple Payback	NPV	IRR
Initial Investment Model	$8,594,052	$87,962,802	10.2	$325,531,769	8.58%
Revised Model with Deferred Maintenance Included	**$8,594,052**	**$43,767,570**	**5.09**	**$412,286,523**	**15.01%**

7.2.3. Canada Infrastructure Bank (CIB) Public Retrofit Initiative

The CIB Public Retrofits Initiative provides financing for decarbonization retrofits in privately-owned commercial buildings in Canada through an investment of up to $2 billion. The Initiative is part of the Canada Infrastructure Bank's (CIB's) $10 billion Growth Plan that aims to stimulate jobs for Canadians and strengthen Canada's economy through new infrastructure investments. By increasing levels of public and private investment in infrastructure, the CIB's Growth Plan will contribute to Canada's competitive, connected, and resilient economy. The program overview is shown below.

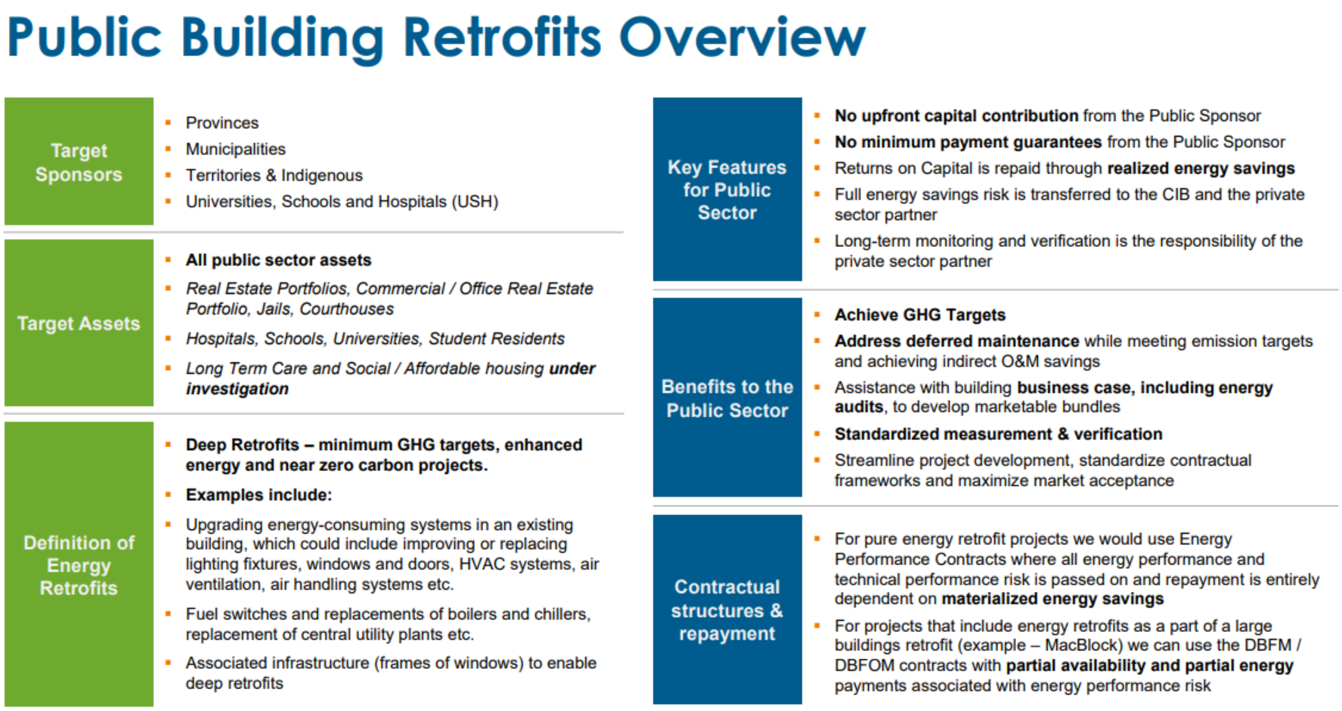


Figure 42. *Public Buildings Retrofits Overview*

The Initiative offers long-term, high leverage, below-market interest rate investments for public sector building retrofits that substantially reduce GHG emissions. Financing can apply to investments in large individual projects, or a pool of investments originated by a retrofit aggregator. To encourage the market to pursue deep retrofits that go beyond the industry norm, the Initiative requires that all projects achieve a minimum level of GHG savings while offering more favourable financing terms (more affordable capital and longer payback periods) for projects that target deeper savings.

CIB's standardized core Initiative offering is a $40M or greater debt product that requires a minimum 30% equity investment. CIB debt is extended based on the forecasted savings derived from improvements to buildings as the primary source of repayment, with one source of recourse being energy performance guarantee contracts applied to the savings forecasts. The CIB offering is depicted on the following page.

CIB offering – large public sector projects

Large **BUNDLED** Projects (>$40m capex)	Financing Approach	CIB Advisory Services
	▪ Work with all levels of government + USH to aggregate portfolios and develop project bundles that are $50M or higher ▪ Some exceptions may exist where bundled or one-off projects less than $40m may also be included in this bucket **Bespoke Project Finance SPV Structures** ▪ CIB's financing is between 40 and 60%; financing may increase (up to 70%) to enable deeper retrofits and fuel switching projects ▪ At this time, the CIB is expected to be sub debt to protect senior lenders from requiring guarantees; Private Financing is raised at Financial Close ▪ Repayment source is based on energy savings materialized as a result of retrofits.	▪ Standardized measurements and verification standards as well as methods developed by WSP ▪ WPS to manage energy savings to avoid disputes/claims ▪ Energy audits financed and conducted by CIB's advisors or through a technical Vendor of Record (VOR). These reports and audits are required for CIB's commitments, as they form the base to build our business case. ▪ Portfolio and aggregation analysis developed by the CIB and its advisors, with Sponsors, to bundle projects ensuring target rate of returns ▪ Business case and financial modelling development by the CIB ▪ Standardized processes, procurement documents and energy performance contracts, where possible

Figure 43. *CIB Offering*

All proposals and retrofit projects are required to meet eligibility requirements and undergo a technical and financial due diligence process. Interest rates of CIB funding can range from 0.05% - 3% for terms of up to 25 years depending upon the level of GHG savings that can be achieved by the project. Example scenarios of the CIB program are illustrated below.

Illustrative example and scenarios

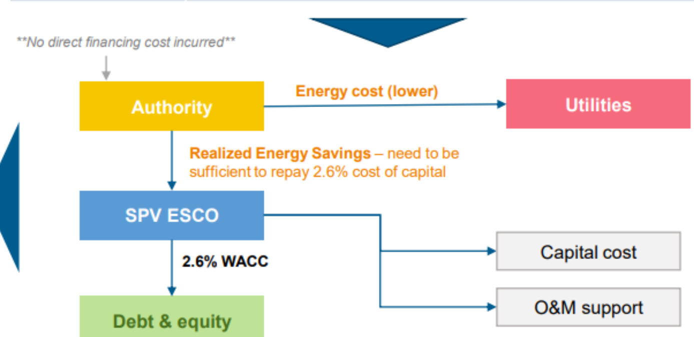
Capital Cost for Retrofit = $100M
(*Replacement of HVAC, windows, air distribution, roof, lightning, heating & cooling etc*)

Annual Buildings Base Energy Cost in 2020 = $12M
Inflation = 2%

Equipment Maintenance = Negligible

ESCO Management Fee = Negligible

ESCO Capital Structure	Rate	Rationale - to be confirmed	Gearing
CIB	1.0%	*Sub debt facility assumed*	*60%*
Third-Party Debt	3.5%	*GOC + 180-220 bps*	*30%*
Equity	9.0%	*Equity IRR close to utility rate (between 8.5 – 10%)*	*10%*
ESCO Cost of Capital	2.6%		



Scenarios	Option 1	Option 2	Option 3
Term (*payback period*)	20	25	30
WACC (weighted average cost of capital)	2.6%	2.6%	2.6%
Debt service + distributions	$6.5M	$5.5M	$4.9M
Minimum required % energy savings for business case	45%	37%	31%
Sponsor net savings (*energy*)	$ 0	$ 0	$ 0
Sponsor savings (*indirect O&M*)	Retained by sponsors		

Note: CIB gearing could vary between 40% to 70% of total project costs, depending on GHG reductions targets
Additional sources of repayment might be required in case cost savings cannot cover full debt service and distributions

Figure 44. *CIB Examples and Scenarios*

7.2.4. Public-Private Partnership and Energy-as-a-Service (EaaS)

To reduce their energy and carbon footprint, public and private sector facility operators and owners are increasingly exploring and leveraging innovative business models that create new opportunities for their organization to finance energy-efficient building technologies, renew infrastructure, and renew or construct net-zero ready buildings. Traditional models previously used to address these opportunities include pay-for-performance contracts, energy savings performance contracts, power purchase agreements, and on-bill financing.

One innovative business model gaining interest offers energy-as-a-service (EaaS). This represents a shift from client-owned equipment toward a model where the service provider maintains ownership and the customer pays for the services provided by the project or program. The maintenance of the equipment is also the responsibility of the service provider. Blackstone anticipates that the integrated nature with much of the EaaS infrastructure and assets, that a hybrid model of collaborative maintenance will emerge to share resources and expertise producing better outcomes for all stakeholders in this critical area of operations.

This financial solution helps organizations implement complex carbon, energy, and water efficiency projects with no upfront capital expenditure. The provider designs the project scope finances the material and construction costs maintain (in partnership with the client) project equipment/systems & buildings (if applicable) and monitors the performance to validate energy and operational savings as shown in the figure below.

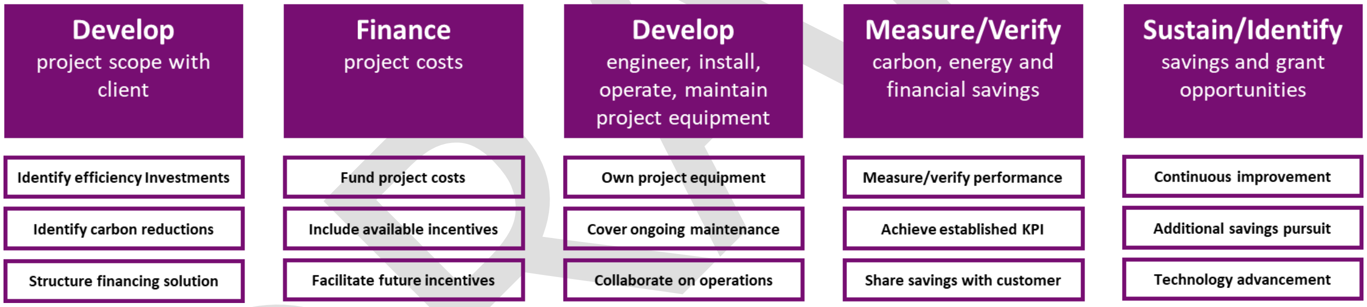


Figure 45. *Roles Overview of Energy-as-a Service Provider*

The client pays back the project/program costs through a monthly, quarterly, or annual fee for the services received. The payment is generally based, directly or indirectly, on the energy, maintenance and other quantifiable operational savings realized on the client's fiscal operating plans. Experience in Europe and the US to date with this service-based model suggests energy-related and operational savings potential up to 20–25% can be achieved to create the value for the service provider and clients to develop a mutually beneficial EaaS agreement.

Traditional energy efficiency solution models focus on lighting, HVAC equipment, software, and general energy conservation measures. EaaS solutions are more comprehensive and include green infrastructure renewal initiatives such as district heating systems, geothermal, heat pumps, solar PV, lighting retrofits, upgrades to HVAC and other equipment, building automation and controls, energy storage, Electric Vehicle charging systems, building envelope upgrades and water efficiency measures.

The EaaS Model

The figure below shows the structure of a typical EaaS relationship.

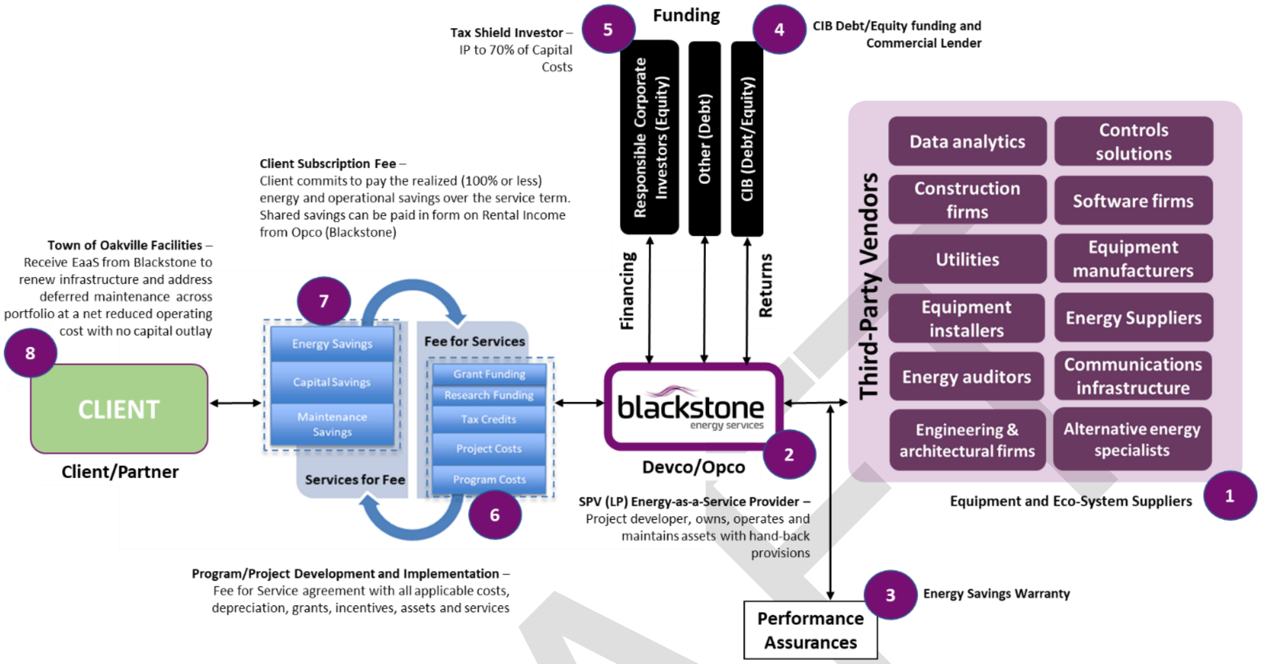


Figure 46. *EaaS Relationship Structure*

The EaaS model usually shifts the burden of financing, owning, installing, and managing the performance of an energy asset from the client to the service provider. Before any energy-related or operational saving measure(s) or services are implemented, the service provider conducts or arranges for detailed investment grade feasibility assessments to establish the business case for the client and provider. Once the project or service scope is finalized and construction completed, a measurement and verification (M&V) analysis determines the actual savings. The client is responsible for a service fee, typically based on the units of energy or operational savings associated with the project or program of works. The payment can be structured either as a percentage of the customer's utility budget or as a fixed amount that may include deemed operational savings. In any case, the client's payments are below its current utility and operating budget and the provider promises a certain level of savings and adjusts payments if it is not realized. At the end of the contract period (generally 10 to 30 years), the client can purchase the equipment at fair market value, have the provider remove it, or extend the EaaS contract.

Large buildings, or a portfolio of smaller buildings that add up to a bigger footprint, provide an opportunity for greater energy savings and represent an ideal situation of the EaaS contracting process.

The EaaS model may seem similar to Energy Services Company (ESCO) financing, but they differ significantly. While the ESCO industry has delivered savings in the public building sectors in the past, the EaaS model is designed to help public sector building owners now facing limited capital and constrained technical resources or expertise to implement these complex green infrastructure projects/programs.

Using an Energy Savings Performance Contract (ESPC) agreement, an ESCO guarantees energy savings to a client over a set period by installing and maintaining equipment. Depending on the ESCO, it may provide financing or require outside funding through loans, capital lease, or bond issuance, which are on-balance-sheet financing mechanisms. Under this structure, the client owns more-efficient equipment but may be vulnerable to the fluctuations in energy prices and cash savings short-fall due to contractual baseline changes and other risk management instruments leveraged by the ESCO. By contrast, the third-party EaaS providers are responsible for meeting the reliability and energy goals of the client. The provider takes on financial and performance risk by guaranteeing lower energy costs from implementing the selected project measures. The table below summarizes these differences.

Table 17. *ESCO financing versus EaaS Model*

Item	ESCO	EaaS
Capital Investment by Customer	Sometimes	No
Off-balance-sheet Financing	No	Yes
Ownership of Equipment by Customer	Often Yes	Often No
Performance Risk Borne by the Customer	Sometimes	No
Flexibility to add Retrofit During Contract Period	Difficult	Yes
Term of Contract	10-20 Years	10-30 Years

The Benefits

The EaaS model can provide valuable services to commercial, municipalities, hospitals, and higher education clients. This section offers a preliminary list of benefits.

First-Cost Savings

Many organizations hesitate to divert capital from essential business objectives to invest in building retrofits. The EaaS model can be a good fit for organizations that want to pursue deep energy and carbon infrastructure renewal without using their own finances. Under an EaaS agreement, the service provider obtains equity funding and secures third-party funding to pay for all project costs, so the client has no upfront expenses or internal capital outlay and can use their own funds for other projects.

Off-Balance-Sheet Financing

EaaS offerings are typically designed as an off-balance-sheet financing solution. The use of service payments allows businesses to shift energy and carbon infrastructure renewal projects from an expensive asset that they must buy, own, maintain, and depreciate to an operating expense similar to a standard utility bill or power purchase agreement.

Since the provider owns the energy equipment, clients have no debt on their balance sheet and their bottom line is improved. Thus, they can secure the energy and services they need with fewer uncertainties because the provider has assumed the risk for achieving energy and operational savings.

Deeper Operational and Maintenance Savings

The cost savings from the projects are calculated and guaranteed using agreed-upon M&V protocols. Because the EaaS paradigm generally relies on the pay-for-performance model, it offers potential operational efficiencies and positive cash flow from energy, water, and maintenance cost savings. The pay-for-performance nature, along with maintenance and verification of project savings, reduces the performance risk for clients and may encourage more-persistent savings and implementation of newer green infrastructure and clean technologies.

Clients have the additional benefit of being able to finance multi-measure deep green infrastructure retrofits with long simple payback periods. EaaS projects may include capital-intensive investments in HVAC upgrades with motor, pump, and boiler replacements, energy management systems, and distributed renewable energy resources. These measures offer greater energy savings, can optimize comfort and tackle carbon reduction targets. However, they are difficult to fund under traditional financing sources due to their lower return on investment.

As the EaaS providers are responsible for the energy equipment, they pay for periodic maintenance services to encourage long-term reliability and performance. The level and structure of such service vary by project type and client needs. By rewarding a third-party provider for successfully managing operations, clients reduce the risks and challenges associated with implementing, managing, and monitoring new technology. Installing more-efficient equipment with continuous maintenance may also mitigate the risk of unplanned events.

Lower Operational Risks

EaaS vendors provide access to experts who can design the project scope and install, maintain, and verify the performance of the efficiency measure. Clients have a lower risk of paying for underperforming equipment because vendors guarantee energy savings at a known cost and can attract large grants and incentives which can be used to lower capitals costs and ultimately service payments.

Long-term agreements allow clients to secure a fixed lower price for energy throughout the contract if the service provider can achieve the promised savings.

Ways forward

With rapid paybacks, upgrades to the latest technology, and no upfront capital investment, the EaaS model could provide solutions for municipalities to achieve net-zero targets and undertake strategic and comprehensive deferred maintenance and capital infrastructure renewal.

Some of the challenges to consider would be that the development and award process for an EaaS solution is long and complicated because it requires pitching the service to multiple organizational players.

Undertaking education and socializing EaaS contracts within an organization can help overcome inertia and simplify communications among the different divisions that are involved in the decision process (e.g., finance, procurement, facilities, and operations departments).

7.3. Factors that Influence Cost

In choosing its path to net-zero emissions, The Town will need to consider several factors that influence project costs, including:

- Replacement Cost
- Operational Cost
- Forecasted Utility Cost
- Cost of Solar/renewables
- Carbon Tax
- Funding Opportunities
- Utility Rate Structure
- Supporting Infrastructure Costs
- Emerging Technology Costs

7.3.1. Replacement Cost

The Aggressive and Delayed scenarios mentioned previously were based on the timing of when The Town's assets will reach the end of life. Each asset was evaluated to determine how expensive high-efficiency natural gas options would be when contrasted with comparable low-carbon, electric options. The investment difference was calculated and used to model the required investment needed to reach The Town's emission reduction goals.

As the tax on carbon-based fuels increases, the cost difference between natural gas equipment and non-fossil fuel-based equipment and other fuel sources will decrease. An example of this is presented in Case Study 5.

Case Study 5: Cost of Heating – Natural Gas vs. Electric Boilers

Table 18 lists the specifications of an industry-standard natural gas boiler and the specifications of the electric equivalent.

Table 18. *Comparing Electric & Natural Gas Boilers*

2 Million BTU Natural Gas Boiler (Space Heating Application)		
Specifications	**Natural Gas Boiler**	**Electric Boiler**
System Size	2 Million BTU	510 kW
Boiler Efficiency	87%	100%
Estimated Installed Cost	$60,000	$95,000
Estimated Equipment Life (Years)	20	25
Annual Maintenance Cost	$500	$125
Annual Utility Consumption	59,883 m^3 of gas	515,680 kWh
Utility Cost (including Carbon Price in 2030)	$0.5413/$m^3$	$0.182/kWh
Estimated Annual Operating Cost	$33,115.3	$93,889.85

The table above shows the equivalent electric boiler capacity required to produce the same energy (BTU) output as a natural gas boiler (510 kW electric boiler to a 2 MBTU natural gas boiler). The higher installation cost of the electric boiler ($95,000 for the electric boiler compared to $60,000 for the gas boiler) is balanced by its life cycle (25 years for electric to 20 years for gas), and operational efficiency (100% for electric and 87% for gas). However, the annual operational costs (based on current utility prices) render the electric boiler impractical from a financial perspective.

The significant difference lies in utility consumption and costs. An electric boiler requires 515,680 kWh to produce the same heat output as a natural gas boiler, which requires only 59,883 m^3 of gas to produce the same output. Grid electricity is approximately 35% more expensive than natural gas per BTU of energy, so it would make financial sense to defer the electrification of boilers to a later time.

However, considering the 20-year lifetime of a gas boiler, the latest The Town could defer its electrification would be 2030, after which it would have no option but to electrify to meet 2050 targets. In other words, no new gas boilers should be installed after 2030 and consideration for electric HVAC should be given to any replacements between 2023 and 2030.

7.3.2. Operational Cost

The cost to operate traditional equipment using fossil fuels is significantly less than using electricity. Converting all fossil fuel burning equipment onsite (including the corporate fleet) would result in an increase in operational cost, or total annual utility expenditure, at The Town.

Figure 47 compares the current price for several fossil fuels and their respective GHG emissions factors. Natural gas is inexpensive compared to other fuel sources. To date, this has made the business case ineffective for converting from natural gas to electricity. On an equivalent cost per unit of energy ($/ekWh), the prices for electricity and natural gas do not intersect under current market rate forecasts. As a result, there is no financial incentive for The Town to convert from natural gas to electricity in the short term.

Electric vehicles reduce fuel costs and carbon emissions. The business case for the replacement of existing fleet vehicles with comparable electric vehicles must be considered on a case-by-case basis. Due to carbon taxes, the cost to operate non-electric vehicles will increase due to the increase in fuel cost. Other technologies like heat pumps provide an example of how existing technology is becoming more cost-effective. This is illustrated in Case Study 6 on the following page.

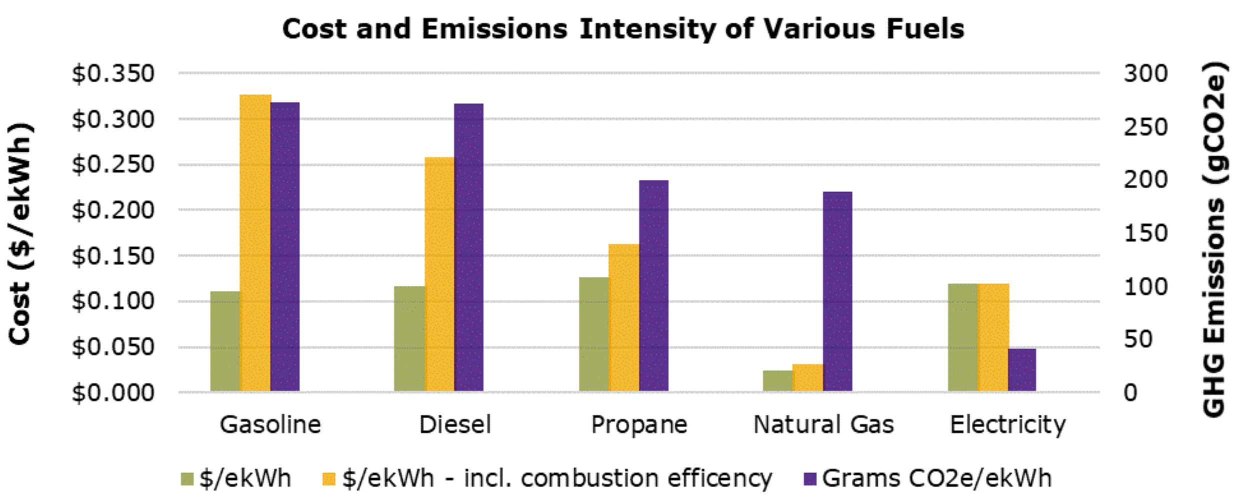


Figure 47. Cost & Emission Intensities of Various Fuels

Case Study 6: The Case for Heat Pump Technology

Heat pumps exchange energy by extracting heat from an outside source (geothermal, solar thermal etc.) and pumping it into a space. Heat pumps can also be scaled to service a wide range of building types and applications. Heat pumps are more energy-efficient than natural gas burners and electric resistance heating coils. Air source heat pumps are capable of operating at outdoor temperatures below freezing at >1.0 annual coefficients of performance.

Heat pumps with Variable Refrigerant Flow (VRF) systems can provide simultaneous heating and cooling and multiple zone control. Outdoor units are connected to indoor fan coil units via refrigerant pipes and can be integrated with smart building technology and BAS. A typical VRF system is demonstrated in the figure below:

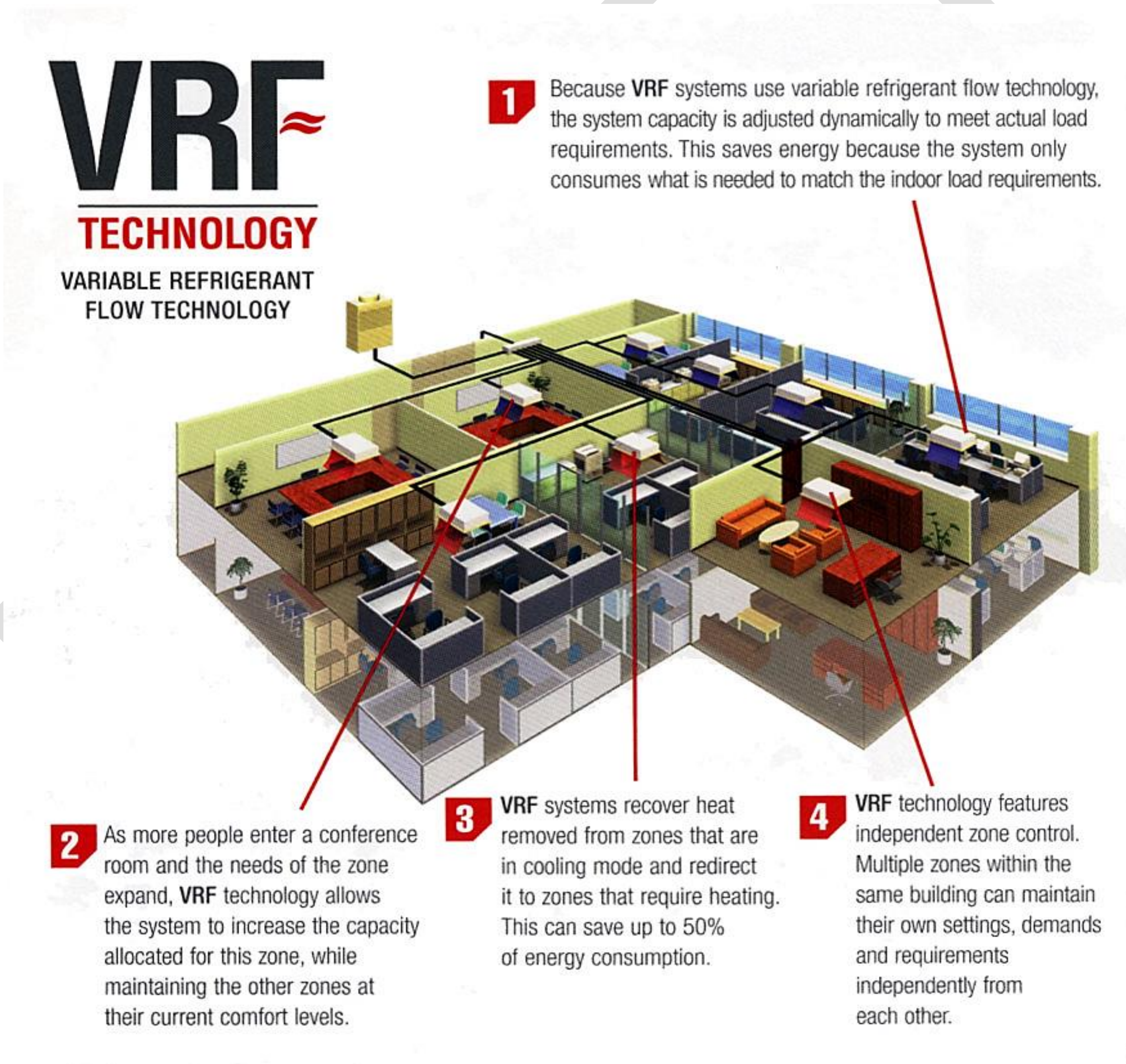


Figure 48. *Variable Refrigerant Flow Technology*

Case Study 6: The Case for Heat Pump Technology

Price

Today, using a heat pump can cost twice as much as traditional packaged rooftop units that consist of direct expansion (DX) cooling and natural gas burners. However, heat pump technology is becoming increasingly cost-effective and, according to the National Energy Board, costs could drop 10% to 20% by 2025 to 2030, and 20% to 30% by 2040. These numbers line up with the forecasted replacement HVAC replacement schedule listed throughout this GRRAP.

Heating

Depending on outdoor air temperature, a heat pump can achieve COP as high as 3.4 in heating mode, meaning the heat pump can produce 3.4 kW of heating energy for every kW of electricity consumed.

As outdoor air temperature drops below 0°C, the efficiency of heat pumps drops significantly and may require additional support from either an electric heating coil, a natural gas burner or a larger heat pump capacity. For example, at sub-zero temperatures, a 20-ton heat pump may only produce the heating equivalent of a 15-ton heat pump. Advances in heat pump technologies are targeting lower ambient temperatures with high COPs.

Cooling

High-efficiency heat pumps or DX units provide substantial energy and utility cost savings compared to traditional standard efficiency DX cooling applications, as demonstrated in the example below. Depending on outdoor air temperature, a heat pump can achieve Integrated Energy Efficiency Ratio (IEER) as high as 18.6 (COP of approximately 5.4), meaning the heat pump can produce 5.4 kW of cooling for every kW of energy consumed.

Example: 20-Tonne Heat pump RTU Annual Operating Costs

The following table shows the difference in annual operating costs associated with using a 20-ton heat pump instead of an RTU that has 15-ton DX cooling and a natural gas burner, based on current electricity and natural gas utility rates. The case is based on a theoretical 5,000 sq. ft space with one exterior wall in the Greater Toronto Area. The assumed operating schedule is Monday to Friday from 7AM to 5PM.

Table 19. *Comparing Heat Pumps with Natural Gas Burning Equipment*

Technology	Cooling Energy ($)	Heating Energy ($)	Fan Energy ($)	Total Annual Energy Cost ($)
Rooftop Unit + Gas Boiler	$1,014	$1,026	$1,688	$3,728
20-ton heat pump	$460	$4,377	$434	$5,271
Heat pump savings	$554	-$3,351	$1,254	-$1,543

Case Study 6: The Case for Heat Pump Technology

Relatively low prices of natural gas compared to electricity prevents electric heat pumps from yielding cost savings compared to high-efficiency natural gas furnaces. A 20-tonne electric heat pump is more expensive to operate annually than a rooftop natural gas unit based on current electricity and natural gas utility rates. However, improvements to heat pump technology and an increased cost of carbon will make heat pumps a cost-competitive alternative to natural gas equipment[8]. The cost of carbon has been mentioned a few times in this report and must be taken into consideration when comparing natural gas and electric systems. A life cycle cost assessment is recommended when this comparison is being made, over 15 years minimum and including the costs of carbon. The technology cost curve mapped against technology efficiency is illustrated in Figure 49.

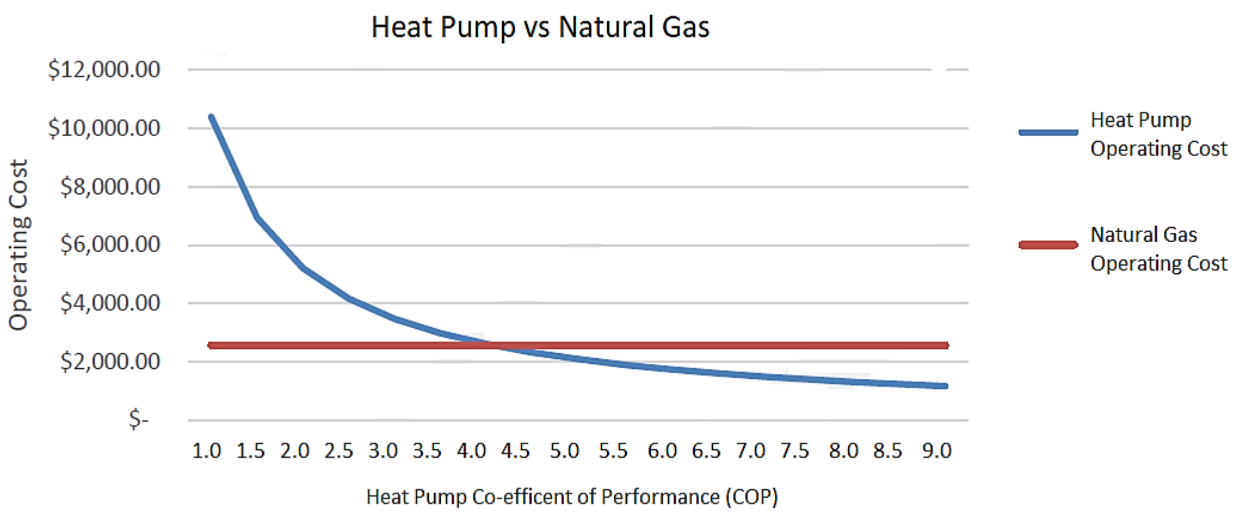


Figure 49. *Technology Cost Curve for Heat Pumps*

[8] Graham Cootes (P.Eng.), HTS Toronto. Email: graham.coote@hts.com

7.3.3. Forecasted Utility Cost

Ontario's 2017 Long Term Energy Plan (LTEP) created by the Independent Electricity System Operators (IESO), states that electricity prices will continue to rise in Ontario between 2019 and 2050. The federal carbon tax will increase the price of electricity and natural gas. The price escalation rate for electricity was derived from Ontario's LTEP[9], and escalation forecasts for natural gas were derived from the current commodity and distribution costs.

Table 20. *Forecasted Utility Prices*

Forecasted Utility Prices	2019	2030	2050
Electricity ($/kWh)	$0.1377	$0.2113	$0.2768
Natural Gas ($/m3)	$0.26	$0.35	$0.46
Natural Gas ($/ekWh)	$0.025	$0.034	$0.047
Nat Gas with Eff Losses ($/ekWh)	$0.032	$0.044	$0.059

The future forecasted rates for both grid electricity ($/kWh) and natural gas ($/ekWh) would not intersect, i.e., the forecasted price for grid electricity was not found to be equal to or less than the price for the equivalent amount of energy from natural gas.

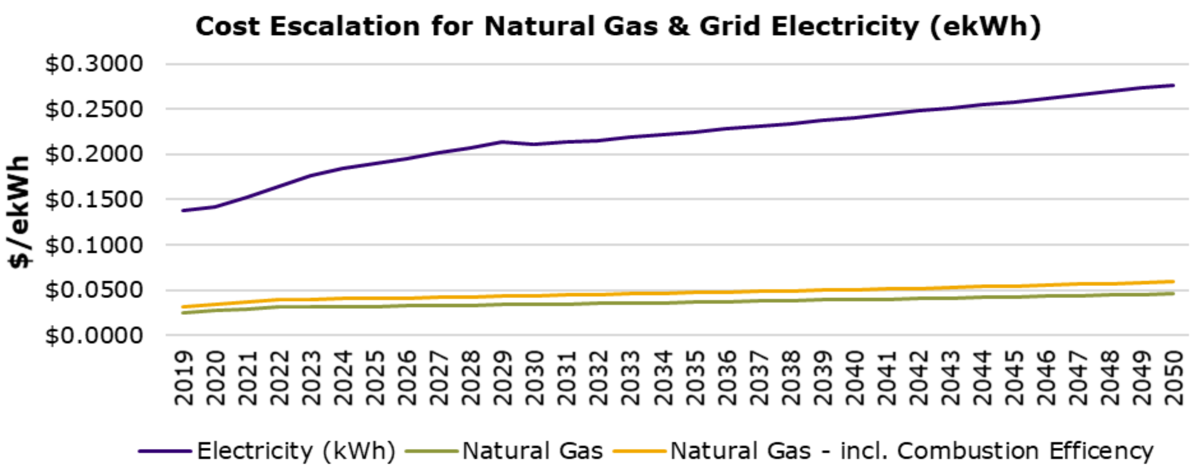


Figure 50*. Forecasted Utility Cost Escalation*

[9] Ontario's Long-Term Energy Plan - Delivering Fairness and Choice, 2017; https://files.ontario.ca/books/ltep2017_0.pdf

7.3.4. Cost of Solar Power

Pillar 4 of The Town's GRRAP, renewable energy, plays a significant role in supporting them in meeting their 2050 targets. Under each scenario, The Town will need to acquire electricity from clean or renewable sources to reduce the impact of electricity costs and electrification. Solar panel prices, for example, have been declining steadily since 2010. The following chart shows the estimated price for solar panel installations in Ontario. Costs are also dependent on system size – larger systems are lower cost/kW.

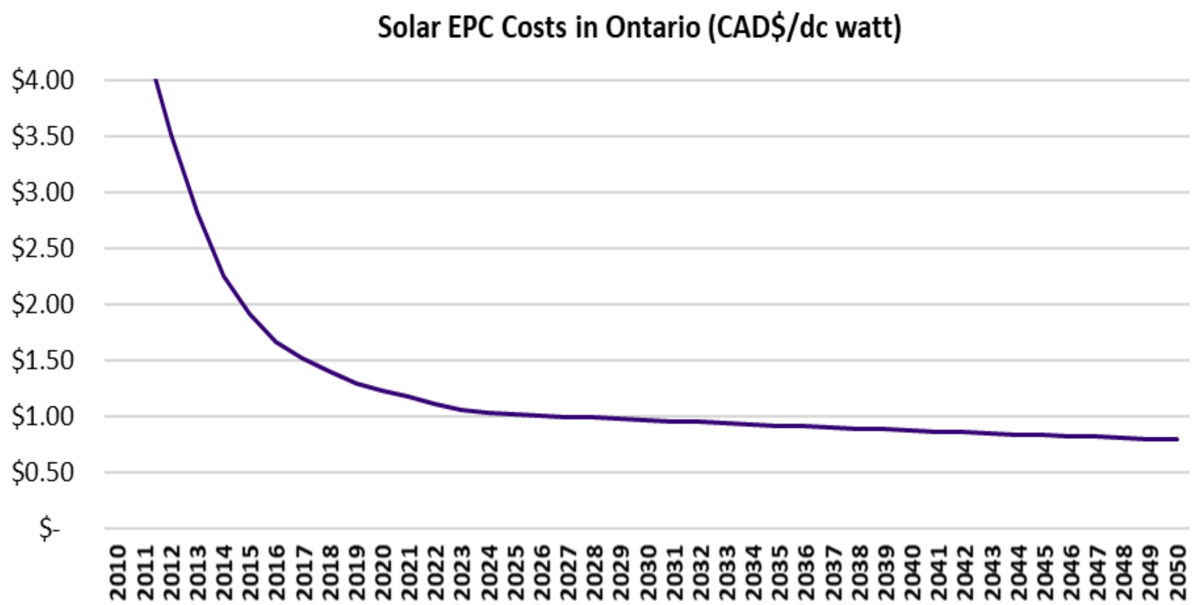


Figure 51. *Forecasted Solar PV Costs*

The following analysis was conducted based on the price curve in the chart above, Solar EPC Costs in Ontario, forecasted grid electricity rates ($/kWh) in Ontario, and the price for electricity generation ($/kWh) for onsite solar generation (including annual maintenance costs) assuming a 25-year life on solar panels.

Figure 52 shows that the price to produce electricity from either roof-mount or carport solar onsite would be less expensive than the cost to purchase electricity from the grid from 2019 through 2050. The chart also shows the cost of solar electricity if The Town was to finance the roof-mount or car park solar. The model assumes an interest rate of 6.5% over a 25-year term. The price for electricity generation ($/kWh) was determined under the assumption that an average solar panel at 1 kW would produce 1,200 kWh/year.

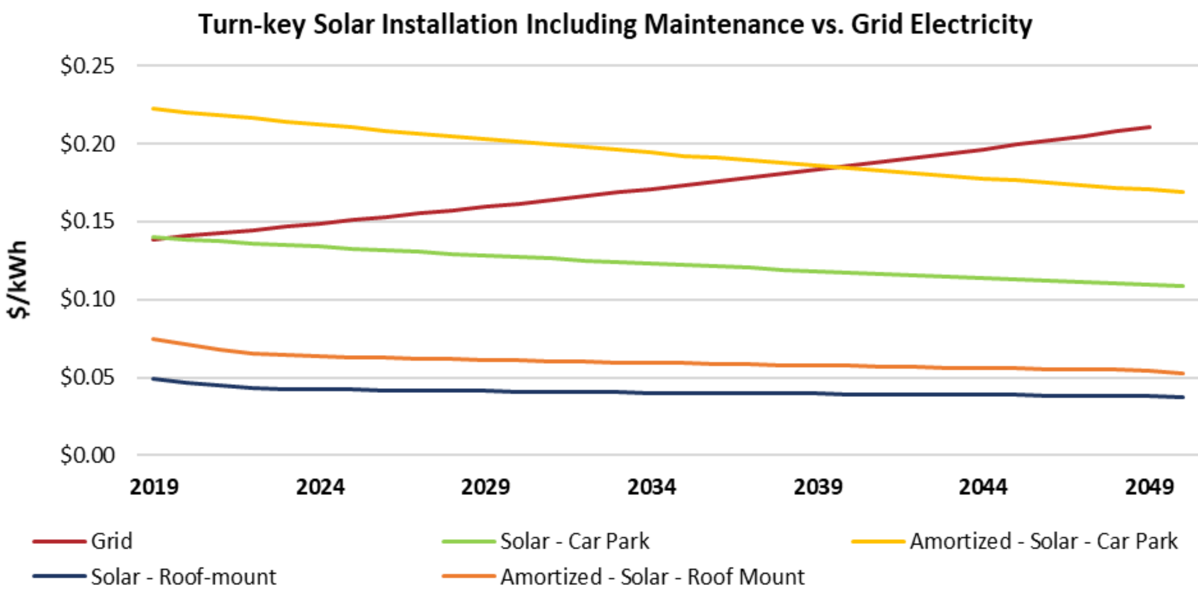


Figure 52. *Solar PV Costs vs Utility Cost for Grid Electricity*

7.3.5. Carbon Tax

A carbon tax increases the price of natural gas, gasoline, diesel, and propane. It will have minimal impact on the price of Ontario's grid-produced electricity, as it is relatively low carbon. The federal government of Canada committed to a carbon tax of \$20/tCO_2e in 2019, which will escalate annually by \$10 until 2022 when it would reach \$50/tCO_2e. this was further revised to escalate annually by \$15 until 2030 when it would reach \$170/tCO_2e.

Table 21. *Effect of Carbon Price on Natural Gas Costs*

Effect of the Federal Carbon Backstop	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Federal Price on Carbon (\$/tCO_2e)	\$20	\$30	\$40	\$50	\$65	\$80	\$95	\$110	\$125	\$140	\$155	\$170
Federal Price on Carbon (\$/m^3)	\$0.039	\$0.059	\$0.078	\$0.098	\$0.127	\$0.157	\$0.186	\$0.215	\$0.245	\$0.274	\$0.303	\$0.333
Actual Price of Natural Gas (\$/ekWh)	\$0.025	\$0.027	\$0.029	\$0.031	\$0.057	\$0.070	\$0.083	\$0.096	\$0.109	\$0.122	\$0.135	\$0.149

The implementation of a carbon tax creates financial incentives to move to low-carbon fuel sources. Currently, the prices of gasoline, diesel and propane are like the price of electricity for the equivalent energy output with a cost of between 0.111 \$/ekWh and 0.127 \$/ekWh. Natural gas, at 0.027 \$/ekWh, is currently about a fifth of the cost of grid electricity for the equivalent energy output.

The Canadian federal government has established a 2030 price for carbon at \$170/tCO_2e. To truly discourage burning natural gas would require a price of ~\$372 - ~\$600/tCO_2e. Carbon pricing schemes in Canada are inconsistent and can vary year to year by jurisdiction.

7.3.6. Funding Opportunities

Identifying funding opportunities to support electrification may be required to support The Town in achieving net-zero targets. Renewable energy, ECDMs and green buildings all have proven fiscally responsible business cases. However, given the low cost of fossil fuel-based technologies, electrification currently does not have a sound business case.

In 2019, the federal government announced multiple initiatives to support Canada's achievement of net-zero emissions by 2050.

Currently, there is insufficient government funding or incentive support to assist in paying for the additional installation and/or operational cost associated with total facility and fleet electrification. However, the GRRAP provides the roadmap for The Town to be "shovel-ready" for grants and incentives as soon as they become available.

7.3.7. Utility Rate Structure

The utility rate structures differ for natural gas and electricity consumption. For natural gas, rates are based on consumption. For electricity, rates consider how much electricity (demand) is required, for how long (kWh) and when the electricity is consumed (time of use). The Town consumers who have a demand of more than 1 MW (and less than 5 MW) can opt into being "Class A" consumers to reduce their global adjustment (GA) charges. In Ontario, the GA charge is a significant component of electricity bills. It covers the cost of building new electricity infrastructure in the province, maintaining existing resources and providing conservation and demand management programs. GA currently represents approximately 80% of the total price of electricity.

To determine the full cost of an ECDM or renewable energy measure, the potential increase of The Town's total electrical cost should be considered if the Class rating is impacted. It is recommended that The Town evaluate each project on a case-by-case basis to evaluate if projects will impact Class rating. For this document, modelling assumed that the price per kWh was based on a Class B consumer rate.

7.3.8. Supporting Infrastructure Costs

In addition to the cost to upgrade infrastructure, further investments may be required to upgrade supporting electrical systems at The Town. It is likely that as each piece of HVAC equipment is converted to fully electric, the supporting electrical infrastructure will also need to be upgraded. This will have cost implications.

7.3.9. Emerging Technology Costs

New clean technologies such as EVs, battery storage and renewable energy are currently quite expensive and face roadblocks during scaling and commercialization. It is expected that these technologies will become more cost-effective in the future, either through government incentives or favourable regulatory and financial market conditions in Ontario, Canada and around the world.

8. Barriers and Considerations

The following section outlines the barriers and considerations that will impact The Town's path to achieving 80% GHG reduction from 2014 level. As The Town moves towards an 80% GHG reduction, each issue should be seriously considered.

8.1. Physical Space Available for Renewal Projects

8.1.1. Barrier

Based on the current solar analysis and a review of the potential for onsite geothermal systems, there is currently not enough space available onsite for The Town to generate the amount of renewable energy required to make its buildings net-zero. Solar PV is a proven and cost-effective form of renewable energy. However, its utility can be limited by the amount of physical space it occupies.

8.1.2. Consideration

Based on the solar review for The Town, they have enough space to accommodate approximately 75,000 kW of rooftop solar, ground and carport. This would generate approximately 86 million kWh of electricity. Based on current forecasts and business as usual scenario The Town would require about 22 million kWh of solar generation to offset the emissions but with consideration of the electrification scenario, this demand will increase significantly to 80 million kWh by 2050.

The more energy-efficient the building is the fewer solar panels required to make it zero carbon. Figure 53 shows the correlation between energy-efficient building design and future renewable energy requirements in terms of solar panels[10]. The image also references the total amount of roof space that would be required to accommodate the solar panels required for The Town's buildings to reach zero carbon.

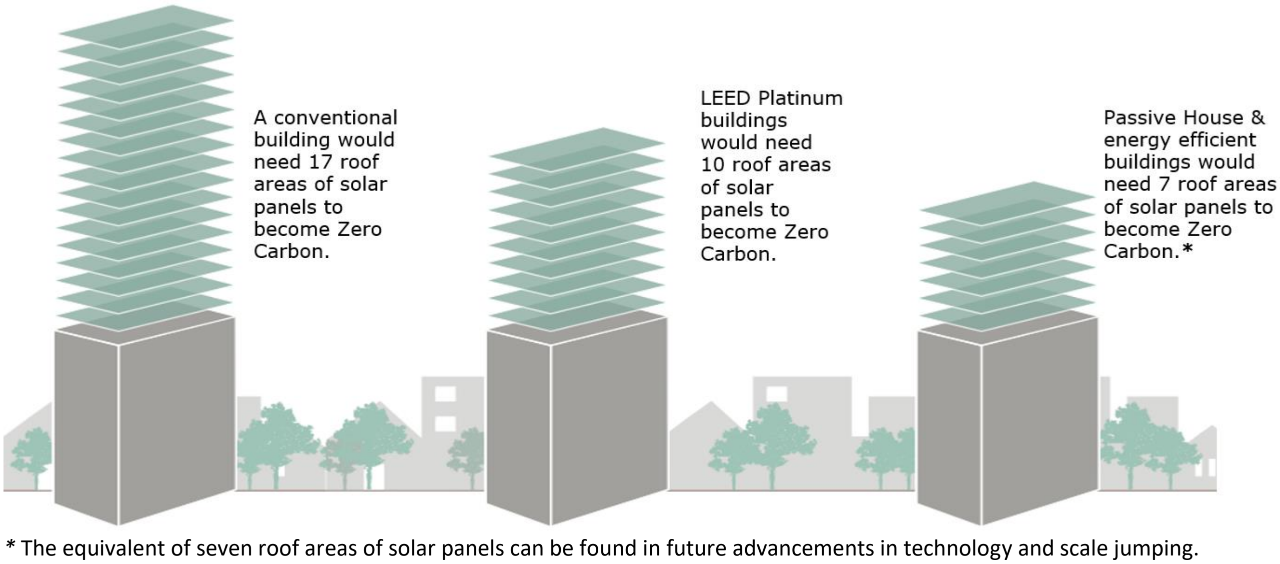


Figure 53. *Energy Efficient Building Design*

[10] New Buildings Institute: Net Zero and Living Building Challenge Financial Study: A cost comparison report for buildings in the District of Columbia

8.2. Virtual Net-Metered Renewable Energy Generation

8.2.1. Barrier

As shown in Figure 54, virtual net metering for renewable energy generation would allow The Town to produce renewable energy offsite that could be credited against the energy use in their facilities. However, virtual net metering is currently not permitted by the IESO.

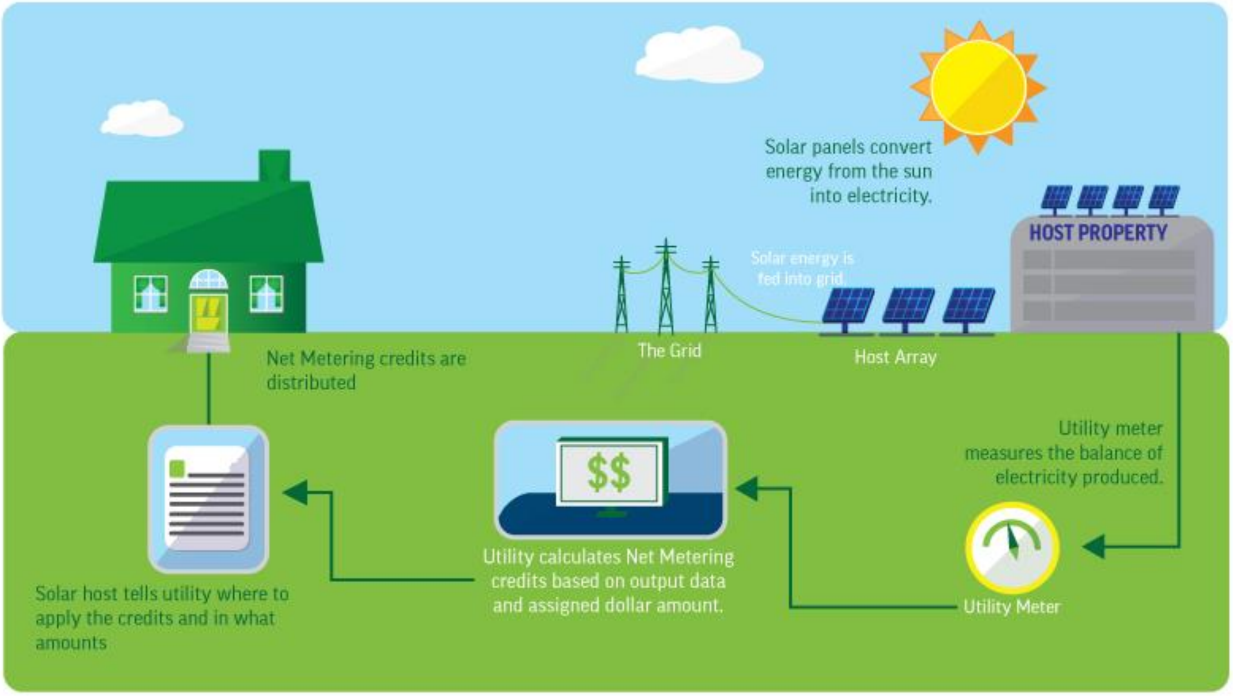


Figure 54. *Virtual Net-Metering Model*

8.2.2. Consideration

Virtual net metering is a bill crediting system administered by the local electricity distribution company that allows the owner of a power-generating asset to be in a different geographic location than that of the actual power-generating asset. With virtual net metering, the owner of the power generating asset might not be the direct consumer of the electricity generated but would still take ownership of the environmental attributes associated with the generation with the local distribution company. The local distribution company would credit The Town’s monthly utility bills for the electricity generated by the renewable generation system. Virtual net metering would eliminate the need for physical space requirements for onsite generation and help The Town meet its 2050 target. However, as mentioned it is not currently permitted by the IESO.

8.3. High GHG Factor for Refrigerants

8.3.1. Barrier

The electrification of cooling systems, specifically installing heat pumps and high-efficiency chillers increase refrigerant use. Refrigerants are prone to leakage and are carbon-intensive.

8.3.2. Consideration

It is recommended that The Town replaces fossil-fuelled equipment with electrical equipment. When electric equipment is installed – specifically chillers, heat pumps and refrigeration equipment – the updated technology requires refrigerants as part of the cooling process. Refrigerants are fluorinated gases, which create GHG emissions. Refrigerants are used onsite when the technology is installed and are refilled annually as a small portion of the refrigerants can leak out. Leakage is dependent upon the operating efficiencies of the equipment and is included in The Town's annual Scope 1 emissions profile.

The refrigerants have a high global warming potential (GWP) and are expressed relevant to CO_2 emissions. The more electrification, the higher the emissions from refrigerants. However, fossil fuel-based equipment is still significantly more carbon-intensive and emits substantially more carbon per GJ produced and consumed.

8.4. Grid Carbon Intensity

8.4.1. Barrier

In every scenario considered, The Town will continue to be reliant on grid-provided electricity for a portion of electrical needs. It is difficult to project the carbon intensity of Ontario's utility-provided electricity.

8.4.2. Consideration

The carbon intensity of the electrical grid, as measured in grams produced per kWh consumed (g/kWh), is determined by the source of electricity production. Compared to other provinces, Ontario's electricity is relatively low carbon. It is predominantly supplied by non-emitting sources of power generation, including hydroelectric and nuclear.

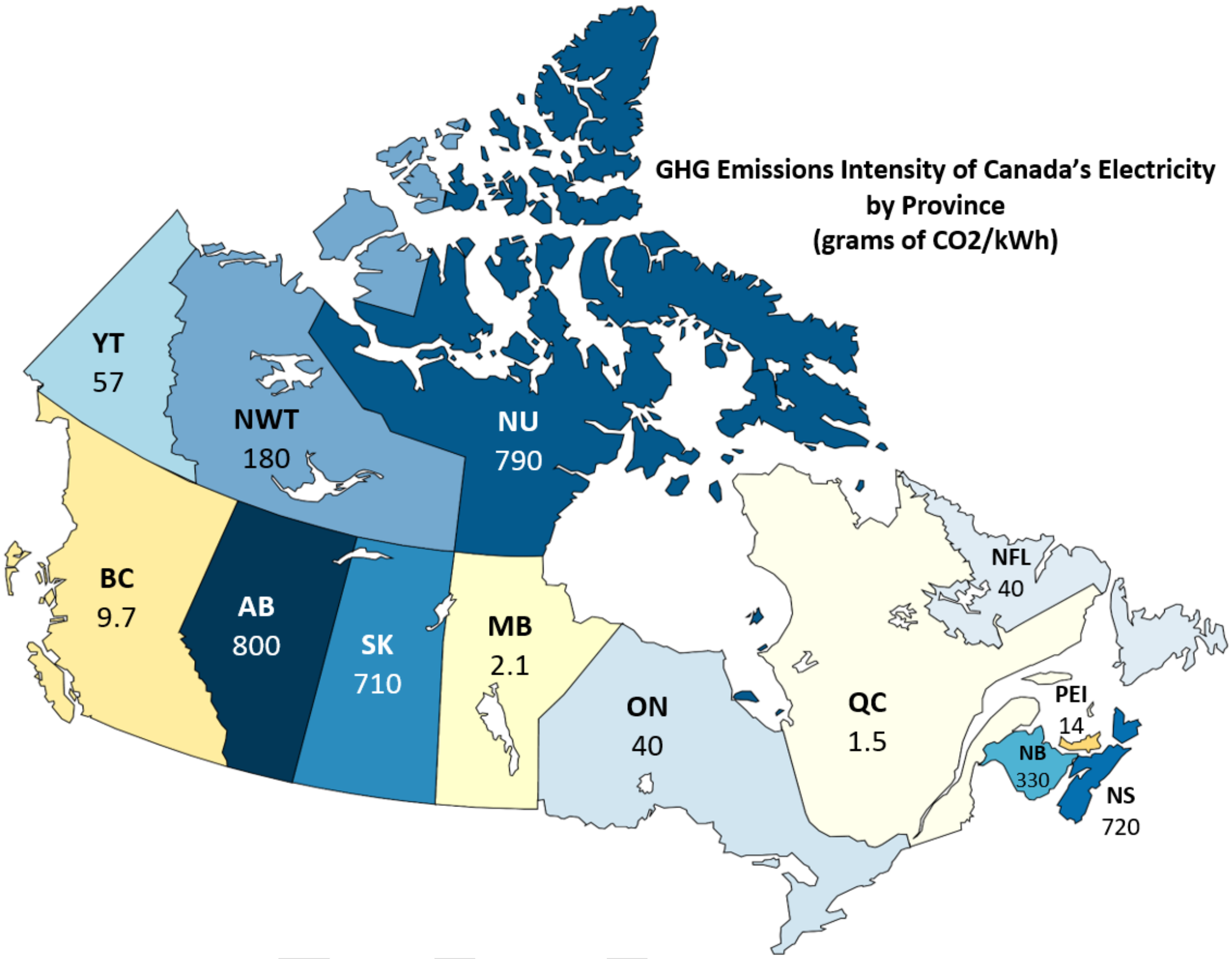


Figure 55. *Emission Intensities of Electrical Grids across Canada (2019)*

The electricity generation in Ontario is mostly powered by nuclear and hydroelectric plants. This has rendered the province with a carbon frugal electric grid – 0.000040 tCO_2e/kWh or 40 grams of CO_2e/kWh. This is one of the lowest emissions intensities of electric grids across all Canadian provinces (see Figure 55). The electrical mix of Ontario's grid is illustrated in Figure 56.

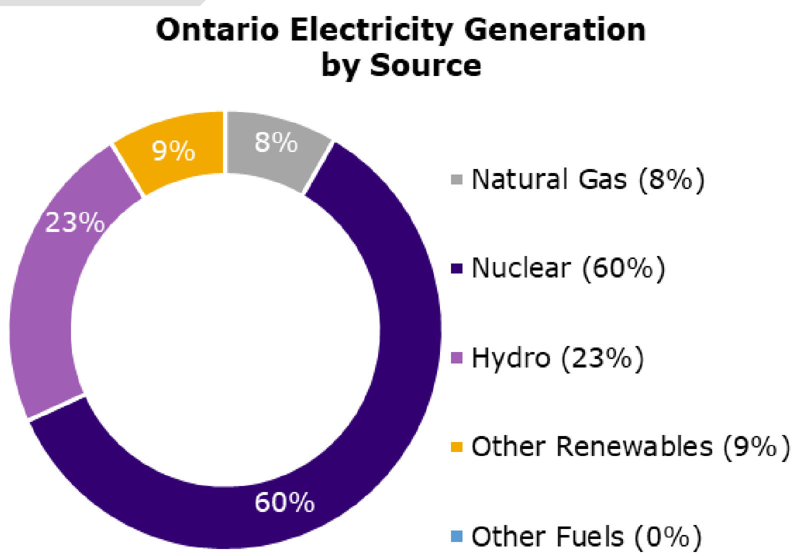


Figure 56. *Electricity Generation Mix in Ontario*

According to Environment and Climate Change Canada (ECCC), natural gas combustion provides approximately 8% of all electricity generation in Ontario. It also accounts for approximately 97% of the total GHG emissions for electricity generation. If Ontario was to replace existing natural gas generators with either nuclear or renewable energy, the GHG emissions intensity of electricity would reduce significantly, thereby reducing The Town's onsite emissions and eliminating the need to invest in its own renewable energy production.

The IESO procures Ontario electricity generation contracts. The 2019 IESO LTEP outlined Ontario's current electricity procurement contracts, including expiration dates. In Ontario, natural gas-fired electricity plants currently provide the peak energy requirements in the province and are the main contributor to the GHG emissions of the electrical grid. The last natural gas-fired generation is contracted to end between 2038 and 2041. The grid mix – and subsequent grid carbon intensity – is not defined past 2041. However, the GRRAP is assumed to be consistent to 2050.

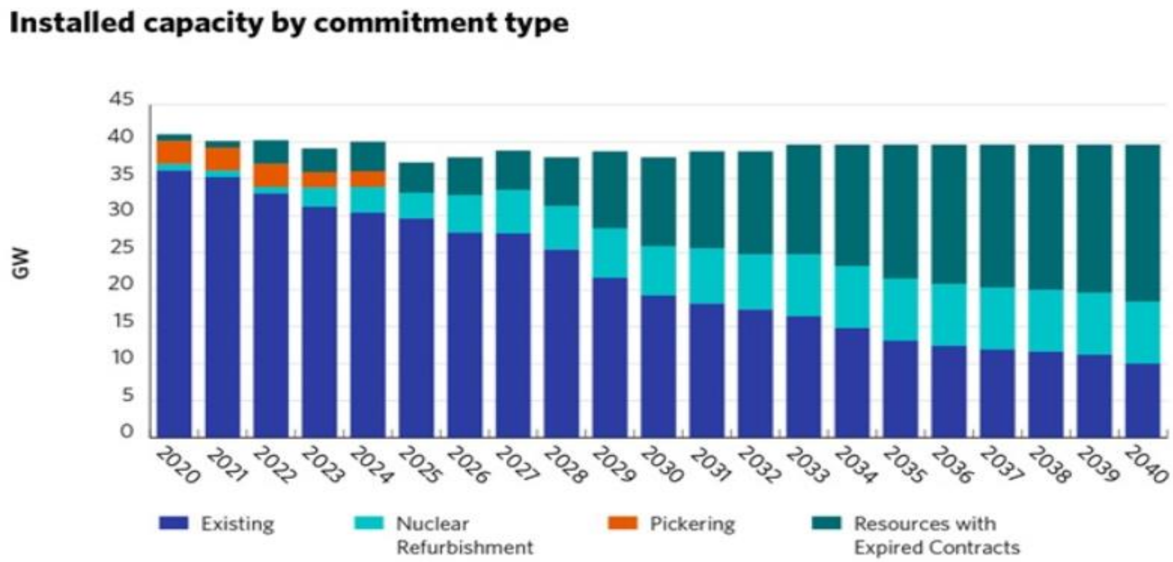


Figure 57. *Ontario's Installed Power Capacity*

Between 2020 and 2050, the grid could potentially decarbonize further if there is political will, which would significantly impact The Town's path to 80% GHG reduction from 2014 level. Ontario's electricity generation is determined by the IESO as directed by the Ontario Ministry of Energy[11]. Currently, the grid has a low carbon intensity factor as the result of eliminating coal from the generation stack in 2013.

[11] *IESO: http://www.ieso.ca/Powering-Tomorrow/Data/The-IESOs-Annual-Planning-Outlook-in-Six-Graphs*

9. Supporting Sustainability Initiatives

This section provides a summary of scope 3 emissions and suggestions on waste to continue to foster sustainable practices in The Town. The Sustainability Policy Cycle will help garner support and spread awareness amongst the broader community. Operational policies established by The Town can influence resident and employee behaviour.

Scope 3 GHG emissions are generated by both The Town's operations and as a direct result of those that live and work there. It is vital to have sustainability policies that align with The Town's climate action strategy and its GHG emissions reduction targets.

The followings are some of the sources for Scope 3 GHG emission:

- Commuting
- Air travel
- Paper purchases
- Waste

9.1. Waste Management

To achieve its GHG emissions target, The Town should implement programs and strategies to continue to reduce emissions from Scope 3 emissions, including a target to reduce waste by 2050.

Three waste diversion strategies should be focused on: upstream, onsite, and downstream. Upstream is waste that is produced before a product reaches The Town; onsite is produced in The Town, and downstream is how a product is disposed of.

The following strategies can be implemented in The Town to help achieve the goal of reducing waste and emissions associated with waste:

Upstream

- Upstream waste reduction through sustainable material management.
- A stronger focus on waste reduction as it related to purchasing decisions. Look for products with less packaging; bring fewer single-use disposable items into The Town and reduce the amount of less non-recyclable and non-compostable materials being purchased.

Onsite

- Eliminate single-use products (i.e., disposable food service ware, disposable cups, straws, etc.).
- Require new buildings, expansions, or renovations to reuse or recycle at least 50% of the construction debris or dispose of no more than 2.5 lbs. per sq. ft.
- Replace plastic bags with reusable, compostable or paper bags labelled with 40% post-consumer recycled content.
- Create programs for residents to submit proposals for service enhancements, innovations, or cost-savings on waste.
- Host recycling/reuse events.

Downstream

- Create multiple locations in facilities where staff and visitors can bring their hard-to-recycle materials (i.e., electronics, small appliances, books, textiles, etc.).
- Increase awareness around proper waste sorting to improve residents Fand staff participation in composting and recycling programs (i.e., improved signage, more centralized waste bins, expand composting).

The reduction strategies focus on reducing the total amount of disposable products purchased by The Town, while the diversion strategies focus on recycling and composting all waste.

Appendix 1: List of Included Buildings

Archetype	Facility	Facility Size (sq. ft)	Facility Size (%)
Arenas	Joshua's Creek Arena	73,400	3.59
	Oakville Arena	41,000	2.01%
	Kinoak Arena	21,000	1.03%
	Maple Grove Arena	28,971	1.42%
	16 Mile Sports Complex	196,000	9.59%
Operations & Administrative	Central Operations	98,232	4.81%
	Canada Post Office	40,290	1.97%
	Commercial Buildings (Cross Avenue)	5,296	0.26%
	Commercial Buildings	3,166	0.15%
	Fire Prevention Portable (Office)	2,000	0.10%
	Fire Prevention Quonset Hut (Storage)	600	0.03%
	Fire Station 1	5,619	0.27%
	Fire Station 2	5,673	0.28%
	Fire Station 4	4,525	0.22%
	Fire Station 5	5,906	0.29%
	Fire Station 6	8,470	0.41%
	Fire Station 7	7,950	0.39%
	Fire Station 8	11,000	0.54%
	Fire Training Centre	5,856	0.29%
	Gairloch Gallery	9,674	0.47%
	Gairloch Gift Shop	960	0.05%
	Nottinghill Park Building	2,400	0.12%
	Old Post Office & Thomas House	1,012	0.05%
	Parks Central Depot	11,100	0.54%
	School Lease Spaces	46,404	2.27%
	Southeast Satellite – Parks Office & Storage	14,100	0.69%
	Transit Main Depot- Garage	49,400	2.42%
	Fire Station 3	15,629	0.76%
	North Ops	17,909	0.88%
	Town Hall	162,092	7.93%
	Transit Facility	265,000	12.96%
Community Centers	Centennial Pool	17,640	0.86%
	Bronte Youth Centre	9,000	0.44%
	Coronation Park – Stone Barn/Outdoor Theatre	2,002	0.10%
	Glen Abbey Library	14,984	0.73%
	Greenhouse	12,250	0.60%
	Harbour Banquet and Conference Centre	23,458	1.15%

	Metro Marine & Bronte Harbour Office Trailer	5,600	0.27%
	North East Hub Building	1,150	0.06%
	Oakville Historical Society	2,379	0.12%
	Oakville Museum – Coach House	1,973	0.10%
	Oakville Museum – Erchless Estate	6,615	0.32%
	Oakville Youth Development Center	1,500	0.07%
	Seniors Drop In Centre	8,072	0.39%
	Woodside Library	14,203	0.69%
	Central Library	47,220	2.31%
	Glen Abbey CC	134,500	6.58%
	OCPA	24,720	1.21%
	Iroquois Ridge CC	69,282	3.39%
	QEPCCC	145,760	7.13%
	River Oaks CC	113,028	5.53%
	Sir John Colborne	9,065	0.44%
	Trafalgar Park CC	62,875	3.08%
	Oakville Trafalgar CC	41,200	2.02%
Other	Park Lights	-	-
	Parking Meters	-	-
	Parks Outdoor Washrooms	17,756	0.87%
	Public Parking Garage	89,165	4.36%
	Sand & Salt Structure	6,447	0.32%
	Splash pads	-	-
	Streetlights	-	-
	Traffic Lighting	-	-
	Tannery Park Harbour – Workshop & Washrooms	1,785	0.09%
Total		**2,078,734 sq. ft**	**100%**

Appendix 2: List of Recommended ECMs and Renewable Initiatives

Archetype	Building	Measure Name	Implementation Year	GHG Reduction (tCO2e)	Cost	Energy Savings	
						Electricity (KWh)	Natural Gas (m3)
Community Center	Central Library	Retrofit Indoor Lighting (T8 to LED)	2022	1.19	44,880	26,493	0
Community Center	Central Library	Install drives on fans and pumps	2022	1.36	68,416	30,192	0
Community Center	Central Library	Replace R22 Units	2023	22.76	188,830	21,512	11,325
Operations and admins	Central Operations Depot	Retrofit Indoor Lighting (T8 to LED)	2022	3.05	114,654	67,683	0
Operations and admins	Central Operations Depot	Retrofit Outdoor Lighting	2022	0.99	17,613	21,934	0
Operations and admins	Central Operations Depot	Replace R22 Units	2023	38.67	41,259	4,700	20,303
Community Center	Glen Abbey Community Centre	Retrofit Indoor Lighting (T8 to LED)	2022	0.66	25,024	14,772	0
Community Center	Glen Abbey Community Centre	Replace old (R22) AC Units	2023	18.24	277,077	31,565	8,601
Community Center	Glen Abbey Community Centre	BAS Controls Recommissioning	2022	36.68	74,350	92,590	17,202
Community Center	Glen Abbey Community Centre	Install VFD's on Fans and Pumps	2022	3.41	171,663	75,756	0
Community Center	Iroquois Ridge Community Centre	Retrofit Indoor Lighting (T8 to LED)	2022	1.28	48,125	28,409	0
Community Center	Iroquois Ridge Community Centre	Retrofit Outdoor Lighting	2022	0.66	11,828	14,731	0
Community Center	Iroquois Ridge Community Centre	Replace old Boilers	2023	17.14	65,945	0	9,070
Community Center	Iroquois Ridge Community Centre	Replace old (R22) AC Units	2023	4.04	85,257	9,713	1,814
Community Center	Iroquois Ridge Community Centre	Replace old Dehumidification Unit	2023	0.20	11,000	3,238	0
Community Center	Iroquois Ridge Community Centre	Install VFD's on Fans and Pumps	2022	2.91	146,725	64,750	0
Arenas	Joshua's Creek Arenas	Replace old (R22) AC Units	2023	12.60	110,000	0	6,667
Arenas	Joshua's Creek Arenas	Seal cracks around doors	2022	6.30	26,146	0	3,334
Arenas	Kinoak Arena	Retrofit Ice Rink Lighting (to LED)	2022	0.45	16,963	10,014	0
Arenas	Kinoak Arena	Install Magnavitalis for Zamboni water	2022	0.10	22,000	262	48
Arenas	Maple Grove Arena	Retrofit Ice Rink Lighting (to LED)	2022	0.86	32,462	19,163	0
Arenas	Maple Grove Arena	Replace outdoor lighting (HID to LED)	2022	0.22	3,990	4,968	0
Arenas	Maple Grove Arena	Seal cracks around doors	2022	1.24	5,144	0	656
Arenas	Maple Grove Arena	Install Magnavitalis for Zamboni water	2022	0.23	22,000	580	107
Operations and admins	North Operations Depot	Retrofit Indoor Lighting (T8 to LED)	2022	1.01	38,058	22,466	0
Operations and admins	North Operations Depot	Install lighting controls	2022	0.34	12,686	7,489	0
Community Center	Oakville Centre for the Performing Arts	Retrofit Indoor Lighting (T8 to LED)	2022	0.85	32,008	18,895	0
Community Center	Queen Elizabeth Park and Community Centre	Retrofit remaining Indoor Lighting to LED	2022	0.33	12,290	7,255	0
Community Center	Queen Elizabeth Park and Community Centre	Install VSD's larger fan and pump motors	2022	2.98	149,883	66,144	0
Community Center	Queen Elizabeth Park and Community Centre	Seal cracks in entrance doors	2022	4.61	19,148	0	2,441
Others	Bronte Beach Park Washrooms	Retrofit Indoor Lighting (to LED)	2022	0.38	14,287	8,434	0
Others	Bronte Beach Park Washrooms	Replace outdoor lighting (HID to LED)	2022	2.66	47,408	59,038	0
Community Center	River Oaks Community Centre	Retrofit remaining Indoor Lighting to LED	2022	0.66	24,747	14,608	0
Community Center	River Oaks Community Centre	Replace old (R22) AC Units	2023	6.05	82,500	0	3,201
Community Center	River Oaks Community Centre	BAS Controls Recommissioning	2022	21.14	17,379	21,642	10,671
Community Center	River Oaks Community Centre	Install VFD's on Fans and Pumps	2022	2.60	130,776	57,712	0
Community Center	River Oaks Community Centre	Seal cracks around doors	2022	2.52	10,461	0	1,334
Community Center	Sir John Colborne Recreation Centre for Seniors	Retrofit Indoor Lighting (T8 to LED)	2022	0.20	7,517	4,438	0
Community Center	Sir John Colborne Recreation Centre for Seniors	Retrofit Outdoor Lighting	2022	0.05	924	1,151	0
Arenas	Sixteen Mile Sports Complex	Retrofit remaining Indoor Lighting to LED	2022	0.93	34,940	20,626	0
Arenas	Sixteen Mile Sports Complex	Retrofit outdoor lighting (HID to LED)	2022	2.41	42,941	53,475	0
Arenas	Sixteen Mile Sports Complex	Use heat from refrigeration plant to melt ice	2022	18.69	11,000	0	9,889
Others	Nautical Park Splash Pad	Retrofit outdoor lighting (HID to LED)	2022	0.36	6,434	8,013	0
Others	Salt & Sand Structure	Replace outdoor lighting	2022	0.35	6,158	7,668	0
Operations and admins	Transit Facility	Retrofit Indoor Lighting (T8 to LED)	2022	8.27	311,505	183,887	0
Operations and admins	Town Hall	Retrofit Indoor Lighting (T8 to LED)	2022	1.15	43,289	25,554	0
Operations and admins	Town Hall	BAS Controls Recommissioning	2022	33.44	93,883	116,915	14,909
Operations and admins	Town Hall	Replace R22 Units	2023	9.24	109,958	12,527	4,473
Operations and admins	Trafalgar Park Community Centre	Install Magnavitalis for Zamboni water	2022	6.54	22,000	16,630	3,063

Community Center	Centennial Pool	Install Solar Domestic Hot water	2025	7.14	66,000	0	3,776
Community Center	Glen Abbey	Install Solar Domestic Hot water	2025	26.76	154,000	0	14,158
Community Center	Iroquois Ridge	Install Solar Domestic Hot water	2025	23.55	143,000	0	12,462
Community Center	Queen Elizabeth Park and Community Centre	Install Solar Domestic Hot water	2025	16.54	110,000	0	8,754
Community Center	River Oaks Community Centre	Install Solar Domestic Hot water	2025	16.48	110,000	0	8,722
Community Center	Trafalgar Park Community Centre	Install Solar Domestic Hot water	2025	12.66	99,000	0	6,697
Operations and admins	Fire Station #3	Install Solar Domestic Hot water	2025	1.85	44,000	0	981
Operations and admins	Transit Facility	Install Solar Domestic Hot water	2025	20.33	132,000	0	10,755
Arenas	Joshua Creek Arena	Install Solar Domestic Hot water	2025	12.51	99,000	0	6,621
Arenas	Maple Grove Arena	Install Solar Domestic Hot water	2025	2.39	46,200	0	1,263
Arenas	Sixteen Mile Sports Complex	Install Solar Domestic Hot water	2025	15.85	107,800	0	8,385
Community Center	Centennial Pool	Install Solar Air Systems	2026	7.14	66,000	0	3,776
Community Center	Glen Abbey	Install Solar Air Systems	2026	26.76	154,000	0	14,158
Community Center	Iroquois Ridge	Install Solar Air Systems	2026	23.55	143,000	0	12,462
Community Center	Queen Elizabeth Park and Community Centre	Install Solar Air Systems	2026	16.54	110,000	0	8,754
Community Center	River Oaks Community Centre	Install Solar Air Systems	2026	16.48	110,000	0	8,722
Community Center	Trafalgar Park Community Centre	Install Solar Air Systems	2026	12.66	99,000	0	6,697
Operations and admins	Fire Station #3	Install Solar Air Systems	2026	1.85	44,000	0	981
Operations and admins	Transit Facility	Install Solar Air Systems	2026	20.33	132,000	0	10,755
Arenas	Joshua Creek Arena	Install Solar Air Systems	2026	12.51	99,000	0	6,621
Arenas	Maple Grove Arena	Install Solar Air Systems	2026	2.39	46,200	0	1,263
Arenas	Sixteen Mile Sports Complex	Install Solar Air Systems	2026	15.85	107,800	0	8,385
Operations and admins	North Operations Depot	Install Solar Air Systems	2026	2.83	107,801	0	1,498
Operations and admins	Central Operations Depot	Install Carport 594 KW	2024	39.12	1,260,000	738,020	0
Operations and admins	Transit Facility	Install Carport 500 KW	2024	51.97	1,050,000	980,500	0
Operations and admins	Central Operations Depot	Install Rooftop PV 594 KW	2024	31.40	1,152,900	592,400	0
Operations and admins	Fire Station #3	Install Rooftop PV 120 KW	2024	5.37	233,100	101,300	0
Community Center	Glen Abbey	Install Rooftop PV 450 KW	2024	27.98	876,750	528,000	0
Arenas	Maple Grove Arena	Install Rooftop PV 90 KW	2024	5.51	178,500	103,900	0
Operations and admins	Transit Facility	Install Rooftop PV 950 KW	2024	64.18	1,890,000	1,211,000	0
Community Center	Community Center	Install PV 1,696 KW	2025	159.93	2,397,296	1,950,400	0
Operations and admins	Operations and admins	Install PV 1,396 KW	2025	131.64	1,973,246	1,605,400	0
Arenas	Arenas	Install PV 916 KW	2025	86.38	1,294,766	1,053,400	0
Others	Others	Install PV 472 KW	2025	44.51	667,172	542,800	0
Town of Oakville	Town of Oakville	Install Carport 4,480 KW	2025	422.46	6,332,480	5,152,000	0
Community Center	Community Center	Install PV2,376 KW	2030	193.97	2,613,160	2,731,940	0
Operations and admins	Operations and admins	Install PV 1,675 KW	2030	136.78	1,842,720	1,926,480	0
Arenas	Arenas	Install PV 917 KW	2030	74.87	1,008,700	1,054,550	0
Others	Others	Install PV 512 KW	2030	41.80	563,200	588,800	0
Town of Oakville	Town of Oakville	Install Carport 5,480 KW	2030	447.43	6,027,780	6,301,770	0
Community Center	Community Center	Install PV 4,410 KW	2040	436.19	4,608,868	5,071,960	0
Operations and admins	Operations and admins	Install PV 3,909 KW	2040	386.58	4,084,696	4,495,120	0
Operations and admins	Arenas	Install PV 2,749 KW	2040	271.88	2,872,705	3,161,350	0
Others	Others	Install PV 1,378 KW	2040	136.28	1,440,010	1,584,700	0
Town of Oakville	Town of Oakville	Install Carport 12,446 KW	2040	1,230.93	13,006,279	14,313,130	0
Community Center	Community Center	Install PV 5,090 KW	2050	503.40	4,759,150	5,853,500	0
Operations and admins	Operations and admins	Install PV 4,188 KW	2050	414.19	3,915,780	4,816,200	0
Arenas	Arenas	Install PV 2,749 KW	2050	271.88	2,570,315	3,161,350	0
Others	Others	Install PV 1,418 KW	2050	140.24	1,325,830	1,630,700	0
Town of Oakville	Town of Oakville	Install Carport 13,445 KW	2050	1,329.71	12,571,075	15,461,750	0
Town of Oakville	Remaining Buildings	Various Energy efficiency improvements	2022	25.59	202,995	103,744	11,068