REPORT

475 & 485 KING STREET NORTH

ENERGY STRATEGY REPORT: ISSUED FOR ZONING BY-LAW AMENDMENT

PROJECT #2200671
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SUBMITTED TO

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EXECUTIVE SUMMARY

RWDI was retained by Drewlo Holdings Inc. to prepare an energy strategy report for the 475 & 485 King Street North development in Waterloo, Ontario. The development consists of a multi-unit residential tower, townhomes, commercial offices, and commercial retail spaces (see Figure 1). The proposed total gross floor area (excluding below-grade parking) is 231,444 m^2.

This report was completed to support the Zoning By-Law Amendment submission, as required by the City of Waterloo ([Reference Link 1]). A more detailed Design Development Stage Energy Efficiency Report will be conducted during the Site Plan Control Application stage, as required.

RWDI has explored how differing energy efficiency strategies may be of benefit to the project. The intent of this exploration is to provide strategic energy options for the project at an early stage, and to identify the steps that should be explored to reduce energy use, ultimately striving towards a near-zero emissions level of performance.

This report should act as a roadmap towards enhanced levels of performance. Particular focus was placed on achieving an energy consumption 15% below a SB-10 Baseline for total building energy use. In addition to energy saving strategies, this report has provided recommendations on how to implement climate resilient design to account for the expected changes in the local microclimate.

This energy strategy identifies a number of interesting opportunities that will continue to be explored by the project team. However, pursuit of opportunities will need to be balanced with the risks of implementing non-traditional development solutions. As such, the implementation of identified opportunities will likely require a collaborative effort between the developers of this project and the City to de-risk any less-conventional development solutions.

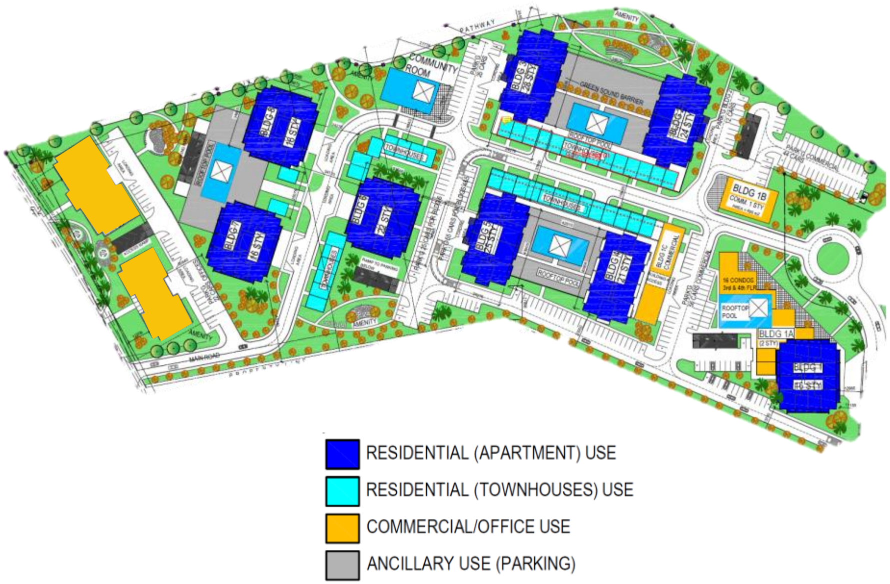

Figure 1: Proposed 475 & 485 King Street North project

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1. INTRODUCTION

1.1 PLANNING FOR A SUSTAINABLE FUTURE

More than ever before, climate change and greenhouse gas (GHG) emissions are a priority on the agenda at all levels of government in Canada. The City of Waterloo has indicated that an Energy Strategy report be submitted for new developments, showing a path to consuming 15% less energy than SB-10.

The motivation for this energy target is province-wide. For example, in 2019 buildings in Ontario were responsible for 38.6 million tonnes of equivalent carbon emissions (CO_2e), as reported in Canada's National Inventory Report on GHGs (Reference Link 2). This represents 24% of the Province's GHG emission inventory and quantifies the important role that buildings will play in Ontario's goal to reduce carbon emissions.

Further, based on Toronto data natural gas consumption in buildings accounts for 94% of building emissions (see Figure 2). The link between a low-energy development and a low-carbon development is both the efficiency of the building and the GHG intensity (i.e., CO_2e/kWh) of the fuels consumed. Over the next 20 years in Ontario, the GHG intensity of natural gas is projected to be 2.3 times that of electricity as a result of electricity being generated primarily using non-GHG emitting energy sources.

This energy strategy report explores opportunities for the proposed development to reduce its energy use and GHG emissions. The focus on carbon will be balanced, however, by the economic challenge presented by the fuel-cost disparity: the cost of electricity is currently over five times greater than that of natural gas.

Beyond GHG emissions, it is important to consider that buildings designed today will have to accommodate an alternative climate future. Renewable energy and climate resilience will have to become part of the design process.

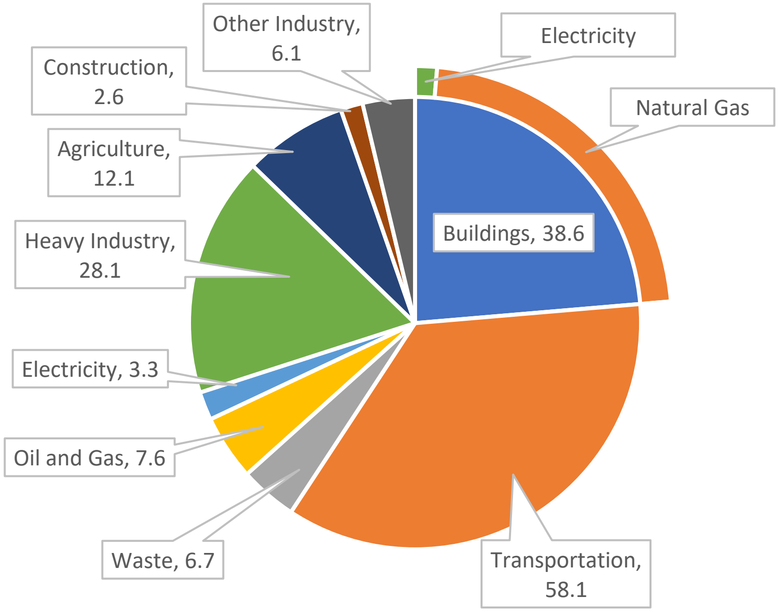


Figure 2: Ontario GHG Emissions in 2019 (in million tonnes CO_2e)

1.2 BUILDING PERFORMANCE METRICS

There are three metrics commonly used to indicate a building's absolute energy performance, shown below:

- **Total energy use intensity (TEUI)**: This metric measures the energy consumed by the building each year (in ekWh) normalized by the conditioned floor area (in m^2). A lower TEUI indicates a more energy efficient building.
- **Thermal energy demand intensity (TEDI):** This metric measures the annual heating energy required for a building to maintain a stable, pre-defined interior temperature (in kWh) normalized by the conditioned floor area (in m^2). A lower TEDI is achieved by designing a high-performance building envelope and using energy recovery ventilation units.
- **Greenhouse gas intensity (GHGI):** This metric looks at the annual GHG emissions of a building (in kg CO_2e) based on the current-year fuel-specific emission factors, normalized by the conditioned floor area (in m^2). This metric encourages the use of highly efficient, lower-carbon emitting fuels.

By reducing each of these intensities, developments can reduce utility costs and associated GHG emissions. Many standards, including the Toronto Green Standard (Reference Link 3), identify absolute targets for each performance metric based on building type (e.g., High Rise Residential, Mid Rise Residential, Commercial Office, or Commercial Retail). For this project, the target requested by the City is that the development's TEUI be 15% better than the SB-10 Baseline. The overall energy performance targets for this development have been determined using an area-weighted average of the relevant building types. In establishing these targets, priority was given to the High-Rise Residential and Commercial Office types given the significant floor areas and novel construction practices needed to achieve sufficient performance for these types. These targets are shown in Table 2.

Table 2: SB-10 Energy Performance Targets for 475 & 485 King Street Development

Performance Metric	Target
TEUI (ekWh/m^2)	217
TEDI (kWh/m^2)	94
GHGI (kg CO_2e/m^2)	30

1.3 METHODOLOGY

The following key steps were applied by RWDI in preparing this energy strategy:

1. **Develop and utilize archetype energy models** representative of the proposed project. The proposed development is comprised of the following building archetypes, as shown in Figure 3:
    1. High Rise Residential
    2. Commercial/Office
    3. Parking
2. **Determine Energy Performance based on Energy Conservation Measures (ECMs)**, targeting three levels of performance:
    - I. SB-10 Compliance
    - II. Developer Package
    - III. 15% Improved from SB10 Package

    Quantify the impact of these ECMs on site-wide energy and greenhouse gas emissions.
3. **Consider low-carbon opportunities for the project,** including on-site renewable energy and district thermal energy networks.
4. **Make recommendations based on the results of the analysis.**

This energy strategy was prepared using the preliminary density and built form concepts from 'New Apartment Mixed Use Development at: 475 King Street N. ' dated Jan 31st, 2022. RWDI has used the energy modelling tool IES Virtual Environment 2018 and 2019 to develop this analysis. A summary of the energy modeling inputs can be reviewed in Appendix A.

Note that "actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, energy use not covered by this standard, changes in energy rates between design of the building and occupancy, and precision of the calculation tool." [ASHRAE 90.1 - 2016, 11.2 Informative Note].

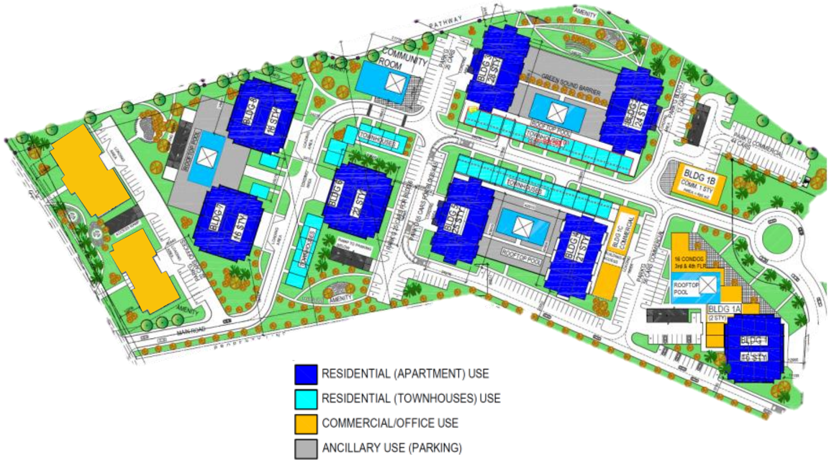


Figure 3: Project Geometry with Modelled Archetypes

2. PROJECT ANALYSIS

2.1 DEVELOPER PACKAGE: ENERGY CONSERVATION MEASURES AND RESULTS

In support of its current development application, the City is requesting that the development demonstrate a potential path to reducing TEUI by 15% relative to a SB-10 Baseline. The first package that was tested was based on a typical design package commonly used by Drewlo for High Rise Residential buildings (provided via email on January 19th, 2022), while keeping the remaining buildings at the SB-10 baseline package. The goal of this analysis step was to determine if the 15% improvement above SB-10 could be achieved for the development by applying this package. Important modelling assumptions for this package are summarized in Appendix A.

The results for each performance metric for this package are shown in Figure 4, and key strategies implemented in the developer performance package are:

1. Achieve a gross window-to-wall ratio of 50% with overall window U values of U-0.41.
2. Achieve an overall opaque wall assembly of R-10.
3. Specify high-performance mechanical plant equipment including condensing boilers, variable frequency drive centrifugal chiller, and cooling tower with variable speed drive fan.

Based on the analysis, this package results in a TEUI improvement of 3% relative to SB-10, and therefore does not meet the 15% better than SB-10 target.

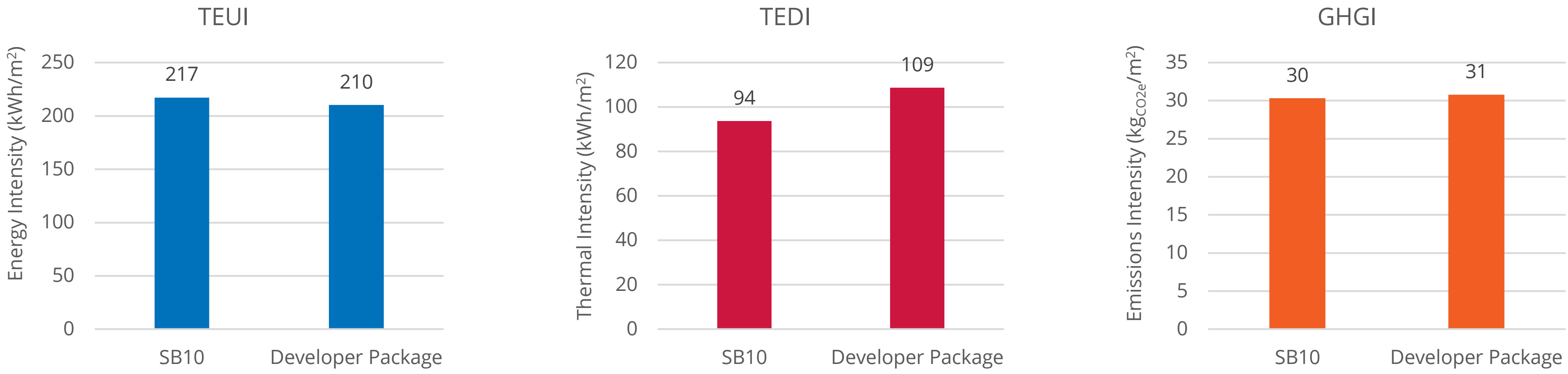


Figure 4: Developer Performance Package Results

2. PROJECT ANALYSIS

2.2 PROPOSED PACKAGE: ENERGY CONSERVATION MEASURES AND RESULTS

Given that the developer package did not achieve the 15% less energy than SB-10 target, additional performance improvements were analyzed. Using the energy model, a package of design strategies and energy conservation measures was employed to meet the 15% TEUI reduction (assumptions listed in Appendix A). As part of these strategies, changes were made to each building type. The results for each of the building performance metrics based on this proposed performance package are shown in Figure 5, below.

The key strategies in this package are:

1. Switch Commercial/Office systems to dedicated outdoor air system with zone-level fan coil units. Ventilation to be provided via energy recovery ventilation (ERV) units with 65% sensible and 55% latent effectiveness.
2. Upgrade Residential ventilation units to in-suite ERVs with 65% sensible effectiveness.
3. Achieve a gross window-to-wall ratio of 50% in the high rise residential with overall window U values of U-0.35.
4. Specify high-performance mechanical plant equipment including condensing boilers, variable frequency drive centrifugal chiller, and cooling tower with variable speed drive fan.

This package results in a TEUI reduction of 20% relative to the baseline, while simultaneously reducing GHGI by 20% and TEDI by 19%.

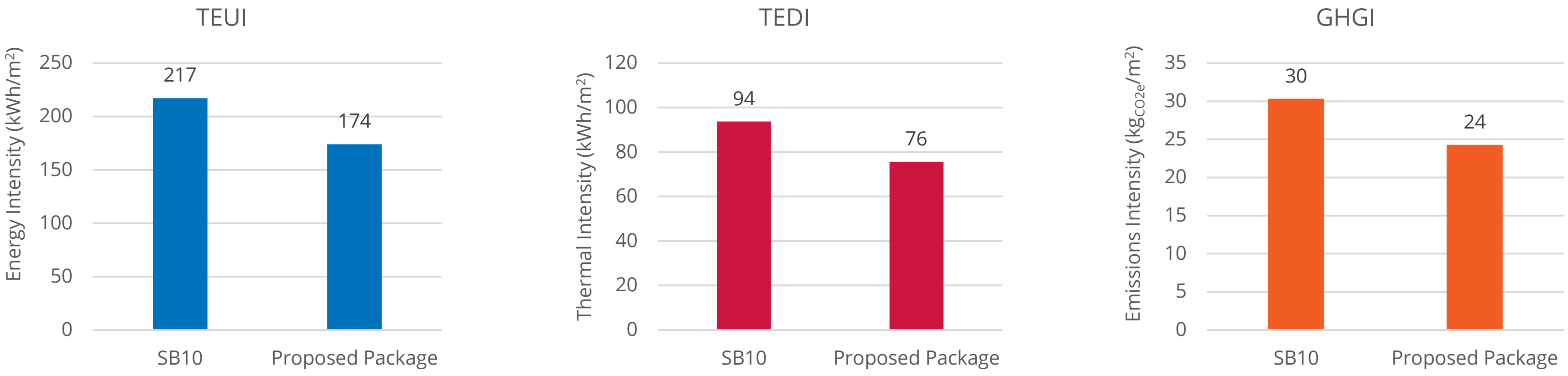


Figure 5: Proposed Performance Package Results

2.3 FINANCIAL PROJECTIONS

The proposed performance package offers energy and carbon cost reductions compared to both the SB-10 Baseline and the Developer Package, which can offset potential increases in capital cost. To begin assessing this offset, annual operating costs that account for changes from electricity, natural gas, and carbon pricing and emission factors (Reference Link 4) were estimated for a 20-year period. Electricity and natural gas prices were assumed to escalate at 3% per year, and carbon prices followed the Federal framework (Reference Link 5) to 2030 and then were assumed constant. The results are shown in Figure 6.

As shown in Figure 6, in Year 1 of operation, the proposed package offers 20% and 7% annual cost-savings relative to the SB-10 and Developer Packages, respectively. Over the 20-year project lifetime, these savings are 20% and 9%, respectively. The increase in savings relative to the developer package occurs because carbon costs over the lifetime of the project increase. For example, in the Developer Package the carbon cost is 7% in the first year and increases to 18% in the 20th year.

While this assessment is preliminary, it supports that the proposed package will consistently offer energy and carbon cost savings. In addition, since we conservatively assumed carbon pricing remains flat from 2030, systems that minimize carbon will offer further savings if prices escalate.

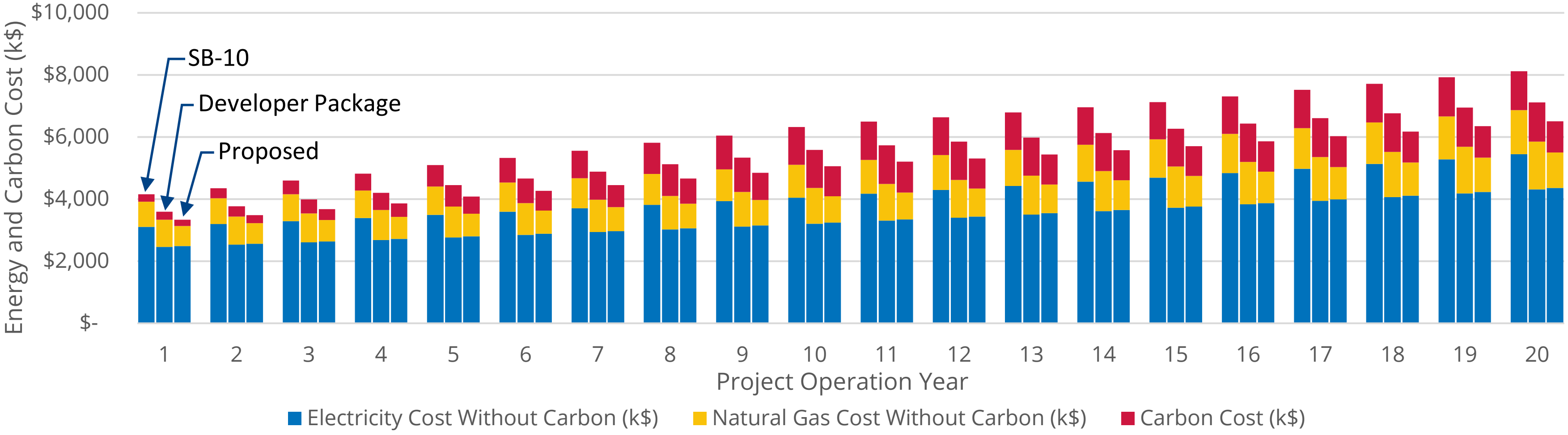


Figure 6: Operating Cost Projections

2.4 SUMMARY OF RESULTS

The results from the energy conservation and demand management strategies presented in Sections 2.1 to 2.3 are visualized on the following pages. The energy use intensity (EUI) of each ECM package is shown broken down by end-use for the development in Figure 7. As shown in Figure 7, compared to the SB-10 Package the Developer Package results in a 3% decrease in EUI. However, it is important to note even though EUI decreases, Natural Gas Heating increases because of increased TEDI. In contrast, the proposed package reduces EUI, while Natural Gas Heating simultaneously decreases. These decreases in the Proposed Package are largely a result of improved performance through energy recovery.

Given the disparity in emissions for electricity and natural gas, a similar breakdown for GHG emissions for each end use is shown in Figure 8 to illustrate emissions reductions. In this analysis, the projected 20-year average GHG emission intensities for each fuel source were used. As shown in Figure 8, the Developer Package results in an increase of GHG emissions by 2%, which is a result of increased Natural Gas Heating. In contrast, the Proposed Package results in a 20% decreased in GHG emissions.

Additional visualizations of the analysis results are shown in Figure 9 on the next page, broken down by space type. Table 3 summarizes other important analysis outputs.

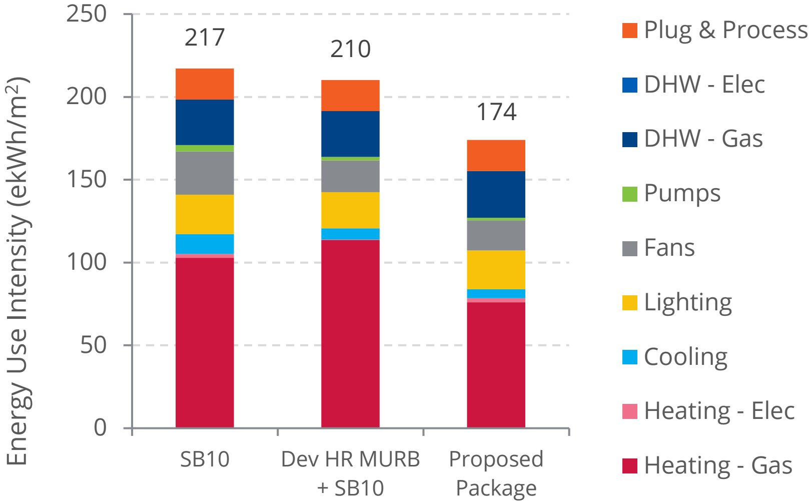


Figure 7: Energy End-Use Breakdown

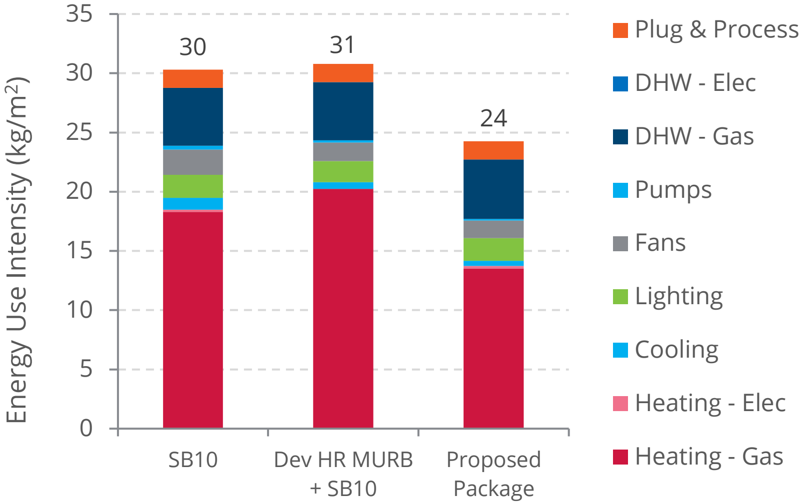
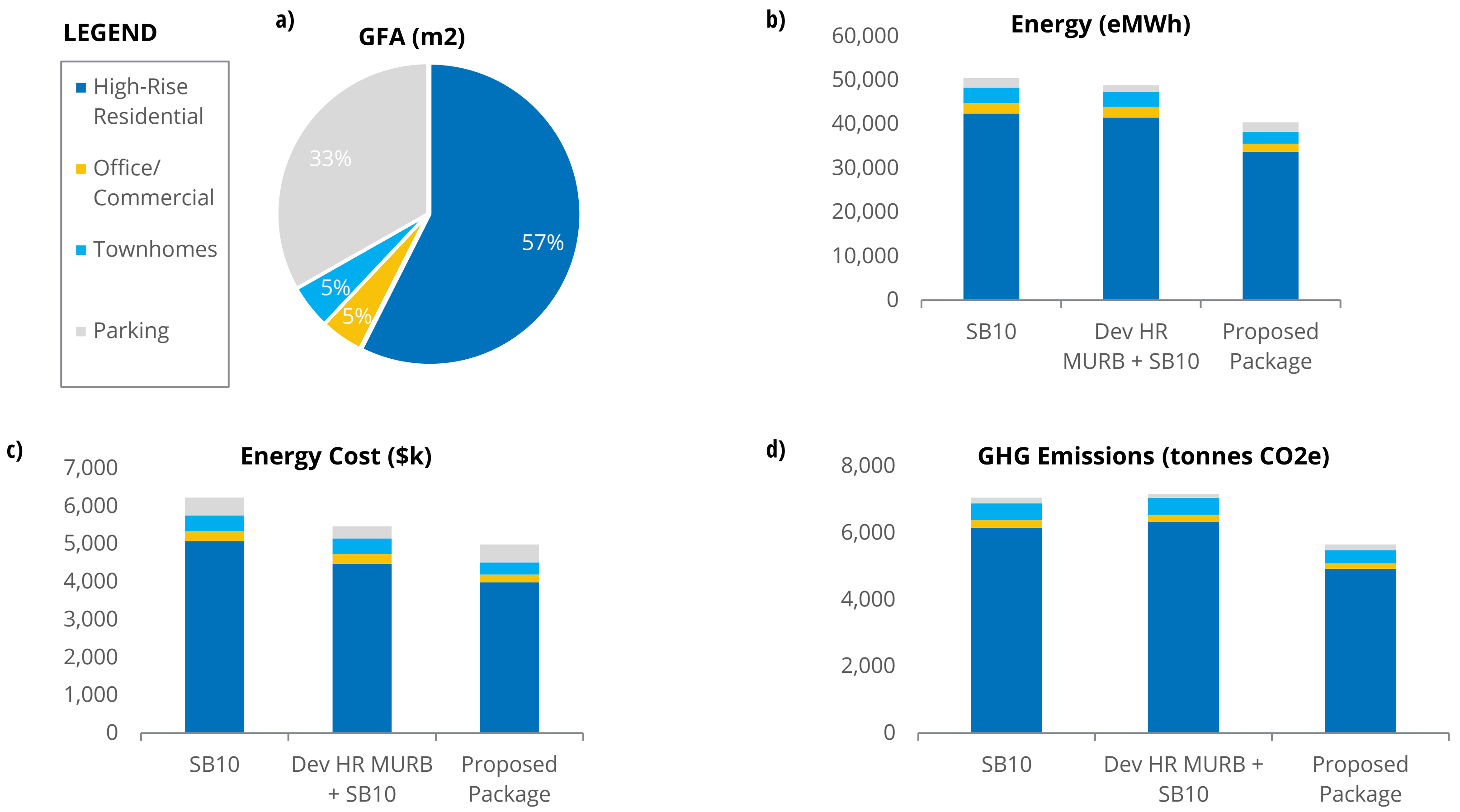


Figure 8: Emission Intensity End-Use Breakdown

2.4 SUMMARY OF RESULTS

Figure 9: a) Breakdown of Development Site Gross Floor Area by Archetype, b) Energy Results, c) Energy Cost Results, d) GHG Emissions Results



2.4 SUMMARY OF RESULTS

Table 3: Site-level Performance Results

Performance Metric	Unit	SB-10 Package	Developer Package	Proposed Package
Total Energy	ekWh	50,275,300	48,661,100	40,255,600
TEUI	ekWh/m^2/yr	217	210	174
Energy Savings	%	--	3%	20%
TEDI	kWh/m^2/yr	94	109	76
TEDI Savings	%	--	-16%	19%
Current-Year Electricity Emission Factor	kg CO$_2$e/kWh	0.0819		
Current-Year Natural Gas Emission Factor	kg CO$_2$e/kWh	0.178		
GHGI	kg CO$_2$e/m^2	30	31	24
GHGI Savings	%	--	-2%	20%
Energy Cost	$	6,211,000	5,460,000	4,977,000
Energy Cost Savings	%	--	12%	20%

3. LOW-CARBON SOLUTIONS

3.1 ON-SITE RENEWABLES

After reducing the total energy consumption of the development by 20% using the Proposed Package, as compared to the SB-10 Baseline, this energy strategy now considers the application of renewables to offset the remaining energy use.

Rooftop solar photovoltaic (PV) potential was explored using the National Renewable Energy Laboratory's (NREL) PVWatts Calculator (Reference Link 6). Given the early design stage of this project, which we assume allows for the prioritization of PV mounting on rooftops, the analysis assumed that 90% of high-rise residential and commercial building roofs are used for PV mounting, resulting in an array size of 9,300 m^2 (Figure 10). Using site-specific solar radiation information and the PVWatts calculator, it was estimated that 2,300 MWh of energy could be generated on-site annually. While this generation is significant, it would only offset 6% of the Proposed Package total energy use (40,256 MWh) and is therefore insufficient to reach a net-zero level of performance using on-site renewable generation.

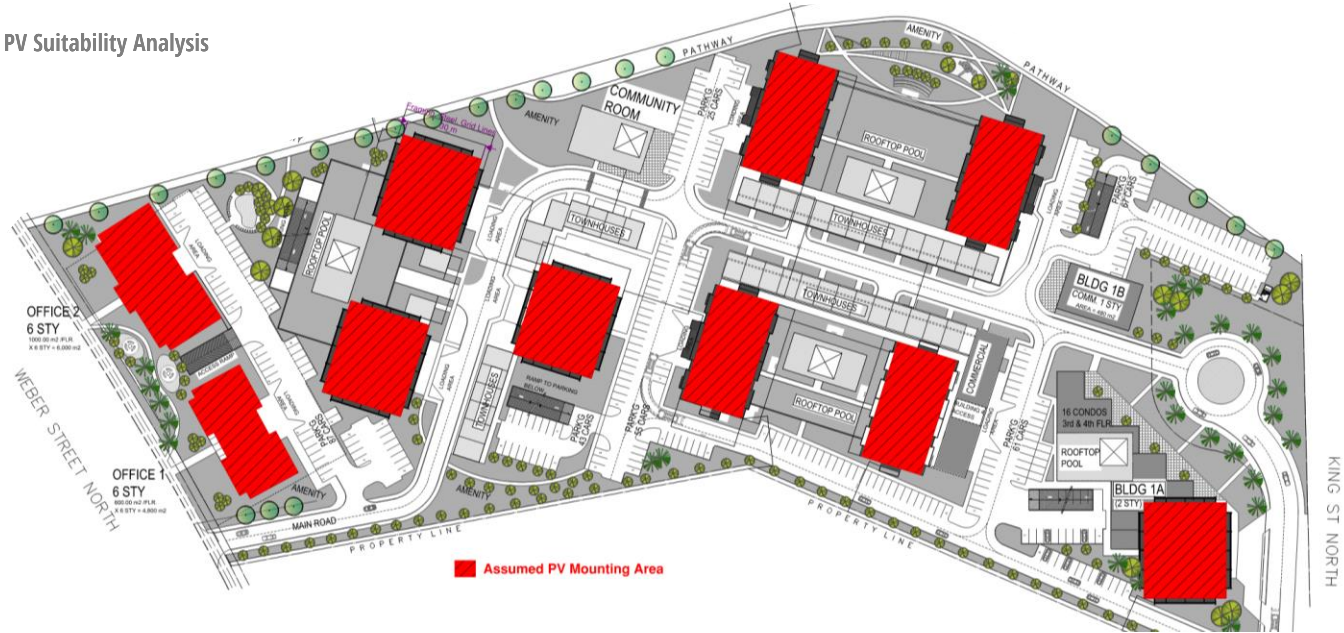


Figure 10: Solar radiation potential on the building

3.2 DISTRICT ENERGY & CHP

District energy systems (DES) use a centralized plant to generate and distribute energy for many buildings, in the form of thermal energy for heating and cooling, and/or electricity. By collaborating, a group of buildings can find an economy of scale that may provide the following benefits:

1. Increased efficiency at the plant level;
2. Reduced energy consumption by sharing waste thermal energy between buildings with different load profiles;
3. Potential reduction in capital costs;
4. Streamlined maintenance and future equipment upgrades with one central plant instead of several smaller plants; and
5. Flexibility to divide energy generation across a number of energy sources, and add future capacity as required.

While there is one DES proposed in the Kitchener Innovation District, the buildings at 475 & 485 King Street will likely be too far to practically connect, as shown in Figure 11 (Reference Link 7). However, planning for compatibility with a future DES can be maintained through the thoughtful selection of building systems. For example, low carbon intensity energy sources for a DES include a central geothermal field, a combined heat and power plant, deep lake water cooling, and bio-fueled boilers. As such, the selection of supply and return temperatures for heating/cooling equipment in the development should be carried out to maintain compatibility with each of these systems.

Importantly, district energy should not be confused with renewable energy or low-CO_2e energy sources. Unless the fuel choice at the district central plant has a lower carbon intensity than that which is proposed at the building level, there is no CO_2e benefit to considering a district energy approach. In fact, there may be a penalty as a result of distribution losses.

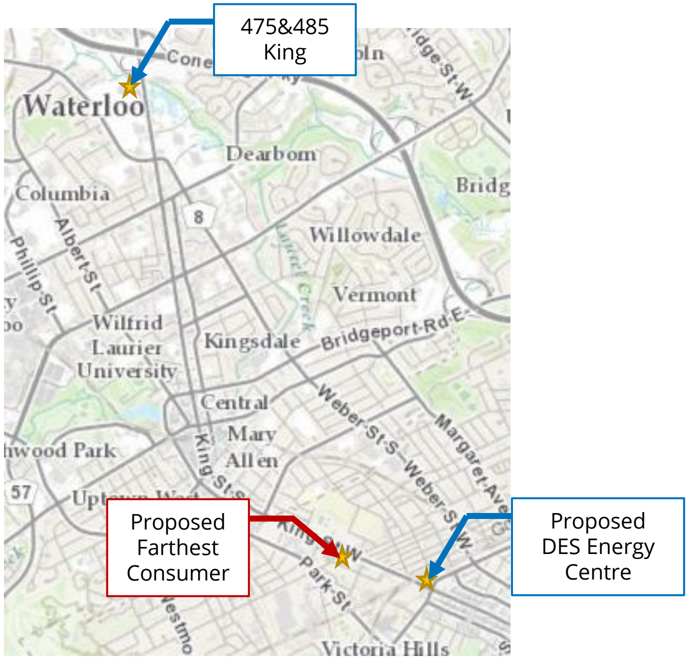


Figure 11: Nearby DES Infrastructure

3.3 EMBODIED CARBON

As stated earlier in Section 1.1, Canada's National Inventory Report on GHGs lists buildings as responsible for 24% of the GHG emissions in Ontario in 2019. It is particularly important to note, however, that this GHG inventory only considers the operational GHG emissions of the building, and does not account for the emissions associated with the construction of buildings – known as the "embodied carbon".

The UN Environment 2018 Global Status Report calculated that the production of building materials for building construction were responsible for 11% of building emissions in 2017, listed as 'Construction industry' in Figure 12 (Reference Link 8). Therefore, it is critical to take a look at both low-carbon design and low-carbon operation in any new development.

There are a multitude of design options available for the design team to reduce the overall embodied carbon of the development. Some strategies include:

1. Evaluating the structural design strategy of the buildings to optimize for minimal embodied carbon. Consider using recycled and/or locally-sourced materials if available.
2. Replacing portland cement with supplementary cementitious materials, such materials include fly ash or ground granulated blast furnace slag (GGbF).
3. Using materials with a high recycled content or materials that are easy to recycle when the building has reached end-of-life.
4. Using materials that have been sourced locally to decrease carbon emissions from transport.

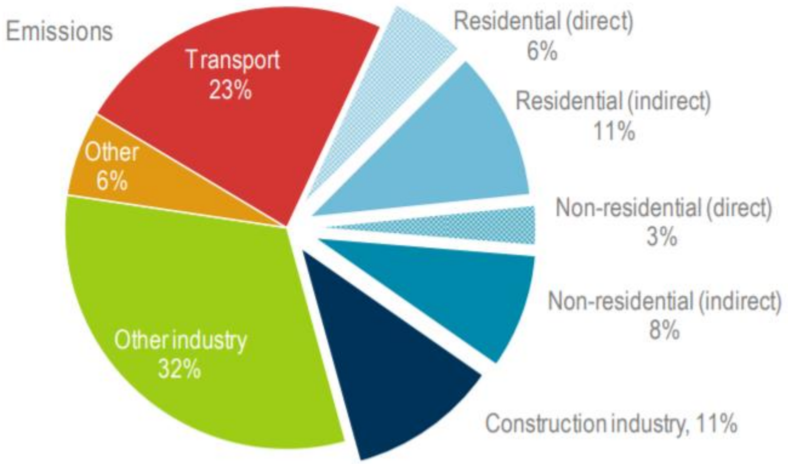


Figure 12: Breakdown of Global GHG Emissions from Buildings, 2017

3.4 LOW-CARBON TRANSPORTATION

Electric Vehicles (EVs) can offer significant reductions in CO_2e emissions as compared to conventional internal combustion vehicles, especially in Ontario given the low CO_2 intensity of Ontario's electricity. As shown in Figure 13 for multiple EV types, CO_2e emissions per kilometer can be reduced by approximately 95% for a vehicle of the same type (e.g., full-sized sedan), which exemplifies the importance of adopting EVs on a societal level.

Given recent and future increases in EV adoption, it is critical to consider infrastructure to support EVs at the building level. This infrastructure typically comes in the form of charging stations. While not a requirement in the City of Waterloo or OBC, in the mandatory tier of TGS V3 (Tier 1) at least 20% of parking spaces in residential buildings must have adjacent energized outlets that support level 2 EV charging (208-240 VAC with 40-amp breakers) and 100% of spaces must permit the future installation of energized outlets (e.g., installation of empty cable raceways). In the upcoming TGS v4, the mandatory inclusion of level 2 EV charging infrastructure will increase to 25% of parking spaces, which aligns with Tier 2 in the current TGS V3. Therefore, we recommend at least 20% - 25% of parking spaces come equipped with level 2 EV charging infrastructure, and that 100% of spaces come with adjacent raceways installed for future charging infrastructure expansion.

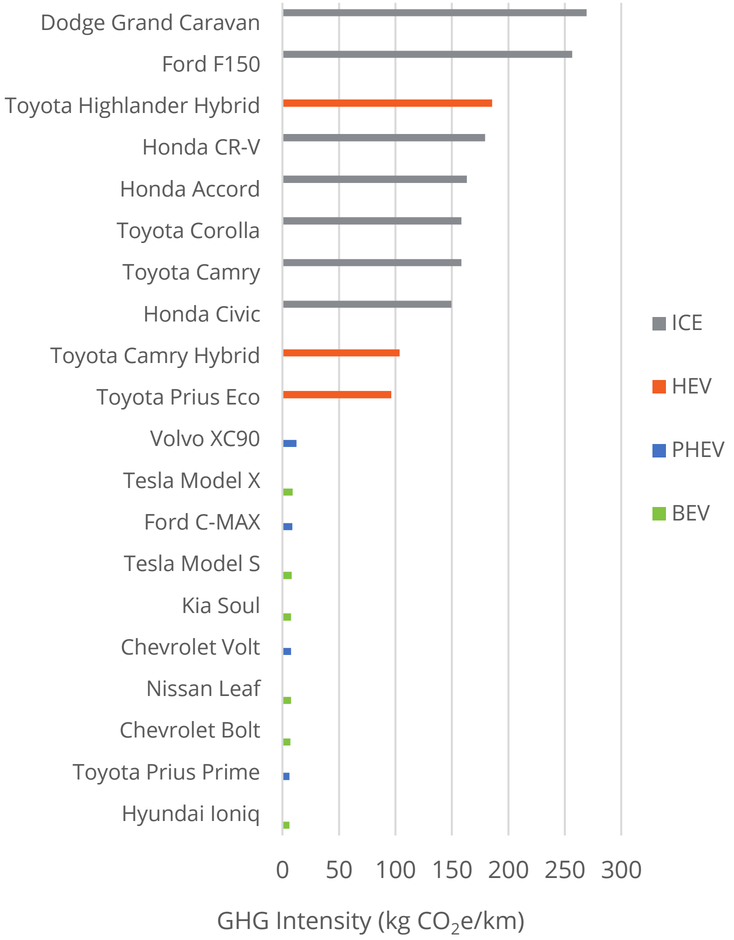


Figure 13: GHG Intensities of Internal Combustion Engine (ICE) Vehicles, Hybrid Electric Vehicles (HEV), Plug-in Hybrid Electric Vehicles (PHEV), and Battery Electric Vehicles (BEV) (Reference Link 9)

4.1 CLIMATE CHANGE

Historically, Southern Ontario has been considered to have a heating-dominated climate, with Toronto for example, categorized in ASHRAE Climate Zone 6. In the last 20 years, however, Ontario's climate has changed – the number of annual heating degree days (HDDs) has reduced. With this weather, Toronto has been recategorized into ASHRAE Climate Zone 5.

Further, the City of Toronto's *Future Weather and Climate Driver Study* predicts that climate change will continue to present a new set of challenges to building developments in Ontario (Reference Link 10). Some of the climatic changes include:

- Increased temperatures throughout the year. This means both an increased number of Cooling Degree Days above 18°C, and an increased frequency and duration of heat waves;
- Increased temperatures throughout the year will also result in a decreased number of Heating Degree Days below 18°C;
- Increased intensity of major rain events; and
- Increased frequency of freeze-thaw events.

As the annual HDDs are forecasted to decrease, Waterloo could shift into ASHRAE Climate Zone 5 between 2040 and 2049. For example, the historical and forecasted heating degree days for Toronto Pearson International Airport are is shown in Figure 14, showing the shift from Climate Zone 6 to Climate Zone 4.

A study by RWDI demonstrated that as the climate changes, controlling summer overheating will become increasingly important for occupant comfort in buildings (Reference Link 11). Designing modular mechanical systems to allow for future increased cooling capacity can help alleviate the increased risk of overheating and occupant discomfort.

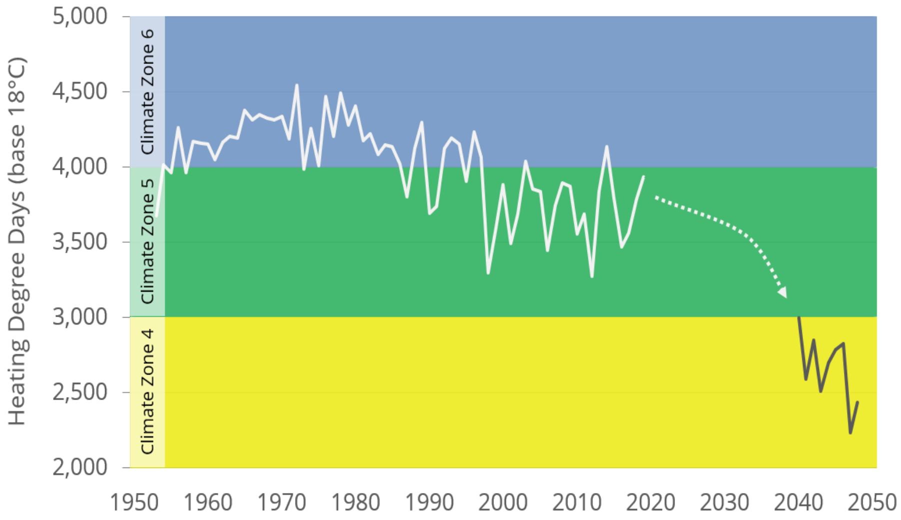


Figure 14: Historical and Forecasted Heating Degree Days at Toronto Pearson International Airport

4.2 DESIGN CONSIDERATIONS

According to the Resilient Design Institute, "resilient design" is the intentional design of buildings, landscapes, communities, and regions in order to respond to natural and man-made disasters and disturbances, as well as long-term changes resulting from climate change, including sea level rise, increased frequency of heat waves, and regional drought (Reference Linke 12).

To better the prepare for the forecasted changes to Ontario's climate, this project's team will be encouraged to consider:

- Back-up power systems, which are suggested to provide at least 72 hours of support for: domestic water (hot & cold), elevator service, space heating, lighting and receptacle power.
- Design solutions that allow the buildings systems to be adapted to future climatic conditions. Examples could include: the ability to add shading devices at a future date, or additional system cooling capacity.
- Enclosure strategies like low window to wall ratios, increased thermal resistance, airtightness, and operable windows to improve the thermal comfort and passive survivability of the building.
- Building materials selected for durability during flooding events, and buildings designed to operate despite water incursion from major rain events, forecasted to become more frequent (shown in Figure 15).

Working resiliency in the design and equipment selection inevitably has an impact on the cost of the building. As a result, it is important to consider the business case for resiliency and how to recoup the investment. This could encompass:

- Higher perceived value because of the resilient features and the ability to market these;
- Lower operating costs from thermal envelope improvements;
- Reduced insurance premiums; and
- Increased safety.

Figure 15: Flooding of Downtown Toronto Streets in 2013 (Courtesy of user:Eastmain / Public Domain)

CONCLUSIONS AND RECOMMENDATIONS

1. To meet the energy performance targets of the development, 15% reduction relative to an SB-10 Baseline, the building design would need to include a combination of best practice measures, envelope upgrades and mechanical system upgrades. Additional modelling will be required as the design progresses to ensure continued alignment with these targets.

2. A detailed financial analysis is required to determine the most economically practical method to achieving the development performance target. While our proposed package demonstrate the project's potential to meet the target, and offer notable annual energy and carbon cost reductions, careful balancing against initial cost is required to overcome the cost disparity between natural gas and electricity.

3. Energy conservation measures related to occupant behaviour can have significant impact on the building energy use, but are challenging to predict in an energy model. These measures, including suite-level thermal sub-metering and kill switches near exits, can have greater marketability because of their visibility and direct link to the residents' utility bills. These visible measures give occupants better control of their utility bills and over the use of their space.

6. REFERENCE LINKS

1. Energy Strategy Terms of Reference: https://www.toronto.ca/wp-content/uploads/2018/01/9446-CEP-Energy-Strategy-Terms-of-Reference-Jan-2018.pdf
2. National Inventory Report 1990 – 2019: Greenhouse Gas Sources and Sinks in Canada: https://publications.gc.ca/collections/collection_2021/eccc/En81-4-2019-3-eng.pdf
3. City of Toronto Zero Emissions Buildings Framework: https://www.toronto.ca/wp-content/uploads/2017/11/9875-Zero-Emissions-Buildings-Framework-Report.pdf
4. Ontario Emission Factor Projections: https://taf.ca/wp-content/uploads/2021/11/20211116_TAF_Emissions-Factors-Guidelines.pdf
5. Federal Carbon Pricing Framework: https://www.canada.ca/en/environment-climate-change/news/2020/12/a-healthy-environment-and-a-healthy-economy.html
6. National Renewable Energy Lab (NREL) PVWatts Calculator: http://pvwatts.nrel.gov/
7. Kitchener/Waterloo District Energy Systems: https://lf.kitchener.ca/WebLinkExt/DocView.aspx?dbid=0&id=1867492&page=1&cr=1
8. UN Environment 2018 Global Status Report: https://wedocs.unep.org/bitstream/handle/20.500.11822/27140/Global_Status_2018.pdf?sequence=1&isAllowed=y
9. GHG Intensity of Different Vehicles: https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2018/market-snapshot-how-much-co2-do-electric-vehicles-hybrids-gasoline-vehicles-emit.html
10. Toronto's Future Weather and Climate Driver Study: https://www.toronto.ca/legdocs/mmis/2012/pe/bgrd/backgroundfile-51653.pdf
11. RWDI White Paper "Modelling Weather Futures": https://rwdi.com/assets/factsheets/Modelling-weather-futures.pdf
12. Resilient Design Institute: http://www.resilientdesign.org/

APPENDIX A

SUMMARY OF ENERGY MODEL INPUTS

APPENDIX A

Summary of Primary Energy Model Inputs

High Rise Residential	**Modelled Area | Description**	214,176 m^2 Residential High-Rise | 113,387 m^2 Parking
	Location | Climate	Elora, Ontario | Elora CWEC
	Primary Space Types	Residential, Amenities
	Occupancy Schedule	Residential: NECB Schedule G | Non-Residential: NECB Schedule C
	Set Points	Heating Set Point: 22°C, Set Back 18°C | Cooling Set Point 24°C, Residential: No Setback; Non-Residential: Set Back to Off
Commercial/ Offices	**Modelled Area | Description**	2,340 m^2 | 2 Storeys
	Location | Climate	Elora, Ontario | Elora CWEC
	Primary Space Types	Office
	Occupancy Schedule	NECB Schedule A
	Set Points	Heating Set Point: 22°C, Set Back 18°C | Cooling Set Point 24°C, Set Back to Off
Townhomes	**Modelled Area | Description**	2,421 m^2
	Location | Climate	Elora, Ontario | Elora CWEC
	Primary Space Types	Residential
	Occupancy Schedule	NECB Schedule G
	Set Points	Heating Set Point: 21°C, Set Back 18°C | Cooling Set Point 25°C

APPENDIX A

Summary of Primary Energy Model Inputs – Developer Package

	High Rise Residential	Townhomes	Commercial/Offices
Envelope			
Typical Exterior Wall Performance	RSI-1.76 (R-10.0)	Follows SB-10	
Typical Roof Performance	RSI-6.2 (R-35.0)		
Gross Window to Wall Ratio	50%		
Glazing Performance	USI-2.27 (U-0.41) | SHGC 0.40		
Infiltration Rate	0.25 L/s-m^2 of façade @ 5 Pa		
System Level – Residential			
Primary HVAC Type	DOAS 4-Pipe Fan Coil with Hydronic Corridor Make-up Air Unit	Follows SB-10	
Airside Energy Recovery	N/A		
Heating	Hydronic Coils		
Cooling	Hydronic Coils		
Outdoor Air Rates (per Unit)	Units: 26.3 L/s (56 CFM) per ASHRAE 62.1 Corridors: Pressurized, 14.2 L/s (30 CFM)		
Fan Power (W/CFM)	HRV: 1 | FC: 0.5 (2-speed)		
System Level – Non-Residential			
Primary HVAC Type	DOAS 4-Pipe Fan Coil	Follows SB-10	
Airside Energy Recovery	N/A		
Heating	Hydronic Coils		
Cooling	Hydronic Coils		
Outdoor Air Rates	Meet but not exceed ASHRAE 62.1-2013		
Fan Power (W/CFM)	ERV: 1 | FC: 0.5 (2-speed)		
Plant Level			
Space Heating Efficiency	Condensing boiler: 95% seasonal	Follows SB-10	
Space Cooling Performance	VFD Centrifugal Chiller: COP 6.5 Cooling tower with VSD speed fan		
DHW Efficiency	Condensing boiler: 95% seasonal		
Space Level			
Equipment Load	4.3 W/m^2 (weighted average)	Follows SB-10	
Lighting Power Density (W/m^2)	Res: 5.0 | Non-Residential: 7.2		
DHW Fixture Flow Rates (W/occ)	Res: 321 W/occ | Non-Residential: 40 W/occ		

APPENDIX A

Summary of Primary Energy Model Inputs – Proposed Package

	High Rise Residential	Townhomes	Commercial/Offices
Envelope			
Typical Exterior Wall Performance	RSI-1.76 (R-10.0)	RSI-3.52 (R-20.0)	RSI-1.6 (R-9.0)
Typical Roof Performance	RSI-7.0 (R-40.0)	RSI-7.0 (R-40.0)	RSI-3.5 (R-20.0)
Gross Window to Wall Ratio	50%	20%	41%
Glazing Performance	USI-2.0 (U-0.35) | SHGC 0.40	USI-2.0 (U-0.35) | SHGC 0.40	USI-1.80 (U-0.32) | SHGC 0.40
Infiltration Rate	0.25 L/s-m^2 of façade @ 5 Pa	0.25 L/s-m^2 of façade @ 5 Pa	0.185 L/s-m2 of façade
System Level – Residential			
Primary HVAC Type	DOAS 4-Pipe Fan Coil with Hydronic Corridor Make-up Air Unit	DOAS 4-Pipe Fan Coil with Hydronic Corridor Make-up Air Unit	N/A
Airside Energy Recovery	In-suite HRVs, 65% sensible Electric OA Preheat	In-suite HRVs, 65% sensible Electric OA Preheat to -5C	N/A
Heating	Hydronic Coils	Hydronic Coils	N/A
Cooling	Hydronic Coils	Hydronic Coils	N/A
Outdoor Air Rates (per Unit)	Units: 26.3 L/s (56 CFM) per ASHRAE 62.1 Corridors: Pressurized, 14.2 L/s (30 CFM)	Townhouses: 55 L/s (117 CFM) per ASHRAE 62.1 Corridors: Pressurized, 14.2 L/s (30 CFM)	N/A
Fan Power (W/CFM)	HRV: 1 | FC: 0.5 (2-speed)	HRV: 1 | FC: 0.5 (2-speed)	N/A
System Level – Non-Residential			
Primary HVAC Type	DOAS 4-Pipe Fan Coil	N/A	DOAS 4-Pipe Fan Coil Unit
Airside Energy Recovery	65% sensible, 50% latent Electric Preheat	N/A	65% sensible, 55% latent | Electric Preheat
Heating	Hydronic Coils	N/A	Hydronic Coils
Cooling	Hydronic Coils	N/A	Hydronic Coils
Outdoor Air Rates	Meet but not exceed ASHRAE 62.1-2013	N/A	Per ASHRAE 62.1-2013 | Effectiveness: 0.8
Fan Power (W/CFM)	ERV: 1 | FC: 0.5 (2-speed)	N/A	ERV SF: 1.0 | FCU: 0.5 (multi-speed)
Plant Level			
Space Heating Efficiency	Condensing boiler: 95% seasonal	Condensing boiler: 95% seasonal	Condensing boiler, 92% efficiency
Space Cooling Performance	VFD Centrifugal Chiller: COP 6.5 Cooling tower with VSD speed fan	VFD Centrifugal Chiller: COP 6.5 Cooling tower with VSD speed fan	VFD Centrifugal Chiller: COP 6.2 Cooling tower with VSD speed fan
DHW Efficiency	Condensing boiler: 95% seasonal	Condensing boiler: 95% seasonal	Heat Pump – Seasonal COP 2.8
Space Level			
Equipment Load	4.3 W/m^2 (weighted average)	Res: 5.0 W/m^2 | Non-Residential: 0 W/m^2	4.4 W/m2 (weighted average)
Lighting Power Density (W/m^2)	Res: 5.0 | Non-Residential: 7.2	Res: 5.0 W/m^2 | Non-Residential: 6.2 W/m^2	4.8 W/m2 (weighted average)
DHW Fixture Flow Rates	Res: 321 | Non-Residential: 40	350 L/day per townhouse	Office: 68 W/occ