



## 36 Westhill Drive

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### Energy Study Report

36 Westhill Drive, Waterloo, ON

Prepared for: Blackdoor Inc.

Project No.: PR-25-RE-017

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Pratus Group

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Document Revision History

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| v.1 | October 8, 2025 | Energy Study Report | Yasaman Bateni | Chris Mohabir | Oleksandra Onisko |

Limitations

This report has been prepared by Pratus Group to inform and investigate energy conservation opportunities for the proposed 36 Westhill Drive development in context of an Energy Study Report under the terms of our agreement with Blackdoor Inc. The results present performance metrics (TEUI, TEDI, and GHGI) for the proposed project design in comparison to the performance levels defined in the City of Waterloo Terms of Reference for Energy Study, expressed relative to the Ontario Building Code (OBC SB-10) baseline. The calculations are applicable only for determining compliance with the City of Waterloo Energy Study requirements and for option comparison. They are not predictions of actual energy use or costs of the proposed design after construction. The opinions of cost presented within this Energy Study report should not be relied on for budgeting purposes and are provided only for the purpose of comparison. Actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, energy use not covered by the standard, changes in energy rates between design of the building and occupancy, and precision of the calculation tool.

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Table of Contents

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|                                                               |           |
|---------------------------------------------------------------|-----------|
| <b>1. Executive Summary .....</b>                             | <b>1</b>  |
| <b>2. Introduction .....</b>                                  | <b>2</b>  |
| <b>3. Overview of Proposed Development .....</b>              | <b>3</b>  |
| 3.1. Proposed Development .....                               | 3         |
| 3.2. Neighbourhood .....                                      | 3         |
| 3.3. Energy Environment .....                                 | 5         |
| 3.4. Carbon Environment .....                                 | 5         |
| 3.4.1. Reducing Carbon Emissions .....                        | 5         |
| 3.5. Embodied Carbon .....                                    | 7         |
| <b>4. Envelope Analysis .....</b>                             | <b>9</b>  |
| <b>5. Energy and Emissions Analysis .....</b>                 | <b>12</b> |
| 5.1. Building Code Baseline .....                             | 13        |
| 5.2. High Performance Design .....                            | 13        |
| 5.3. Net-Zero Carbon and Net-Zero Energy Design .....         | 14        |
| 5.3.1. Passive Design Measures towards Net-Zero .....         | 15        |
| 5.3.2. Active Design Measures towards Net-Zero .....          | 16        |
| 5.4. Net-Zero Ready Performance .....                         | 17        |
| 5.5. Costing .....                                            | 18        |
| <b>6. Renewables and Low-Carbon Options .....</b>             | <b>22</b> |
| 6.1. On-Site Solutions .....                                  | 22        |
| 6.1.1. Solar PV .....                                         | 22        |
| 6.1.2. Ground Source Heat Exchanger .....                     | 22        |
| 6.1.3. Off-Site Solutions .....                               | 23        |
| <b>7. Electrical Distribution System Considerations .....</b> | <b>24</b> |
| <b>8. District Energy .....</b>                               | <b>25</b> |
| 8.1. District Energy System Opportunity .....                 | 25        |
| 8.1.1. Energy Impact .....                                    | 26        |
| 8.1.2. Design Impact .....                                    | 26        |
| <b>9. Embodied Carbon .....</b>                               | <b>27</b> |



**10. Resiliency..... 30**

10.1. Back-up Power Systems / Resilience .....30

10.2. Critical Equipment Location .....31

10.3. Future Proof HVAC Systems .....31

**11. Funding Sources..... 33**

11.1. Enbridge Savings by Design.....33

11.2. CHMC – Rental Construction Financing Initiative .....33

11.3. CMHC – Multi-unit Loan Insurance MLI Select Program .....34

**12. Discussion and Recommendations..... 35**

12.1. Financial Analysis .....35

12.2. Closing.....37

List of Appendices

Appendix A - Proposed Design Model Characteristics

## 1. Executive Summary

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This Energy Study Report summarizes analysis and results of energy conservation measures considered for the proposed 36 Westhill Drive development which is a residential development located in the City of Waterloo. The proposed project includes residential suites and amenity spaces with a total gross floor area of 12,729 m<sup>2</sup>. The development consists of 2 buildings of 6 and 8 storeys, with lower-level amenities and surface parking spaces. There are a total of 140 new residential units proposed for the development.

Pratus Group has been retained by Blackdoor Inc. to identify opportunities for integrating local energy solutions that are efficient, low carbon and resilient into the proposed project's design. The energy conservation strategies analyzed have been completed in accordance with the City of Waterloo's Energy Study Terms of Reference. The exercise completed as a part of this report is the first step and will serve to inform subsequent design decisions that will be reflected in the City of Waterloo Design Development Energy requirements.

## 2. Introduction

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The purpose of this Energy Study Report is to evaluate strategic energy options for the proposed 36 Westhill Drive development in alignment with the City of Waterloo's Energy Study Terms of Reference (TOR). An Energy Study explores how different approaches to energy efficiency can impact new development, with the goal of reducing energy consumption and greenhouse gas emissions while minimizing project disruption and cost. This report serves as an early-stage analysis intended to identify opportunities for improved building performance, inform subsequent design decisions, and support the City's climate action commitments under TransformWR.

This Energy Study Report fulfills the City of Waterloo's requirements that apply to the following Planning Act applications:

- Zoning By-law Amendments proposing at least one building of 7 storeys or more in height;
- Draft Plans of Subdivision proposing predominantly low-rise residential development; and
- Other planning applications, as determined by the City.

Exclusions include:

- Zoning By-law Amendments that are deemed to be minor by the City.
- Zoning By-law Amendments that are limited to removing a Holding Symbol
- Other exclusions at the discretion of the City.

As per the City of Waterloo's Energy Study Terms of Reference, the intent of this study is to contribute to achieving the City's objectives of reducing energy consumption and GHG emissions while promoting environmental, economic, and social sustainability. The City of Waterloo has committed to reducing community-based GHG emissions by 50% by 2030 and 80% by 2050 relative to 2010 levels.

Undertaking an Energy Study at the early stages facilitates the following evaluations:

- Identification of opportunities to increase energy efficiency and reduce greenhouse gas emissions in new development at the conceptual design stage.
- Consideration of opportunities to site buildings and configure blocks to take advantage of existing or proposed energy infrastructure, energy capture, and/or solar orientation.
- Consideration of opportunities to optimize the installation of future building energy systems that will allow the development to cost-effectively achieve net-zero energy performance.
- Consideration of opportunities to increase resiliency.
- Consideration of embodied carbon and material selection.
- Exploration of potential operational cost savings and capital cost incentives.

## 3. Overview of Proposed Development

### 3.1. Proposed Development

Blackdoor Inc. is proposing to redevelop the lands of 36 Westhill Drive, situated east of Ira Needles Boulevard and north of Erb Street in Waterloo. The gross floor area is approximately 12,729 m<sup>2</sup> with 140 residential units.

The proposed development will be comprised multi-unit residences, amenities and surface parking spaces. 175 vehicle parking spaces will be provided.

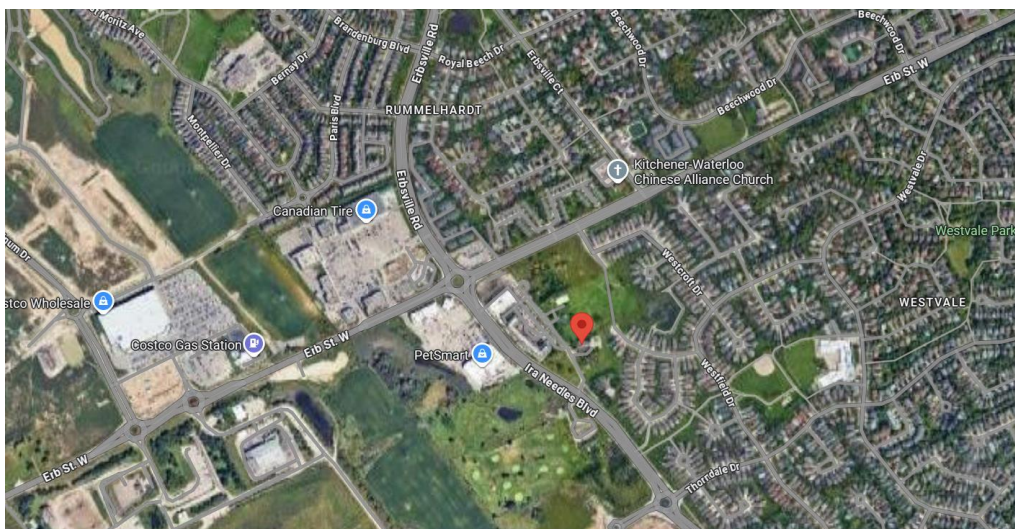


Figure 3-1 – Bird's Eye View of 36 Westhill Drive in Waterloo, Ontario. (Pin on Proposed Site Location)

### 3.2. Neighbourhood

The site is located within the Westvale neighbourhood in Waterloo, Ontario. The site is bound by a residential neighbourhood to the north and south, and Westvale Park to the east of the site.



**Figure 3-2 – Map of the Neighbourhood**

The site is located near the intersection of Erb Street West and Ira Needles Boulevard and is approximately 5.3 km from the University of Waterloo ION station.

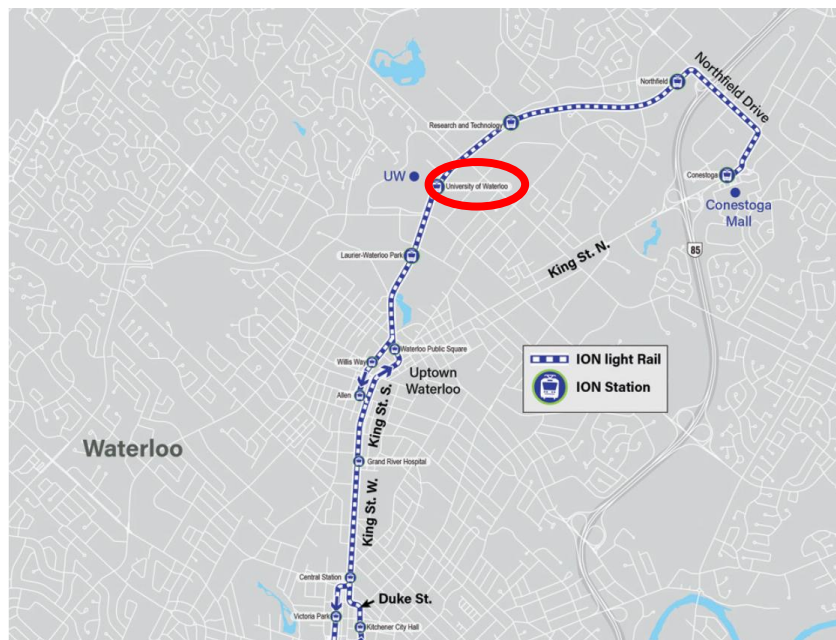
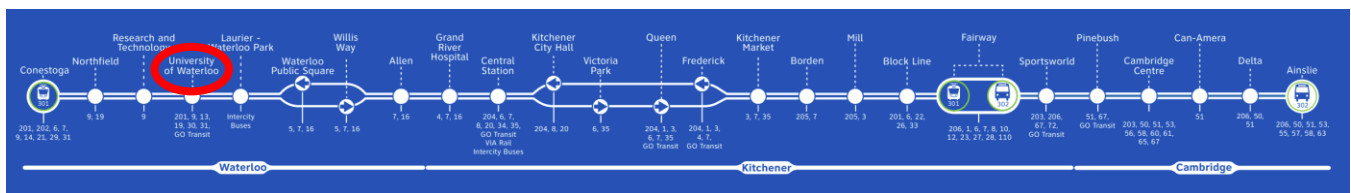


**Figure 3-3 – ION Station and Bus Connections Map with Closest Station Highlighted**

### 3.3. Energy Environment

The site is serviced by Enova Power for electricity, Enbridge for natural gas, and by the City of Waterloo for domestic potable water. The Time-of-Use rates are summarized in Figure 3-4. For the purposes of this report a blended electricity rate of 14.5 cents/kWh is used.

| TOU Price Periods | Summer (May 1 – October 31)                         | Winter (November 1 – April 30)                      | TOU Prices (effective until October 31, 2025) (¢/kWh) |
|-------------------|-----------------------------------------------------|-----------------------------------------------------|-------------------------------------------------------|
| Off-Peak          | Weekdays 7pm – 7am<br>Weekends and holidays all day | Weekdays 7pm – 7am<br>Weekends and holidays all day | 7.6                                                   |
| Mid-Peak          | Weekdays 7am – 11am and 5pm – 7pm                   | Weekdays 11am – 5pm                                 | 12.2                                                  |
| On-Peak           | Weekdays 11am – 5pm                                 | Weekdays 7am – 11am and 5pm – 7pm                   | 15.8                                                  |

**Figure 3-4 – Enova Power Waterloo Time-of-Use Rates (Enova Power, 2025)**

The natural gas rates are summarized in Table 3-1 below:

**Table 3-1: Enbridge Gas Rates (July, 2025) (Enbridge, 2025a)**

| Enbridge Gas Rates      |                      |
|-------------------------|----------------------|
| Total                   | cents/m <sup>3</sup> |
| First 30 m <sup>3</sup> | 54.3938              |
| Next 55 m <sup>3</sup>  | 53.6417              |
| Next 85 m <sup>3</sup>  | 53.0528              |
| Next 170 m <sup>3</sup> | 52.6138              |

### 3.4. Carbon Environment

#### 3.4.1. Reducing Carbon Emissions

Reducing carbon emissions is a priority for the City of Waterloo and the mandate for Energy Study Reporting is a part of the process in meeting this objective. Reducing carbon emissions at the municipal level aligns with the broader provincial and federal carbon reduction targets and commitments. Canada has committed to reducing Greenhouse Gas (GHG) emissions to 30% below 2005 levels by 2030 to limit global climate warming below the 1.5°C degree threshold established by the Paris Agreement in 2015.

### Pathway to 2030

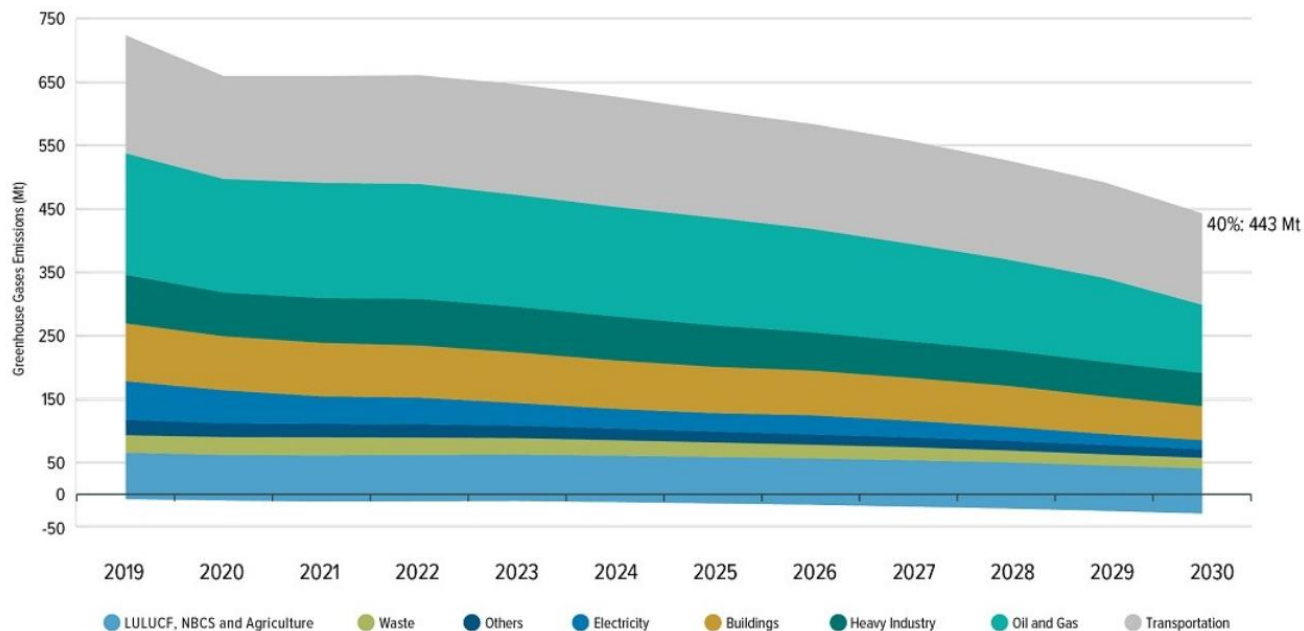


**Figure 3-5 –Canada's GHG Reduction Commitment (ECCC, 2022)**

Carbon reduction is very closely tied to energy use reduction; higher annual energy use results in a higher annual carbon emission factor associated with the project. Energy source mix, not just overall energy use, contributes to the carbon emission profile of the project. Electricity, natural gas, oil, etc. have different emissions factors associated with them.

In November 2018, the province of Ontario released their new climate plan with a framework to meet the Paris Agreement commitments. The new plan involves regulation of large emitters, incentives for green innovation and investment.

The Federal Government of Canada's goals exceed those of the Paris Agreement and target a net 80% reduction in emissions by 2050 from 2005 levels. The planned actions to reach these goals have been outlined in the Canada's Pan-Canadian Framework on Clean Growth and Climate Change released in 2016.

#### 3.4.1.1. Municipal Targets

Waterloo has an ambitious climate action strategy, which sets out long-term goals and initiatives to reduce greenhouse gas emissions and adapt to climate change. The Corporate Climate Action Plan and Energy Conservation Demand Management Plan outline steps the City is taking to reduce emissions from municipal buildings, vehicles, and equipment, while the Corporate Climate Change Adaptation Plan addresses how the City will protect its assets, operations, and services from climate impacts. At the community level, the TransformWR strategy aims to reduce greenhouse gas emissions from homes, businesses, transportation, and waste, supporting a healthier, more sustainable, and resilient community.

The City of Waterloo has an ambitious climate action strategy, TransformWR, which lays out a set of intermediate as well as long term low carbon goals and strategies. Waterloo's greenhouse gas (GHG) emissions reduction targets, based on 2010 levels are as follows:

- 30% by 2030
- 80% by 2050

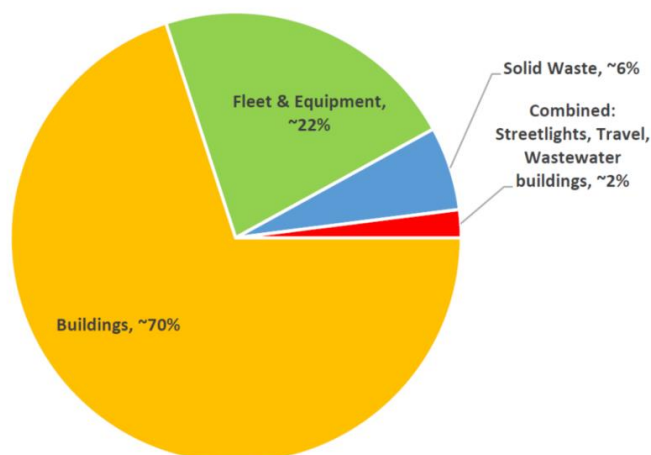


**Figure 3-6 – Profile of City of Waterloo Corporate Greenhouse Gas Emissions by Source (City of Waterloo, 2019)**

The City of Waterloo has developed an Energy Study framework that establishes performance requirements for new developments as part of the planning approval process. The framework sets out two levels of performance relative to the Ontario Building Code (OBC SB-10) Baseline, High Performance (30% reduction in TEUI and TEDI, 50% reduction in GHGI), and Net-Zero Ready (60% reduction in TEUI and TEDI, 90% reduction in GHGI). These performance levels guide new development toward significant reductions in energy use and greenhouse gas emissions, supporting the City's climate action goals.

### 3.5. Embodied Carbon

Embodied carbon refers to the greenhouse gas emissions associated with the entire life cycle of a building. As such, a building's embodied carbon includes the extraction of raw materials, the processing and manufacturing of the raw materials into construction/building products, the transportation of construction products to site, the construction process itself, any replacements or refurbishments incurred within the building's proposed lifetime, and the deconstruction and disposal of products at the end of the building's life. In Canada, building materials and construction practices represent 11% of carbon emissions, this is in addition to the 17%, associated with building operations. Designing to support a life-cycle approach that includes carbon accounting helps to promote resource efficiency and further reduce the environmental impacts of buildings.

A Life Cycle Analysis (LCA) is a tool used in quantifying the carbon impact associated with the construction process used in projects. Once the decision makers have this information, choices about the

embodied carbon associated with the extraction, processing, transport, and disposal of building materials can be made.

Per the Energy Study Terms of Reference, the City of Waterloo requires projects to identify the expected highest embodied carbon materials in the proposed design and identify at least one potential method of reduction. High-level discussion of the GHG impacts of expected building materials and identification of low-carbon sustainable material alternatives are presented in the Embodied Carbon section of this report.

## 4. Envelope Analysis

As per the City of Waterloo Energy Study Terms of Reference, projects must consider the impact of thermal bridging when evaluating building envelope performance under the High Performance and Net-Zero Ready scenarios.

Thermal bridging is a key player in the overall performance of the building envelope that is often overlooked. Thermal bridges occur in an assembly when there is a highly conductive material that bypasses the insulation layers. This creates a pathway that allows significant amounts of undesirable heat transfer to occur, and it can greatly affect the overall thermal performance of an assembly.

A poor building envelope will increase the demand on the mechanical system which will drive up annual energy consumption. Careful selection of architectural details can substantially improve thermal performance as we will see in the example below.

The following is an example showing the thermal characteristics of a standard curtain wall assembly with increasing back pan insulation.

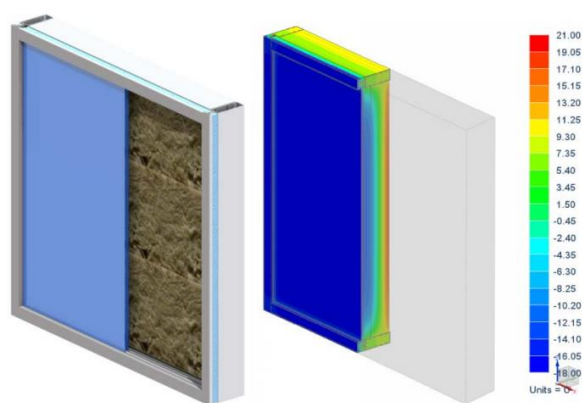


Figure 4-1 –Example Detail of Standard Curtain Wall

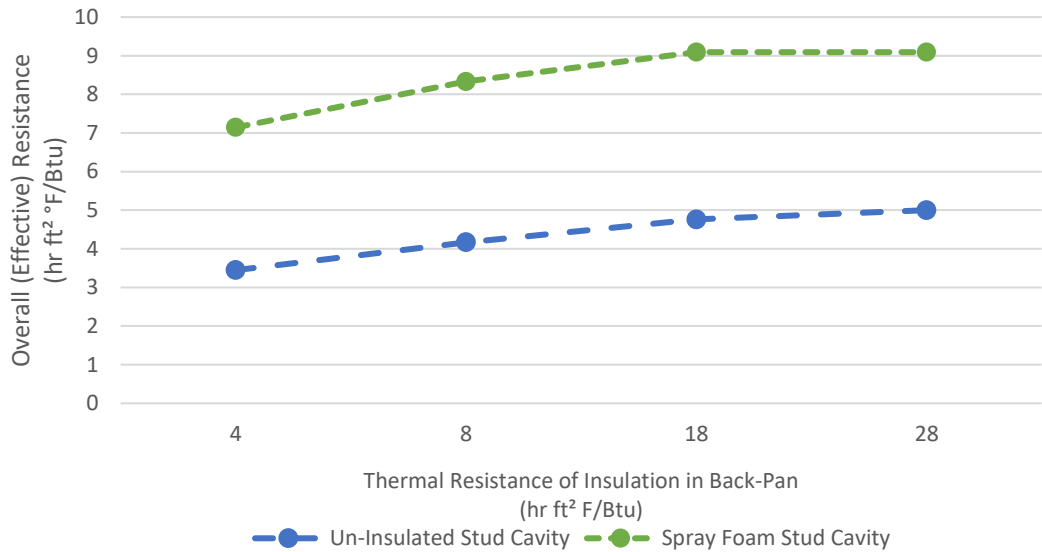


**Figure 4-2 – Diminishing Rate of Return of Spandrel Section Overall Thermal Reaction**

As seen in Figure 4-2, the minimal performance gain with increasing insulation shows that the heat is flowing around the insulation through the frame. Therefore, adding additional insulation in the back pan to non-thermally broken assemblies only has slight improvements on the overall assembly performance.

Pratus Group conducted a façade thermal bridging analysis for 36 Westhill Drive development in Waterloo. Figure 4-3 shows a high-level impact of each detail on the overall envelope's performance. The overall envelope performance decreases as each of the thermal bridging effects are accounted for.

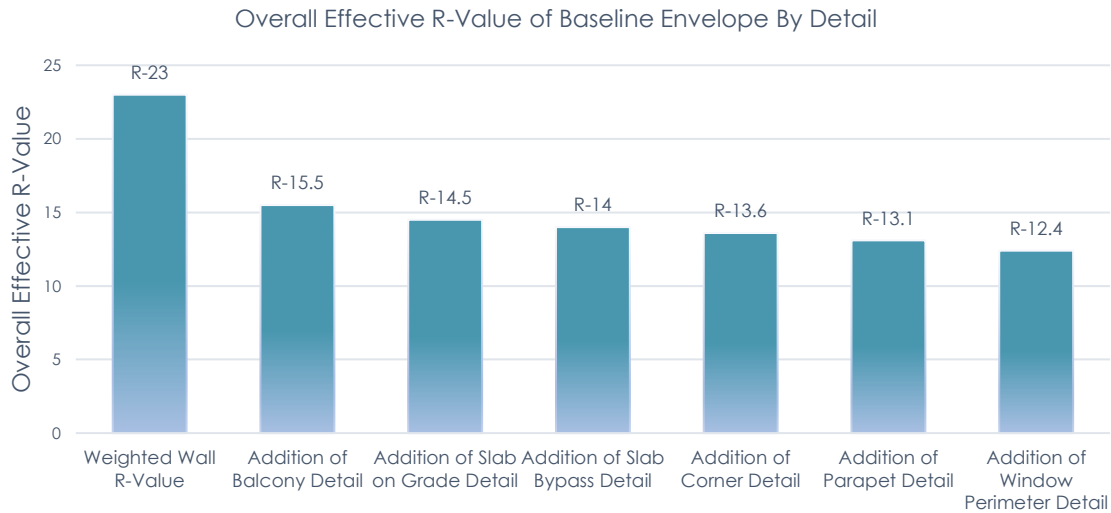


**Figure 4-3 –Effect of Individual Details on the Overall Envelope Thermal Performance for Building Code Baseline**

As 36 Westhill Drive development is a mid- rise MURB, the details that occur in the highest frequency are the slab balcony, slab on grade, slab bypass and window wall interface assemblies. These details are found to have the highest impact on the overall thermal performance of the envelope.

Accounting for the effects from each detail reduces the nominal R-23 opaque wall assembly to R-12.4 effective, a 46% decrease. Due to the large impact on envelope performance from the thermal bridges, especially the key details listed above, the importance of reviewing the thermal characteristics of each assembly prior to selection cannot be overstated.

Although this analysis is provided for a MURB, thermal bridging as a result of linear and point interfaces is also significant in non-residential buildings. Based on analysis completed by BC Hydro, non-residential buildings can expect a 40%+ decrease in wall thermal performance as a result of the inclusion of thermal bridging at interface details.

By accounting for these effects, the selected sample envelope detail supports the energy targets of the High Performance and Net-Zero Ready scenarios while providing a realistic representation of the design challenges for mid-rise buildings in Waterloo. Detailed building envelope assumptions and further analysis are provided in Appendix A.

## 5. Energy and Emissions Analysis

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Pratus Group has estimated energy use for this project.

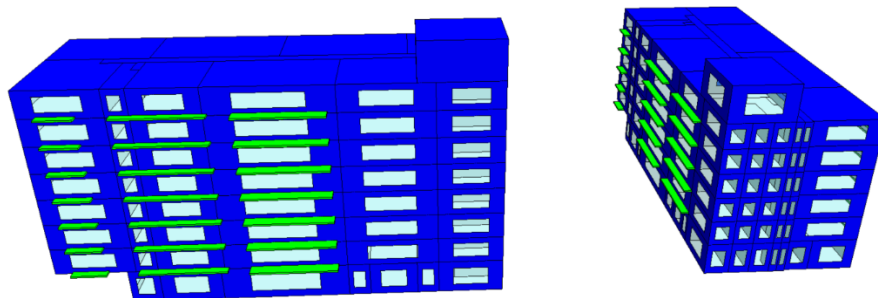


Figure 5-1 – 3D Rendering of the Building in IES VE

Various metrics are used to evaluate energy performance for a project. The ones that will be discussed in this report are summarized below:

**TEUI:** Total Energy Use Intensity is the sum of all energy used on site (i.e., electricity, natural gas, and district heating and cooling), minus all Site Renewable Energy Generation, and divided by the Modelled Floor Area. TEUI is reported in kWh/m<sup>2</sup>/year.

**TEDI:** Thermal Energy Demand Intensity is the annual heating delivered to the building for space conditioning and conditioning of ventilation air. Measured with modelling software, this is the amount of heating energy delivered to the project, that is output from any and all types of heating equipment, per unit of modelled floor area. TEDI is reported in kWh/m<sup>2</sup>/year.

**GHGI:** Greenhouse Gas Intensity is the total greenhouse gas emissions associated with the use of all energy utilities on site on a per area basis, using the emissions factors in SB-10 2017 Division 3. GHGI shall be reported in kg eCO<sub>2</sub>/m<sup>2</sup>/year.

These metrics are analyzed in relation to the performance pathways defined in the City of Waterloo Energy Study Terms of Reference. The framework is based on relative improvements compared to the Ontario Building Code baseline (SB-10, 2017). Projects are evaluated under three scenarios:

1. Ontario Building Code Baseline (SB-10)
2. High Performance (30% TEUI/TEDI reduction and 50% GHGI reduction relative to baseline)
3. Net-Zero Ready (60% TEUI/TEDI reduction and 90% GHGI reduction relative to baseline)

The following sections outline the performance of the proposed 36 Westhill Drive development under each of these scenarios.

### 5.1. Building Code Baseline

For the exercise required for the Energy Study Report, it is important to establish a baseline or reference scenario for the proposed development. At this very early design stage, only preliminary architectural drawings and rendering are available to describe the development.

The baseline case selected for the purpose of this analysis is a building architecturally identical to the proposed development and meets or exceeds the minimum requirements of the current Ontario building code energy regulations as outlined in SB-10 2017. The design characteristics of this Baseline building, and the subsequent improved scenarios are summarized in Appendix A.

The proposed development's Baseline Case energy performance is summarized in the following energy dashboard. The Total Energy Use Intensity (TEUI) for this scenario is 140 ekWh/m<sup>2</sup>. The associated Thermal Energy Demand Intensity (TEDI) is 59 ekWh/m<sup>2</sup> and the Greenhouse Gas Intensity (GHGI) is 13 ekgCO<sub>2</sub>/m<sup>2</sup>. These performance metrics represent compliance with the Ontario Building Code SB-10 Division 3 (2017), using NECB 2015 as the baseline reference.

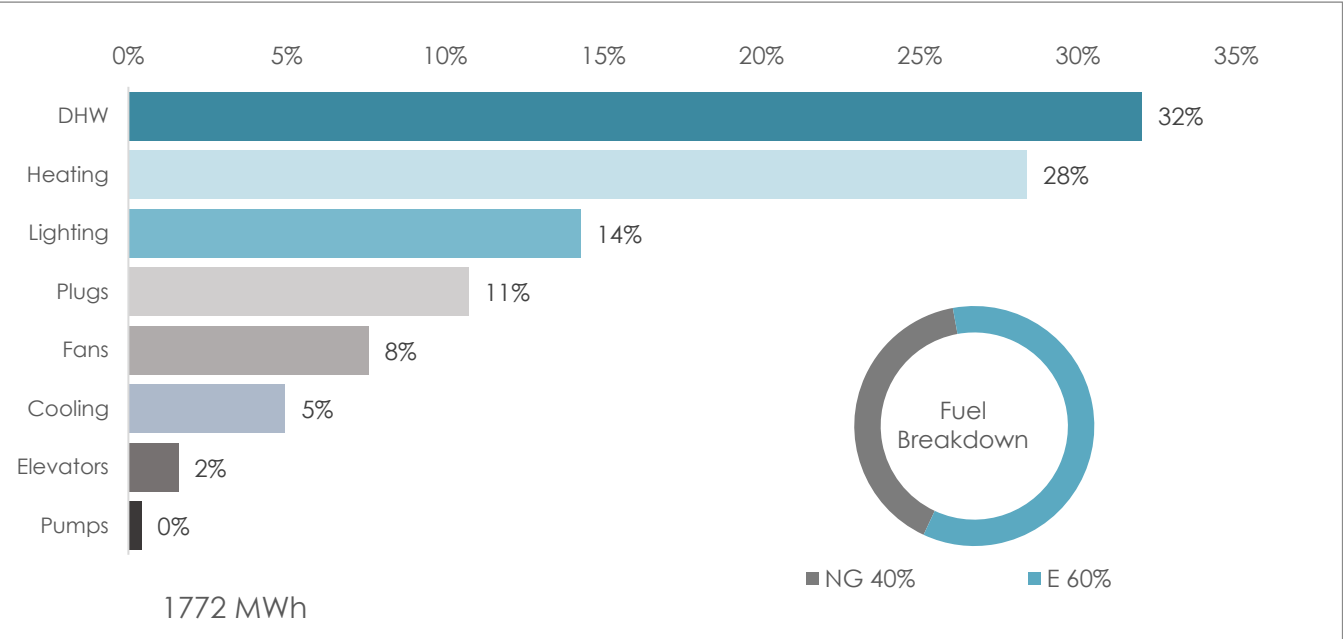


Figure 5-2 – Baseline Annual Energy

### 5.2. High Performance Design

The High Performance Design scenario represents a 30% reduction in TEUI and TEDI and a 50% reduction in GHGI compared to the Ontario Building Code baseline. Achieving this performance typically requires improvements in envelope insulation, ventilation energy recovery, domestic hot water heating, and overall HVAC efficiency.

The Total Energy Use Intensity (TEUI) for this scenario is 90 ekWh/m<sup>2</sup>. The associated Thermal Energy Demand Intensity (TEDI) is 23 ekWh/m<sup>2</sup> and the Greenhouse Gas Intensity (GHGI) is 6 ekgCO<sub>2</sub>/m<sup>2</sup>.

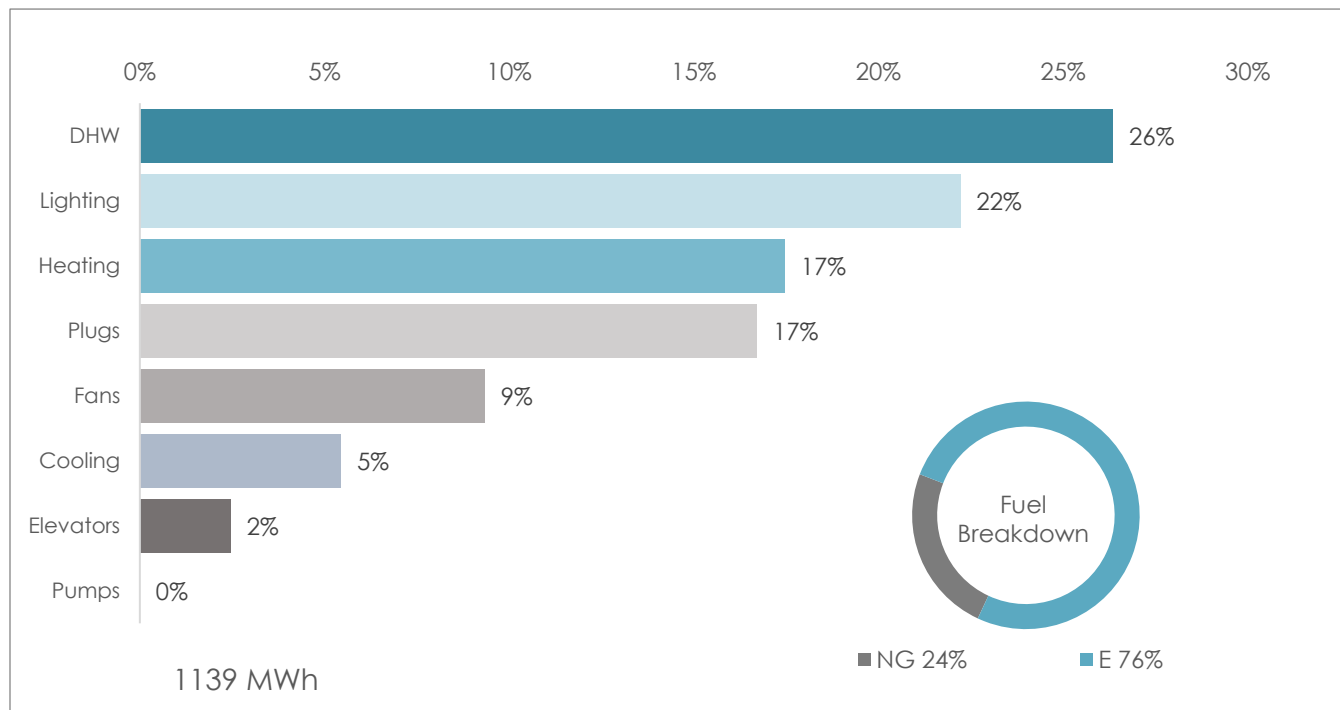


Figure 5-3 – High Performance Design Annual Energy

### 5.3. Net-Zero Carbon and Net-Zero Energy Design

The pathway to achieving Net-Zero, whether Net-Zero Carbon or Net-Zero Energy, looks very similar.

Net-Zero Carbon centers around achieving a zero-carbon balance through on-site and off-site renewable, carbon free energy sources while eliminating on-site combustion of fossil fuels. The energy mix of natural gas and electricity has a large impact on this target.

Net-Zero Energy focuses on meeting a net-zero energy balance and is independent of fuel source.

The first step is to reduce project energy loads; this includes improving the building envelope to minimize the heating and cooling requirements, reducing lighting loads through smart design and daylighting or occupancy sensors, reducing ventilation to only provide what is required, optimizing orientation and massing, etc.

Once the loads are reduced, the next step is to meet those loads in an efficient manner. This includes having an efficient HVAC system, efficient lighting technologies, energy recovery, etc.

Once the loads have been reduced and met in the most efficient way, it is time to consider meeting the rest of the energy requirements through on-site or off-site renewable resources such as solar or wind generation.

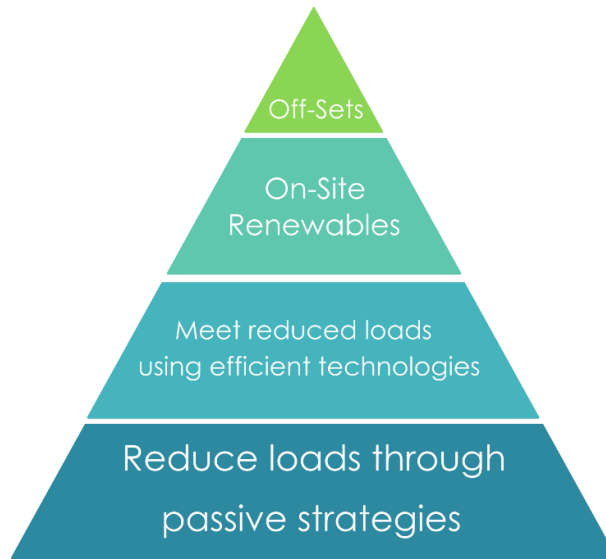


**Figure 5-4 –Net-Zero Design Pyramid**

### 5.3.1. Passive Design Measures towards Net-Zero

The first step in the path towards Net-Zero is to reduce loads and the most effective way is to do so through passive measures. Most passive design measures will address the building envelope and mitigate the thermal bridging effects of linear and point interfaces.

#### 5.3.1.1. **Building Massing**

Opportunities for thermal bridging increase as the articulation of the building is increased. Frequent floor plate changes, insets and other architectural articulation gives rise to discontinuity in the insulation and allows thermal bridging to occur. Some strategies to reduce articulation include:

- Avoid complex floor plates
- Reduce variety of floor plates; this prevents a large amount of soffit and terrace conditions.
- Reduce inset balconies where possible
- Avoid shallow floor plates

#### 5.3.1.2. **Building Envelope**

The building envelope has a significant effect on the loads of the building. Passive measures to reduce loads through the building envelope include:

- Using 'real wall' construction and avoiding window-wall and curtainwall
- Increasing continuous insulation outside of repetitive structural elements
- Minimize thermal bridging through linear interfaces (Refer to Section 5 of this report for further discussion) including:
  - Slab and wall interface (slab bypass)
  - Balconies (thermally broken balconies when possible)
  - Parapet details

- Wall to window interfaces
- Corners
- Do not exceed 40% glazing to wall area
- Consolidate areas of glazing to avoid additional window to wall interfaces
- Select Low-e coated windows in thermally broken frames
- Consider triple glazed windows

### 5.3.2. Active Design Measures towards Net-Zero

Active design strategies follow the initial reduction in load through passive strategies; active strategies aim to meet the loads in efficient ways and may include high efficiency equipment, controls strategies and the use of other technology.

#### 5.3.2.1. Heating, Ventilation and Air Conditioning

The quantity and delivery methods of ventilation represent a significant impact on the energy use, thermal energy demand and emissions associated with building energy use. Particularly in residential developments such as 36 Westhill Drive ventilation represents one of the largest energy end uses in the building. Energy associated with ventilation can be mitigated using some of the following strategies:

- Where possible, implement energy recovery for ventilation
- Reduce uncontrolled envelope infiltration to reduce corridor pressurization requirements
- Right-size corridor and suite ventilation
- Implement controls to reduce corridor pressurization when lower rates are sufficient

The selection of the mechanical system plays a significant role in the energy use of the building. Systems which use combustion of fossil fuels, such as furnaces and boilers, have a limited efficiency and higher carbon impact. System which use heat pumps tend to provide more opportunities for efficiency and carbon reduction. Some recommendations for mechanical system selections on the path to Net- Zero include:

- Consider eliminating fossil fuel fired equipment
- Water-source or air source heat pumps
- Evaluate geothermal systems
- Evaluate district energy systems

#### 5.3.2.2. Domestic Hot Water

Domestic hot water and associated energy is a large component of residential energy use. Several ways to reduce this energy include:

- Select low flow fixtures
- Energy recovery from shower stack
- Wastewater heat recovery
- Air source heat pump for domestic hot water pre-heat

The following performance scenario demonstrates the impact of the Net-Zero design strategies outlined above, showing the potential reductions in energy use and greenhouse gas emissions there, relative to the OBC baseline.

5.4. Net-Zero Ready Performance

The Net-Zero Ready scenario represents a 60% reduction in TEUI and TEDI and a 90% reduction in GHGI compared to the Ontario Building Code baseline. For 36 Westhill Drive, this involves the use of electric heat pumps for DHW heating and electric Makeup Air Unit preheat. Keeping carbon emissions in mind, an HVAC and DHW system which uses electricity was preferred over a gas combustion one.

The Total Energy Use Intensity (TEUI) for this scenario is 47 ekWh/m². The associated Thermal Energy Demand Intensity (TEDI) is 13 ekWh/m² and the Greenhouse Gas Intensity (GHGI) is 1 ekgCO₂/m².

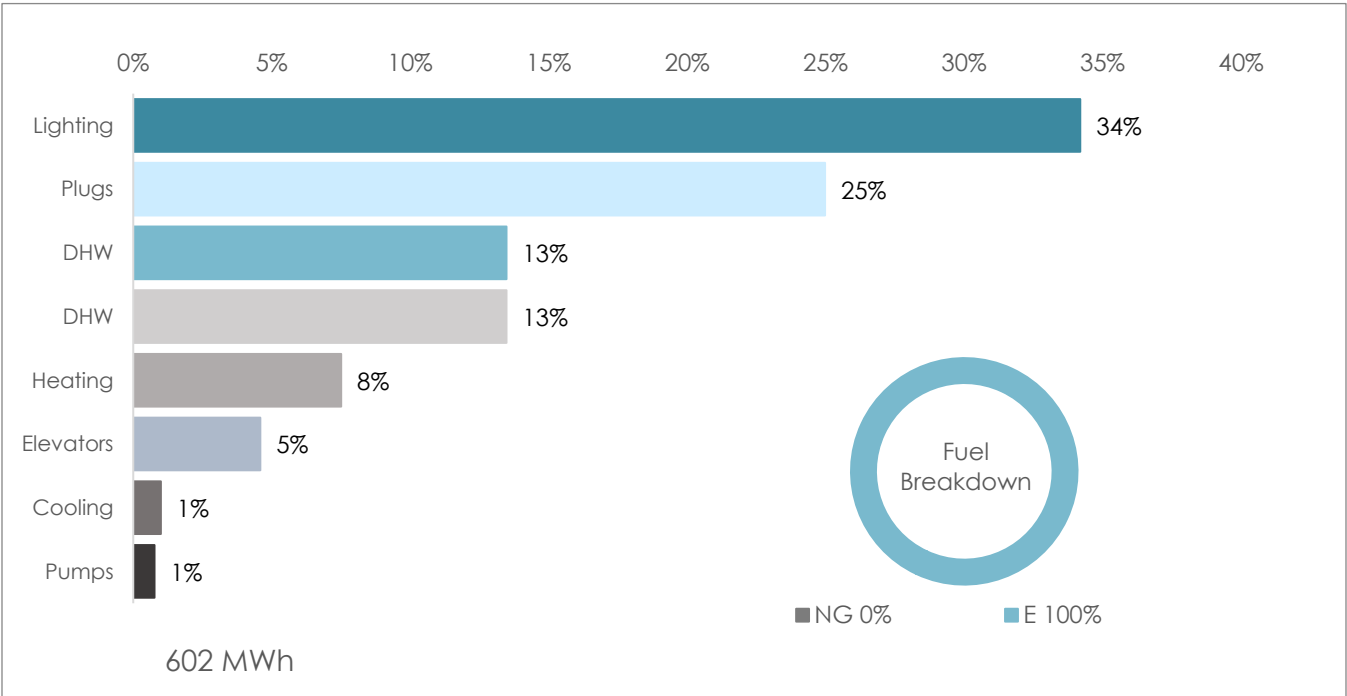


Figure 5-5 – Net-Zero Ready Performance Annual Energy

The summary of the energy metrics and utility cost for the three scenarios is presented in Table 5-1.

**Table 5-1: Summary of Scenarios**

| Scenario                                  | Building Code Baseline | High Performance Design | Net-Zero Ready Performance |
|-------------------------------------------|------------------------|-------------------------|----------------------------|
| TEUI [kWh/m <sup>2</sup> ]                | 140                    | 90                      | 47                         |
| TEUI Savings over Baseline                | -                      | 36%                     | 66%                        |
| TEDI [kWh/m <sup>2</sup> ]                | 59                     | 23                      | 13                         |
| TEDI Savings over Baseline                | -                      | 61%                     | 79%                        |
| GHGI [kgCO <sub>2</sub> /m <sup>2</sup> ] | 13                     | 6                       | 1                          |
| GHGI Savings over Baseline                | -                      | 51%                     | 90%                        |
| Gas [\$ x 1000]                           | 20                     | 9                       | 0                          |
| Electricity [\$ x 1000]                   | 154                    | 122                     | 87                         |
| Total Operational Cost [\$ x 1000]        | 174                    | 130                     | 87                         |

## 5.5. Costing

The incremental cost premium for all of the scenarios is presented in Table 5-2 for the various suggested energy conservation measures.

**Table 5-2: Capital Cost Premium from Baseline Code Building to High Performance Design and Net-Zero Ready Performance**

| Building Code Baseline                                                  | High Performance Design    | Net-Zero Ready Performance |
|-------------------------------------------------------------------------|----------------------------|----------------------------|
| Energy Conservation Measure                                             | Incremental Cost Premiums* | Incremental Cost Premiums* |
| Roof R-36.4 to R-50                                                     | \$45,600                   |                            |
| Roof R-36.4 to R-60                                                     |                            | \$64,000                   |
| Wall Insulation (R-12.4 to R-20)                                        | \$70,100                   |                            |
| Wall Insulation (R-12.4 to R-45)                                        |                            | \$439,600                  |
| Window (U-Value 0.335 to 0.20   SHGC 0.40 to 0.27   Glazing 40% to 30%) | \$226,600                  |                            |
| Window (U-Value 0.335 to 0.19   SHGC 0.4 to 0.25   Glazing 40% to 15%)  |                            | \$256,300                  |
| Add ERV (75% Efficiency)                                                | \$288,000                  |                            |



|                                                      |            |
|------------------------------------------------------|------------|
| <b>Add ERV (85% Efficiency)</b>                      | \$648,000  |
| <b>ASHP Heating &amp; Cooling</b>                    | -\$360,000 |
| <b>Geothermal VRF Heating &amp; Cooling</b>          | -\$431,600 |
| <b>Dedicated DHW boiler 96% Eff</b>                  | -\$14,100  |
| <b>DHW with ASHP at COP 3.5</b>                      | \$80,300   |
| <b>Lighting Power Density (20% better than code)</b> | \$206,100  |
| <b>Infiltration (25% better than code)</b>           | \$28,200   |

\*Costs have been prepared based on current information and drawing packages provided and is an opinion of probable cost at this time. We recommend that a detailed cost estimate be completed by a third-party cost consultant to verify any conservation measures suggested.

There is a cost savings when improving windows from Baseline to High Performance Design as the Window to Wall Ratio is also reduced from 40% to 25% as part of this package of measures. The price of High Performance Design and Net-Zero Ready Performance windows increases due to the higher cost of Passive House certified window products.

Additionally, the cost of using a ground-source VRF (geothermal) for heating and cooling in Net-Zero Ready Performance is proposed. The cost of this system is lower than the other two scenarios due to the reduced heating and cooling loads of this package. These reduced loads are a product of the passive measures also implemented as part of the Net-Zero Ready Performance .

Cost estimates (in net present value) over a 30-year period were evaluated for each of the scenarios using

Equation 1 and presented in Figure 5-6 and Table 5-3 below.

**Equation 1 - Total Cost**

$$\text{NPV Total Cost (30-year period)} = \text{Upfront Capital Cost} + \text{Energy Costs} + \text{Maintenance Costs} + \text{Replacement Costs} + \text{Carbon Costs}$$

Total costs consist of several components as highlighted below:

|                                |                                                                                                                    |
|--------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Total Cost (30-year period)    | Total cost (in net present value) of implementing and operating the proposed system                                |
| Upfront Capital Cost           | Incremental capital cost of the proposed system                                                                    |
| Capital Cost Escalation Rate   | Cost Estimate to account for increases in the cost of labour, equipment and materials                              |
| Discount Rate / Borrowing Cost | The difference between the value-return on an investment in the future and the money to be invested in the present |

|                              |                                                                     |
|------------------------------|---------------------------------------------------------------------|
| Annual Maintenance Cost      | Cost to maintain the proposed system for a period of one year       |
| Maintenance Inflation Rate   | Inflation Rate on maintenance costs                                 |
| Annual Energy Cost           | Utility (gas/electricity) cost incurred over the period of one year |
| Utility Inflation Rate       | Inflation rate on utility costs                                     |
| Replacement Cost             | Cost to replace system components over the 30-year study period     |
| Carbon Cost                  | Cost associated with operational carbon emissions                   |
| Carbon Offset Inflation Rate | Inflation Rate on Carbon Costs                                      |

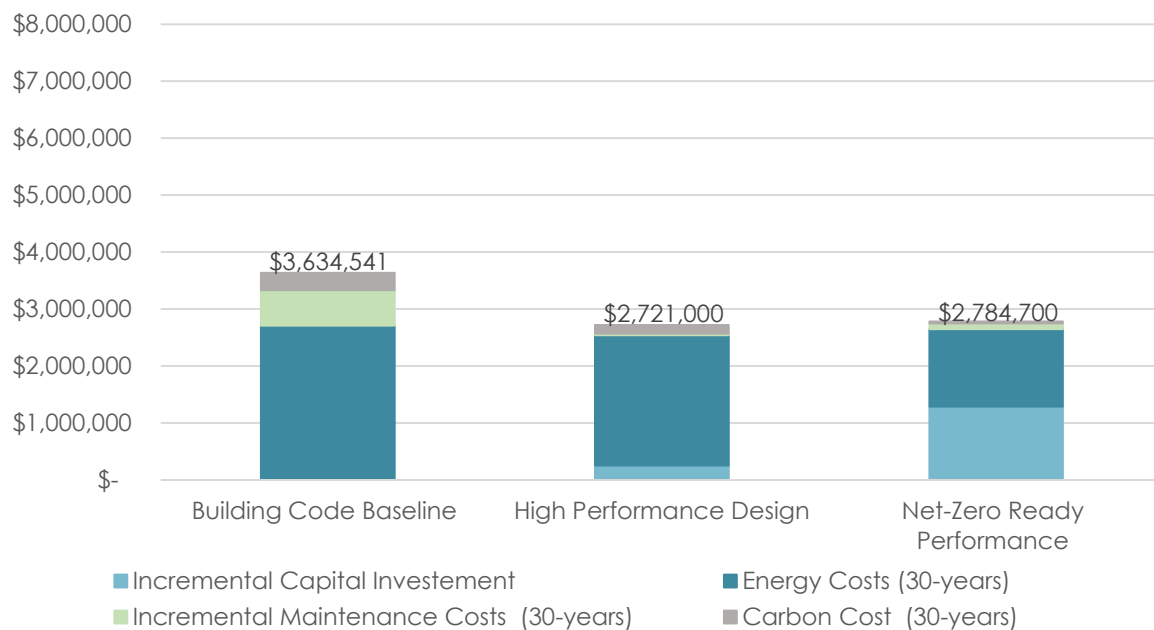


**Figure 5-6 – Total NPV by Scenario**

**Table 5-3: NPV Cost Analysis**

| Scenario                   | Initial Estimated Incremental Cost | Estimated 30-Year NPV | Delta to Baseline Code Building |
|----------------------------|------------------------------------|-----------------------|---------------------------------|
| Building Code Baseline     | -                                  | \$3,634,500           | \$0                             |
| High Performance Design    | \$256,231                          | \$2,721,000           | -\$913,500                      |
| Net-Zero Ready Performance | \$1,290,734                        | \$2,784,700           | -\$849,900                      |

As shown in Figure 5-6, the energy costs and carbon costs decrease from Baseline to High Performance Design and Net-Zero Ready Performance, respectively, as a result of the reduction in energy consumption and reduction of carbon emissions with the inclusion of more energy efficient building system components associated with each scenario design. Additionally, the maintenance cost of Net-Zero Ready Performance is lower as a result of decreased maintenance cost of the geothermal VRF. While Net-Zero Ready Performance has an increased capital cost compared to the Baseline scenario, it nevertheless achieves substantial 30-year NPV savings of approximately \$0.85 million, whereas the High Performance scenario delivers the greatest savings, approximately \$0.91 million, relative to the Baseline, as shown in Table 5-3.

## 6. Renewables and Low-Carbon Options

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### 6.1. On-Site Solutions

#### 6.1.1. Solar PV

An annual analysis of the total available solar energy for the building was performed. The penthouse roofs are optimal locations for on-site solar generation because these locations are not shaded by adjacent buildings or structures and therefore shading will not hinder the generation capacity.

The annual solar generation potential for the site was analyzed considering 50% of the roof area is covered with solar PV panels, approximately 918 m<sup>2</sup>. Based on the IES VE 2024 analysis, this would generate over 117 MWh of electricity annually. This represents approximately 15% of the building's annual energy usage for the Net-Zero Ready Performance scenario.

#### 6.1.2. Ground Source Heat Exchanger

Ground Source Heat Exchange does not provide electricity generation on site but rather an opportunity to connect the building's HVAC to a low-carbon renewable system. Using the ground as a heat source in the heating season and a heat sink during the cooling season would allow for an HVAC system that uses far less energy than a conventional heat pump system. Conventional heat pump systems rely on combustion and electricity to meet the heating/cooling needs for the building and therefore have a greater carbon impact.

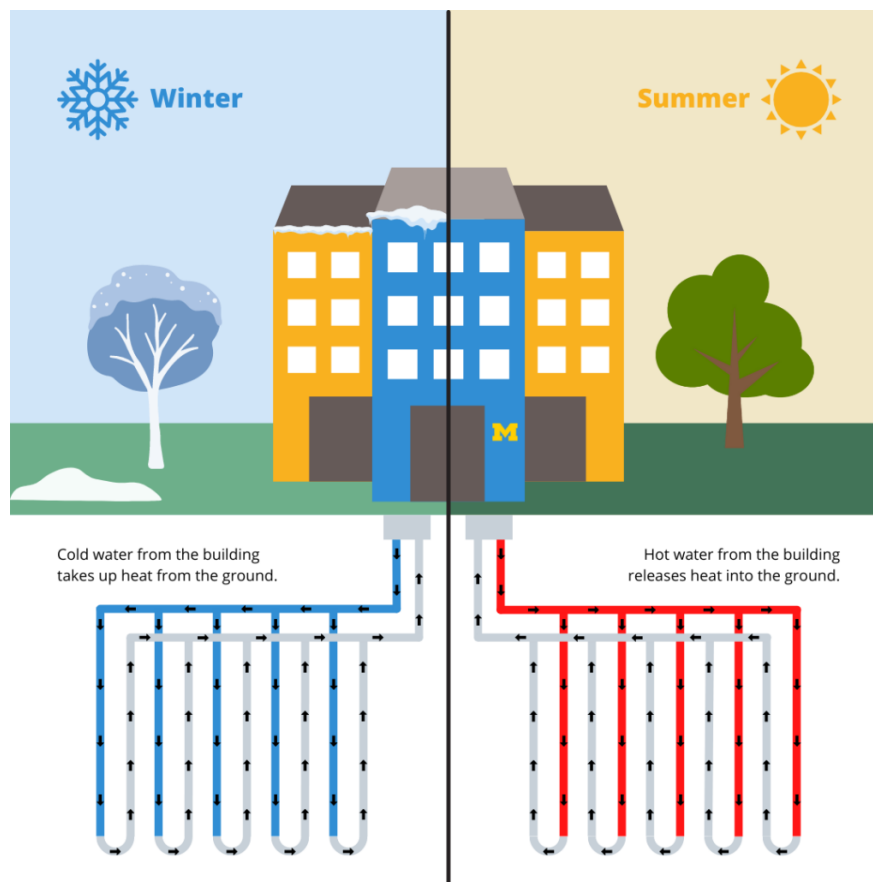


**Figure 6-1 – Ground Source Heat Exchanger Illustration (University of Michigan, 2022)**

A ground source heat exchanger system involves drilling deep into the ground (300 ft +) and circulating fluid through the tubes to reject or extract heat from the ground which remains at a relatively constant temperature throughout the year. Further investigation of this system would be required to ascertain the available on-site capacity and benefits to the project.

Based on the current proposed design assumptions, Pratus explored ground source VRF in the Net-Zero Ready Performance scenario. Comparable systems for Net-Zero Ready Performance compliance can include central air-to-water heat pumps or distributed air-to-air heat pumps.

### 6.1.3. Off-Site Solutions

Although on-site solar and energy generation capacity may be limited for the proposed project, off-site solutions can also be considered to achieve net-zero energy and net-zero carbon goals.

If the project were interested in meeting 100% of the annual energy use through solar generation, the total area of solar panels would have to be approximately 6,300 m<sup>2</sup>.

## 7. Electrical Distribution System Considerations

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The switch from fossil fuel-based heating to an electric system will increase the peak electric demand of the building, increasing both the required power delivery to the building as well as the power draw from the grid. Enova Power may be engaged to evaluate the impact the increased power draw will have on the electrical grid as well as methods to minimize negative impacts. Time-of-day use and electric battery storage may be considered to flatten the electric demand profile and minimize peak power draw from the grid.

## 8. District Energy

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The City of Waterloo and regional partners such as WR Community Energy have identified district energy systems (DES) as an important opportunity to reduce GHG emissions from new and existing buildings while also reducing the demands on local energy infrastructure. The City seeks to:

- Connect new buildings to DES where it is already established or in the process of development
- Design new buildings to be district energy ready where future DES opportunities exist
- Provide opportunities for existing buildings to connect to future DES

DES is a thermal energy distribution strategy for multiple buildings at a development or neighborhood scale. A DES consists of a heating and/or cooling center, and a thermal network of pipes connecting groups of buildings. The central equipment can include low-carbon technologies such as lake water cooling, ground source heat exchangers (GSHX) and combined heat and power (CHP). District energy systems create the economies of scale and energy sharing opportunities necessary to integrate local, low-carbon sources required to achieve large-scale, cost-effective GHG reductions.

To be district energy ready, the following guidelines are presented:

- Provide adequate space required for future equipment and thermal piping
- Design building mechanical systems to be compatible with a future district energy service, including the following features:
  - Hydronic system with large temperature differentials
  - Variable volume flow with variable speed pumps
  - Two-way controls valves on terminal equipment
  - Return water temperature kept to a minimum
- For multi-building developments, design a single, slightly larger mechanical room in one building and connect other buildings through a thermal energy distribution network.

Within the Waterloo Region, WR Community Energy has identified 12 potential DES sites, including opportunities in Downtown Kitchener, where a pre-feasibility study demonstrated the potential to reduce annual GHG emissions by approximately 5,000 tonnes a year with a financial payback of around 6%.

For the 36 Westhill Drive development, the site is not currently within the service area of an existing district energy system. However, the project can be designed to be district-energy ready, in alignment with Waterloo Region's long-term energy strategies, thereby allowing for future connection should an extension of the system or new DES infrastructure be developed in the surrounding area.

### 8.1. District Energy System Opportunity

The section of the report will expand on the proposed benefits of a centralized heating and cooling plant on site.

### 8.1.1. Energy Impact

Centralizing the mechanical equipment may allow for better energy sharing and part load performance than having individual mechanical plants. This is the most notable for systems which use a central loop allowing energy sharing such as Water-Loop Heat Pump (WLHP) systems or Water-Source Variable Refrigerant Flow (WS VRF) systems. Additionally, centralizing the plant may allow opportunities for ground source energy to be incorporated on a centralized scale with one bore-hole field being shared by the entire development. These measures have the opportunity to reduce the energy consumption of the central equipment when compared to having individual mechanical plants.

### 8.1.2. Design Impact

Locating the mechanical equipment in a central location to serve the entire development may have an impact on the use of space which is typically devoted to mechanical equipment such as the mechanical penthouse. Pending necessary approvals, the mechanical penthouse areas may be relocated to leasable or saleable space, providing a financial incentive for the owner. Additionally, having a common plant may occupy less total area than four or more building mechanical plants. The size of the proposed development at 36 Westhill Drive makes the project a good candidate for creating a common central plant for the development, effectively creating a district energy system. A central plant will have an impact on the phasing of the project which will need to be carefully considered.

## 9. Embodied Carbon

**Table 9-1** below outlines the expected building parameters for the proposed design.

**Table 9-1 – Baseline and Proposed Building Parameters**

| Parameter                        | Description                                                                                                                                                                                                                                 |
|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Building type</b>             | Multi-Unit Residential                                                                                                                                                                                                                      |
| <b>Total Floor Area</b>          | 12,728.60m <sup>2</sup>                                                                                                                                                                                                                     |
| <b>Number of floors</b>          | Building A: 6 + MPH<br>Building B: 8 + MPH                                                                                                                                                                                                  |
| <b>Building service life</b>     | 60 Years                                                                                                                                                                                                                                    |
| <b>Structural framing</b>        | Concrete cast-in-situ, column-beam frame with interior core load-bearing walls                                                                                                                                                              |
| <b>Internal floor height</b>     | 2.8m                                                                                                                                                                                                                                        |
| <b>Column &amp; Slab Details</b> | Max Column Spacing: 7.5m<br>Typical Slab Thickness: 240mm                                                                                                                                                                                   |
| <b>Exterior Walls</b>            | Fiber cement/steel sheet cladding with horizontal z-girts<br>50mm exterior XPS insulation<br>Glass mat gypsum sheathing and self-adhesive air/vapour barrier<br>150mm steel stud with mineral wool batt fill<br>Interior grade gypsum board |
| <b>Window-to-Wall Ratio</b>      | 15%                                                                                                                                                                                                                                         |

Based on these proposed building parameters and typical construction materials, the embodied carbon intensity of the development is expected to be between **375 – 450 kgCO<sub>2</sub>e/m<sup>2</sup>**. **Figure 9-1** shows the expected embodied carbon breakdown for major construction materials.

Structural materials typically constitute up to 80% of the global warming potential of a building and are the primary area of focus when striving for embodied carbon reductions. Reinforced concrete, as the primary building framing material, is expected to make up the largest proportion of the embodied carbon footprint of the building, accounting for 55-65% of the overall GHG emissions. Secondary steel framing, typically steel studs and girts, is expected to make up a smaller but non-negligible proportion of embodied emissions.

Overall, optimization of structural materials, which are used in the largest quantities, tends to be highly impactful for new construction projects and so should be prioritized. As the building is expected to have a relatively low window-to-wall ratio, the most impactful architectural materials are expected to be insulation, roofing components, and cladding panels.

Expected GWP Breakdown by Material

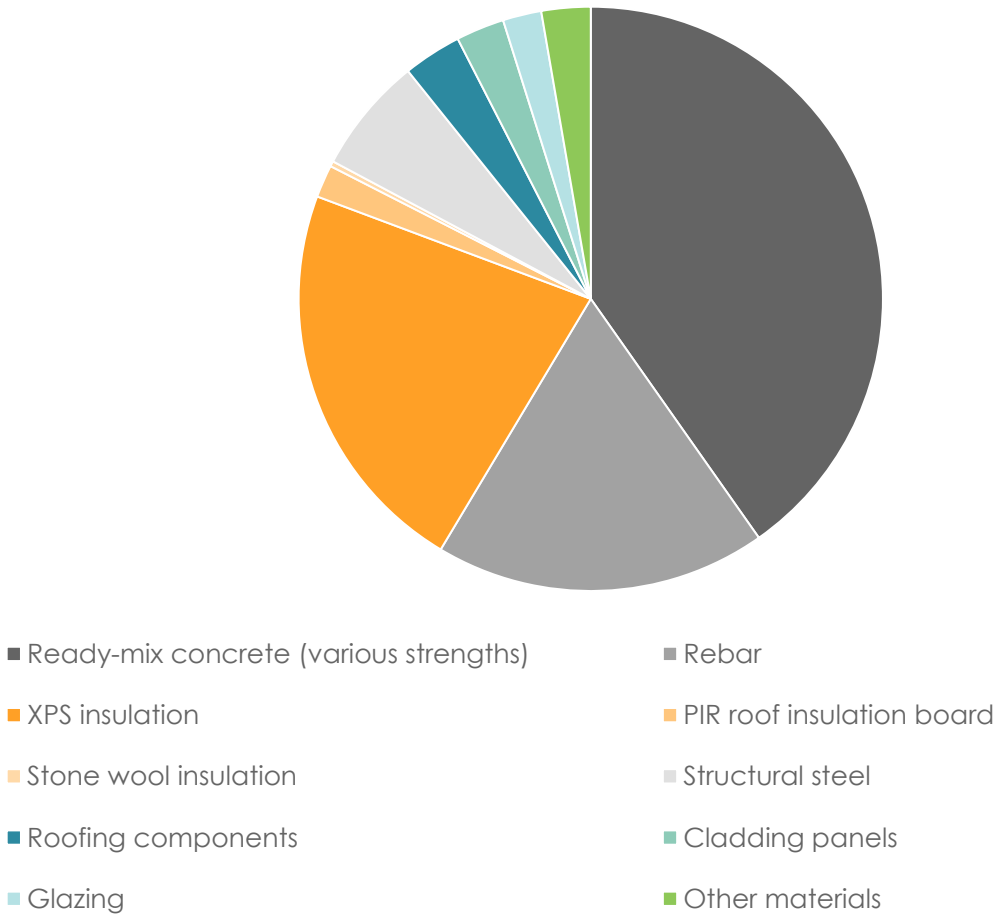


Figure 9-1 – Expected Material GWP Breakdown of Baseline Modelled Design

9.1. Material Optimization: Concrete

As concrete is not a singular product, it can be made using a variety of cementitious materials and substitutes. Depending on the concrete mix composition, embodied carbon reductions of >30% are possible versus “baseline” concrete mixes. Viable strategies to reduce embodied emissions include the use of supplementary cementitious materials (SCMs) such as steel slag or fly ash, alternative cements such as Portland-limestone (GUL) cement, and carbon capture technologies that utilize and sequester CO<sub>2</sub>. However, low-carbon mixes can create tradeoffs and can affect project structures and schedules. Replacing high quantities of cement with SCMs for example can create requirements for longer cure times, impacting project schedules. Other strategies are limited by the availability, suitability, and cost of substitute materials. As such, selection of concrete products should involve the structural engineer, contractor, and the concrete supplier. The best solution is to contact local suppliers during the design process to advise on possible product options.

## 9.2. Material Optimization: Steel

Steel is often used in large quantities in building framing, either through concrete reinforcement, steel sections, or steel studs and girts. Steel also has a particularly high Global Warming Potential (GWP) per unit volume, particularly when compared to concrete. The GWP of steel sections and rebar is primarily related to the included content of recycled materials and the steelmaking process utilized. Typically, electric arc furnace (EAF) steel will include significantly higher recycled content and have lower operational carbon emissions than basic oxygenated furnace (BOF) steelmaking. Steel suppliers providing EAF steel and with high recycled content (>90%) should be prioritized wherever possible.

## 9.3. Material Optimizations: Architectural Products

While the building structure accounts for most of the building construction GWP, optimizations within the envelope and enclosure can also reduce embodied carbon. Like the choice of structural materials, designs should strive to minimize use of raw materials and should prioritize use of locally available and recycled or repurposed products. Beyond this, designers should look to reduce material quantities and select products with longer lifespans.

Insulation selection tends to have a highly significant impact on the overall GWP of a building, particularly when large amounts of rigid XPS insulation are used. Consider limiting use of extruded polystyrene (XPS), as available products vary widely and typically have high embodied carbon per R-value. Expanded polystyrene (EPS), mineral wool batt or boards, or polyisocyanurate (PIR) insulation are typically lower carbon insulation choices. Organic options, such as cellulose, have even lower impact. If XPS is required to achieve desired operational building performance, products with low-GWP blowing agents should be prioritized.

## 10. Resiliency

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The City of Waterloo, in collaboration with the Region of Waterloo, is actively enhancing its resilience to the physical, social, and economic challenges posed by climate change. This effort is guided by the Community Climate Adaptation Plan, which focuses on health and community, the built environment, natural resources, and energy and economy.

The City's Corporate Climate Change Adaptation Plan outlines actions to reduce vulnerability, build resilience, and address opportunities arising from climate change. These plans are complemented by the City's Green Building Policy (A-033), which requires that new construction and major retrofits incorporate strategies to reduce greenhouse gas emissions and improve overall building resilience.

It is not only important to consider resilience measures to meet the energy and stormwater needs of the development under current conditions, but also worthwhile to consider future needs based on forecasted values as a result of climate change. By designing today to meet the predicted needs of the future building owners can safeguard their assets and the individuals who occupy them.

A number of design considerations can be taken when designing with resiliency in mind. These include:

- Using future climactic data to inform building design, including weather extremes
- Designing for thermal resiliency by reducing TEDI
- Passive ventilation strategies
- Tenant and occupant emergency preparedness guides
- Indoor refuge areas (heating and/or cooling)
- Ceiling fans
- Shade trees/shrubs
- External pools
- Reduced hardscape
- On-site power including solar PV, solar thermal, battery storage, CHP systems, GSHX, etc.
- Flood proofed electrical, HVAC and back-up generation systems (above 1st floor)

It is recommended that the development consider enhanced back-up power systems which will improve the resilience of building to area-wide power outages, especially for the residential portion of the building. The recommended system should provide 72 hours, at minimum, back up to life safety systems including:

- Domestic water (hot and cold);
- Elevator service; and
- Space heating, lighting and receptacle power to the central common area/amenity space/lobby, where applicable

### 10.1.Back-up Power Systems / Resilience

This section evaluates opportunities for backup power systems that will improve the resilience of buildings to area-wide power outages. This includes meeting all emergency power (life safety) requirements, as well as providing for 72 hours (at a minimum) of domestic water (hot and cold), elevator service, space

heating, lighting, and receptacle power to the central common area/amenity space/lobby, where applicable. Generally, a standby emergency diesel power electricity generator will provide emergency power for all OBC required life-safety systems, as well as selective non-life-safety systems.

To aid in the evaluation of the backup power system extension for common area heating, ventilation, lighting and all domestic water, the electricity use for those end uses was sub-metered in the model for the Baseline scenario. The peak building electricity demand is 6 kW.

## 10.2.Critical Equipment Location

Critical electrical and mechanical equipment should be located such that risk of equipment fault/failure from extreme weather is minimized. Considerations include:

- Locate heating and cooling equipment in the basement (reduced exposure to elements)
- Locate data center in core or basement (reduced thermal load from solar exposure)
- Install leak detection to identify flooding before damage occurs
- Barrier features such as epoxy flooring and floor drain, elevating equipment from floor, doorway spill barrier, etc.
- Consider battery electric storage for power outage events instead of fossil fuel based generators

## 10.3.Future Proof HVAC Systems

Given the potential for building retrofits and future low-carbon energy opportunities in Waterloo, designing mechanical systems to be future-ready is recommended. While Waterloo does not currently have a widespread district energy system, new developments can be prepared for potential future connections to low-carbon district energy or shared mechanical systems.

Considerations for these systems are listed in the City of Toronto's Minimum Backup Power Guidelines for Multi-Unit Residential Buildings (Mechanical System Design Guidelines for Low Carbon Buildings, 2021) and include:

- District Energy/Ground-Source Heating: Connection to a district energy system can be a cost-effective approach to reducing GHG emissions. In situations where a district energy system is being planned but will not be constructed in time to connect a building, the building can be future-proofed for connection (i.e. district energy-ready). This approach has the added benefit of also making the building ready for ground-source heating:
  - Install connections on reverse return piping - Arrange the reverse return piping from residential suites so that they have accessible points for future connections (ideally be a pair of riser isolation valves or a pair of Tee connections in common areas). These connections would also prepare the building for a central heat pump.
  - Provide space for future vertical piping - Allocate vertical space from the parking through to the building level to the reverse return piping connections, in the form of sleeves over which flooring may be installed to avoid future costs. Service vestibules (elevator, garbage, corners of stair landings) may minimize the impact on space planning.

- Provide space for the energy transfer station or central heat pump - Allocate parking spaces adjacent to the building core to create physical space for a future energy transfer station (ETS) or central heat pump. An ETS requires two (2) spaces, while a central heat pump would require approximately ten (10). MURBs using 4-pipe fan coil units require additional power to be allocated for the future low carbon heating equipment. The estimated cost is \$105/kVa.
- Allocate power for the low-carbon heating source - A reasonable estimate is to double the power allocated to the cooling plant to account for the lower efficiency. When a similar technology is producing beneficial heat.
- Lower Heating Water Temperatures: Where a district energy connection is not likely, there are commercially available heat pumps with the capacities and temperature ranges to provide low carbon heating and cooling on-site. Mechanical systems must be designed for lower heating water supply temperatures to increase the efficiency and cost effectiveness of heat pumps.
  - Allocated roof space, structural support and power for an air-source heat pump to replace conventional cooling plant – allocate 25% additional peak electrical demand beyond conventional cooling plant for heat pumps
  - In a heat pump building, plan for water to water heat pumps in series with the air-source heat pump
  - In a fan-coil building, select building heating water distribution with ~50C supply water temperature – 50° C supply water temp in line with commercially available heat pump supply water temp
- Retrofits: Heating and cooling plants of existing MURBs can be retrofitted to accommodate air- or ground-source heat pumps, or for connection to a district energy system. The key is to time the retrofit with a boiler replacement such that the new boilers are able to accept lower return temperatures.
  - Replace the existing cooling plant with air-source heat pumps to supplement the conventional heating capacity – This could extend the life of the existing boilers by reducing operating hours and would enable smaller boilers when they are eventually replaced. Commercially available heat pumps are expected to operate all heating hours above -10°C (95% of hours), which would reduce GHG emissions by 60-80%.
  - Replace existing boilers to accept return water temperatures of 40° C - Replacement options include condensing boilers or cast-iron boilers designed for low return water in order to preserve the existing boiler flues.
  - Provide ground-source heat pump at the baseline level of the building for 5-10% of peak demand capacity – Ground-source heat pumps have higher capital costs, but are more efficient than air source heat pumps. In situations where building mechanical systems are planned to be retrofitted, and where the site has space to accommodate bore field drilling,

## 11. Funding Sources

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The current development may not be pursuing higher optional levels of energy performance and as a result, the funding sources discussed herein may not be made available to the developer. They will be discussed for the sake of highlighting their potential financial impact from a hypothetical perspective. A number of funding options are available for projects which are looking to exceed the minimum energy performance standards of the OBC SB-10.

### 11.1. Enbridge Savings by Design

Savings by Design is a green building initiative administered by Enbridge Gas Distribution. The program aids builders/developers to design and construct buildings with improved energy performance, with a target of at least a 15% improvement over the current Ontario Building Code. The Savings by Design program provides industry professional design support and financial incentives during design, construction, and commissioning stages of a project.

The project includes multi-residential units. As such, the project is eligible for the Savings by Design Commercial & Multi-Residential new constructions program, an energy performance incentive. The SBD program provides support and financial incentives during the design (facilitated integrated design workshop and schematic design energy model report), construction and commissioning stages of a project. A no cost to applicant (up to \$35,000 value) integrated design process set of meetings is facilitated to identify the optimal mix of design elements and technologies to maximize energy efficiency.

Based on the verified energy performance of the building once constructed, the Participant is eligible to receive financial incentives

In addition, there is an incentive of \$15,000 available for Participant's that submit their 'as-designed' energy model that demonstrates 25% savings over code and \$15,000 for 'as-built' energy model subject to the same savings. There is a further incentive of \$15,000 once the property is constructed provided it exceeds code performance. Another \$15,000 is available when the final commissioning report and final "as-built" energy model is submitted within six months of construction completion.

### 11.2. CHMC – Rental Construction Financing Initiative

Another source of funding to be considered is the Canada Mortgage and Housing Corporation's (CMHC) Apartment Loan Construction Program (ACLP), formerly known as Rental Construction Financing initiative (RCFi), now known as ACLP. This initiative is available to projects that are either, purpose built residential rental, or of mixed use between residential rental and non-residential, that offer affordable residential rents, accessible units, greater energy efficiency and reduced greenhouse gas emissions.

The CMHC rental construction financing provides low-cost funding to eligible borrowers during the riskiest phases of product development such as during construction through to stabilized operations. CHMC mortgage loan insurance is included and provides access to preferred interest rates lowering borrowing costs for the refinancing of multi-unit residential properties and facilitates renewals throughout the life of the mortgage. The program is designed to support sustainable apartment projects in areas where there

is a need for additional rental supply. Totalling \$13.75 billion in available loans, the initiative is open from 2017 through to the end of 2027.

To be eligible, the project must decrease energy use and greenhouse gas emissions 15% below the 2015 National Energy Code for Buildings or the 2015 National Building Code at minimum in addition to fulfilling various affordability and accessibility criteria.

### **11.3.CMHC – Multi-unit Loan Insurance MLI Select Program**

Another source of funding to be considered is the Canada Mortgage and Housing Corporation's (CMHC) Multi-unit Loan Insurance MLI Select Program. This initiative is available to both new and existing rental housing projects with a minimum project size of 5 units where non-residential part does not exceed 30% gross floor area. The loan insurance is provided with an amortization period of up to 50 years. The maximum loan to value ratio is 95% for the residential and 75% for the non-residential component of the project. Up to 95% of the loan may be advanced during construction with the remainder being available once construction/retrofit is complete.

It is a points-based system where borrowers can commit to any combination of social outcomes: affordability, energy efficiency and accessibility. A minimum of 50 points is needed to qualify for MLI Select. Affordability is assessed by comparing rent with median renter income and has to be applicable for the entire duration of MLI Select. Energy efficiency is assessed by comparing energy performance against NECB/NBC baseline by using energy modelling techniques. This needs to be demonstrated once and not on an ongoing basis. A 25% improvement over NECB 2017 enables projects to gain 50 points and qualify for this initiative. Accessibility is assessed in accordance with CSA standard B651-18, universal design or RHFAC.

More details may be found at the CMHC MLI Select website.

## 12. Discussion and Recommendations

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The project has many opportunities for energy, carbon, and operational cost reductions. The current baseline meets the minimum requirements of the Ontario Building Code Baseline (OBC SB-10). However, implementing a number of identified strategies could aid the project in achieving advanced sustainable design goals. Again, the current development is not pursuing higher optional levels of energy performance, however concepts/strategies will be summarized as required by the City of Waterloo's Energy Study Terms of Reference.

Recommended strategies include:

- Limiting window to wall ratio to 40%
- Reducing the energy and emissions associated with domestic hot water by using low flow fixtures
- In-suite energy recovery ventilators to reduce ventilation energy
- Improving the performance of the walls through careful consideration of linear interfaces
- Right sizing corridor ventilation units
- Using low-carbon technologies such as heat pumps, whether air to air, air to water or ground-source.

High Performance Design targets for this project are achievable with additional consideration surrounding improving the domestic hot water boiler with heat pump heating. Net-Zero Ready Performance targets are achievable with further efficiency improvements such as opaque wall insulation/thermal bridging improvements and triple glazing, improved energy recovery, electric MAU preheat and by incorporating off-site energy generation resources.

Lastly, resiliency continues to have an ever-increasing influence on development, particularly residential developments. Future weather conditions and extreme climate events present a significant potential risk to property owners and occupants. Safeguarding assets today by designing for resiliency helps mitigate climate change risks, fuel security threats, and infrastructure damage predicted as a result of our changing weather patterns. It is recommended the design team should consider providing 72-hour back-up power for OBC required systems, with the addition of several non-required systems. It is recommended that the team explore adding additional systems such as domestic water, space heating, lighting, and receptacle power to the central and common areas.

### 12.1. Financial Analysis

The incremental cost premium for all scenarios are presented below for the various suggested energy conservation measures.

**Table 12-1: Capital Cost Premium from Baseline Code Building to High Performance Design and Net-Zero Ready Performance**

| Building Code Baseline                                                         | High Performance Design    | Net-Zero Ready Performance |
|--------------------------------------------------------------------------------|----------------------------|----------------------------|
| Energy Conservation Measure                                                    | Incremental Cost Premiums* | Incremental Cost Premiums* |
| <b>Roof R-36.4 to R-50</b>                                                     | \$45,600                   |                            |
| <b>Roof R-36.4 to R-60</b>                                                     |                            | \$64,000                   |
| <b>Wall Insulation (R-12.4 to R-20)</b>                                        | \$70,100                   |                            |
| <b>Wall Insulation (R-12.4 to R-45)</b>                                        |                            | \$439,600                  |
| <b>Window (U-Value 0.335 to 0.20   SHGC 0.40 to 0.27   Glazing 40% to 30%)</b> | \$226,600                  |                            |
| <b>Window (U-Value 0.335 to 0.19   SHGC 0.4 to 0.25   Glazing 40% to 15%)</b>  |                            | \$256,300                  |
| <b>Add ERV (75% Efficiency)</b>                                                | \$288,000                  |                            |
| <b>Add ERV (85% Efficiency)</b>                                                |                            | \$648,000                  |
| <b>ASHP Heating &amp; Cooling</b>                                              | -\$360,000                 |                            |
| <b>Geothermal VRF Heating &amp; Cooling</b>                                    |                            | -\$431,600                 |
| <b>Dedicated DHW boiler 96% Eff</b>                                            | -\$14,100                  |                            |
| <b>DHW with ASHP at COP 3.5</b>                                                |                            | \$80,300                   |
| <b>Lighting Power Density (20% better than code)</b>                           |                            | \$206,100                  |
| <b>Infiltration (25% better than code)</b>                                     |                            | \$28,200                   |

\*Costs have been prepared based on current information and drawing packages provided and is an opinion of probable cost as this time. We recommend that a detailed cost estimate be completed by a third-party cost consultant to verify any conservation measures suggested.

**Table 12-2: NPV Cost Analysis**

| Scenario                          | Initial Estimated Incremental Cost | Estimated 30-Year NPV | Delta to Baseline Code Building |
|-----------------------------------|------------------------------------|-----------------------|---------------------------------|
| <b>Building Code Baseline</b>     | -                                  | \$3,634,500           | \$0                             |
| <b>High Performance Design</b>    | \$256,231                          | \$2,721,000           | -\$913,500                      |
| <b>Net-Zero Ready Performance</b> | \$1,290,734                        | \$2,784,700           | -\$849,900                      |

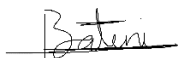
The energy costs and carbon costs decrease from Baseline to High Performance Design and Net-Zero Ready Performance, respectively, as a result of the reduction in energy consumption and reduction of carbon emissions with the inclusion of more energy efficient building system components associated with each scenario design. Additionally, the maintenance cost of Net-Zero Ready Performance is lower as a result of decreased maintenance cost of the geothermal VRF. While Net-Zero Ready Performance has an increased capital cost compared to the Baseline scenario, it nevertheless achieves substantial 30-year NPV savings of approximately \$0.85 million, whereas the High Performance scenario delivers the greatest savings, approximately \$0.91million, relative to the Baseline, as shown in Table 12-2.

## 12.2.Closing

We trust the foregoing provides the information required at this time. Please do not hesitate to contact the undersigned with any questions or comments.

**Report Prepared By:**

Yasaman Bateni, M.Eng.

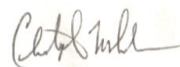


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**Report Approved by:**

Oleksandra Onisko, P.Eng., LEED AP BD+C, BEMP, CMVP

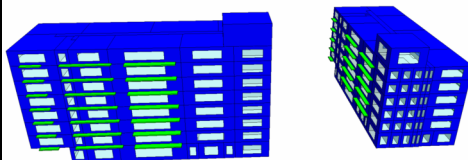
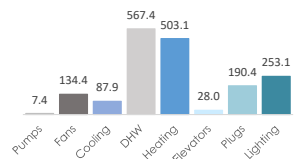
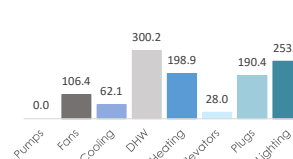
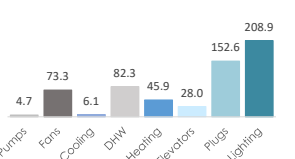


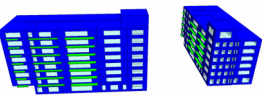
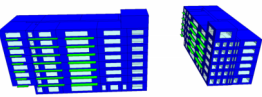
Building Performance Executive Vice President

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## APPENDIX A

### Proposed Design Model Characteristics

| Proposed Design Model Characteristics |                                                                                                                                                                                             |                                                                                          |                                                                                                                                                                        |                                                                                        |                                                                                                 |                                                                                        |                                |      |      |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|--------------------------------|------|------|
| General                               |                                                                                                                                                                                             |                                                                                          |                                                                                                                                                                        |                                                                                        |                                                                                                 |                                                                                        |                                |      |      |
| Location                              | 36 Westhill Drive, Waterloo, ON                                                                                                                                                             |                                                                                          |                                                                                                                                                                        |                                                                                        |                                                                                                 |     |                                |      |      |
| Climate Zone                          | Table 1.3.1.1 SB-10 Zone 6                                                                                                                                                                  |                                                                                          |                                                                                                                                                                        |                                                                                        |                                                                                                 |                                                                                        |                                |      |      |
| Building Area                         | Modelled Area                                                                                                                                                                               | 12,729                                                                                   | m² (Excluding Surface Parking Spaces)                                                                                                                                  |                                                                                        |                                                                                                 |                                                                                        |                                |      |      |
| Number of units                       | Multiunit Residential: 140 total units (59 units Building A and 81 units Building B)<br>Building A: 1 Bedroom - 39;<br>2+D Bedroom - 20;<br>Building B: 1 Bedroom -53;<br>2+D Bedroom - 28; |                                                                                          |                                                                                                                                                                        |                                                                                        |                                                                                                 |                                                                                        |                                |      |      |
| Building Type                         | 2 Multi Unit Residential Buildings                                                                                                                                                          |                                                                                          |                                                                                                                                                                        |                                                                                        |                                                                                                 |                                                                                        |                                |      |      |
|                                       | Residential                                                                                                                                                                                 | 7 days a week, 24 hours a day (NECB 2015 Operating Schedule G)                           |                                                                                                                                                                        |                                                                                        |                                                                                                 |                                                                                        |                                |      |      |
|                                       | Amenity                                                                                                                                                                                     | 7 days a week, 118 hours/week (NECB 2015 Operating Schedule B)                           |                                                                                                                                                                        |                                                                                        |                                                                                                 |                                                                                        |                                |      |      |
|                                       | (the above and all other schedules as per TGS v4- Energy Efficiency Report Submission & Modelling Guidelines – May 2022)                                                                    |                                                                                          |                                                                                                                                                                        |                                                                                        |                                                                                                 |                                                                                        |                                |      |      |
| Overall Building Performance          |                                                                                                                                                                                             |                                                                                          |                                                                                                                                                                        |                                                                                        |                                                                                                 |                                                                                        |                                |      |      |
| Modelled Scenario                     | Building Code Baseline                                                                                                                                                                      |                                                                                          | High Performance Design                                                                                                                                                |                                                                                        | Net-Zero Ready Performance                                                                      |                                                                                        |                                |      |      |
| Energy TEUI kWh/m²                    | 140                                                                                                                                                                                         |                                                                                          | 90                                                                                                                                                                     |                                                                                        | 47                                                                                              |                                                                                        |                                |      |      |
| TEUI Savings over Baseline            | -                                                                                                                                                                                           |                                                                                          | 36%                                                                                                                                                                    |                                                                                        | 66%                                                                                             |                                                                                        |                                |      |      |
| Energy TEDI kWh/m²                    | 59                                                                                                                                                                                          |                                                                                          | 23                                                                                                                                                                     |                                                                                        | 13                                                                                              |                                                                                        |                                |      |      |
| TEDI Savings over Baseline            | -                                                                                                                                                                                           |                                                                                          | 61%                                                                                                                                                                    |                                                                                        | 79%                                                                                             |                                                                                        |                                |      |      |
| Emissions GHGI ekgCO <sub>2</sub> /m² | 13                                                                                                                                                                                          |                                                                                          | 6                                                                                                                                                                      |                                                                                        | 1                                                                                               |                                                                                        |                                |      |      |
| GHGI Savings over Baseline            | -                                                                                                                                                                                           |                                                                                          | 51%                                                                                                                                                                    |                                                                                        | 90%                                                                                             |                                                                                        |                                |      |      |
| Energy Cost (\$)                      | \$174,000                                                                                                                                                                                   |                                                                                          | \$130,000                                                                                                                                                              |                                                                                        | \$87,000                                                                                        |                                                                                        |                                |      |      |
| Energy demand by use type MWh         |                                                                                                           |                                                                                          |                                                                                     |                                                                                        |             |                                                                                        |                                |      |      |
| Envelope Performance                  |                                                                                                                                                                                             |                                                                                          |                                                                                                                                                                        |                                                                                        |                                                                                                 |                                                                                        |                                |      |      |
| Opaque Envelope                       |                                                                                                                                                                                             |                                                                                          |                                                                                                                                                                        |                                                                                        |                                                                                                 |                                                                                        |                                |      |      |
| Wall Type                             | Building Code Baseline                                                                                                                                                                      |                                                                                          | High Performance Design                                                                                                                                                |                                                                                        | Net-Zero Ready Performance                                                                      |                                                                                        |                                |      |      |
|                                       | Description                                                                                                                                                                                 | R-IP                                                                                     | Description                                                                                                                                                            | R-IP                                                                                   | Description                                                                                     | R-IP                                                                                   |                                |      |      |
| Roof                                  | Targeting overall R-value of 36.4 per Table SB 3.2.2.2 (Zone 6)                                                                                                                             | R-36.4                                                                                   | Targeting overall R-value of 50                                                                                                                                        | R-50                                                                                   | Targeting overall R-value of 60                                                                 | R-60                                                                                   |                                |      |      |
| Vertical Wall                         | Targeting overall R-value of 23.0 per Table SB 3.2.2.2 (Zone 6)                                                                                                                             | R-12.4 (Effective R-value including all linear transmittance losses and thermal bridges) | Improved R-value of R-20 after improving thermal bridging in construction details and junctions                                                                        | R-20 (Effective R-value including all linear transmittance losses and thermal bridges) | Improved R-value of R-45 after improving thermal bridging in construction details and junctions | R-45 (Effective R-value including all linear transmittance losses and thermal bridges) |                                |      |      |
| Slab on Grade                         | 38mm thick rigid insulation (R-7.5), 4ft vertical per Table SB 3.2.2.2 (Zone 6)                                                                                                             | F-0.65                                                                                   | 38mm thick rigid insulation (R-7.5), 4ft vertical                                                                                                                      | F-0.65                                                                                 | 38mm thick rigid insulation (R-7.5), 4ft vertical                                               | F-0.65                                                                                 |                                |      |      |
| Fenestration                          |                                                                                                                                                                                             |                                                                                          |                                                                                                                                                                        |                                                                                        |                                                                                                 |                                                                                        |                                |      |      |
| Aluminium framed Windows              | Table SB 3.2.2.3 (Zone 6): Maximum U Value: 1.9 W/(m²K)                                                                                                                                     | U-IP                                                                                     | 0.335                                                                                                                                                                  | Triple glazed windows with low-e coating on surface #2 and thermally broken frame      | U-IP                                                                                            | 0.20                                                                                   | Passive House Standard Glazing | U-IP | 0.19 |
|                                       |                                                                                                                                                                                             | SHGC                                                                                     | 0.40                                                                                                                                                                   |                                                                                        | SHGC                                                                                            | 0.27                                                                                   |                                | SHGC | 0.25 |
| Percentage Glazing                    | 40%                                                                                                                                                                                         |                                                                                          | 30%                                                                                                                                                                    |                                                                                        | 15%                                                                                             |                                                                                        |                                |      |      |
| Infiltration                          | (0.05 cfm/ft2) of total above grade envelope surface area (roofs, exterior walls, and windows, exposed floors), flow varied with windspeed as per PNNL-18898 guideline                      |                                                                                          | (0.05 cfm/ft2) of total above grade envelope surface area (roofs, exterior walls, and windows, exposed floors), flow varied with windspeed as per PNNL-18898 guideline |                                                                                        | 25% better than code                                                                            |                                                                                        |                                |      |      |

| Mechanical Systems                     |                                |             |                                                                                                                                                                                                        |                              |             |                                                                                                              |                                 |                                                                                       |                                                                                                                   |
|----------------------------------------|--------------------------------|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|-------------|--------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| System Description                     | Building Code Baseline         |             |                                                                                                                                                                                                        | High Performance Design      |             |                                                                                                              | Net-Zero Ready Performance      |                                                                                       |                                                                                                                   |
|                                        | Air Source Heat Pumps (ASHP)   | Serving     | Residential suites                                                                                                                                                                                     | Air Source Heat Pumps (ASHP) | Serving     | Residential suites                                                                                           | Variable Refrigerant Flow (VRF) | Serving                                                                               | Residential suites                                                                                                |
|                                        |                                | Description | Air to air heat pump for heating and cooling.                                                                                                                                                          |                              | Description | Air to air heat pump for heating and cooling. Ventilation is provided by energy recovery ventilators (ERVs). |                                 | Description                                                                           | Ground source VRFs connected to geo-exchange loop. Ventilation is provided by energy recovery ventilators (ERVs). |
|                                        |                                | Efficiency  | Heating COP: 3.3<br>Cooling COP: 3.22                                                                                                                                                                  |                              | Efficiency  | Heating COP: 3.31<br>Cooling COP: 3.29<br>ERV effectiveness: 75% sensible<br>60% latent                      |                                 | Efficiency                                                                            | Heating COP: 3.92<br>Cooling COP: 5.1<br>ERV effectiveness: 85% sensible<br>75% latent                            |
|                                        |                                | Fan Power   | Central fan: 0.9 W/cfm<br>Supply fan: 0.3 W/cfm                                                                                                                                                        |                              | Fan Power   | Central fan: 0.9 W/cfm<br>Supply fan: 0.3 W/cfm                                                              |                                 | Fan Power                                                                             | Central fan: 0.9 W/cfm<br>Supply fan: 0.3 W/cfm                                                                   |
| System Description                     | System 3<br>NECB Table 8.4.4.7 | Serving     | Amenity spaces                                                                                                                                                                                         | Air Source Heat Pumps (ASHP) | Serving     | Amenity spaces                                                                                               | Variable Refrigerant Flow (VRF) | Serving                                                                               | Amenity spaces                                                                                                    |
|                                        |                                | Description | Packaged rooftop unit with gas furnace and DX cooling. Hydronic baseboards for the auxiliary heating.                                                                                                  |                              | Description | Air to air heat pump for heating and cooling. Ventilation is provided by energy recovery ventilators (ERVs). |                                 | Description                                                                           | Ground source VRFs connected to geo-exchange loop. Ventilation is provided by energy recovery ventilators (ERVs). |
|                                        |                                | Efficiency  | Furnace Efficiency: 80%<br>Cooling COP: 3.3                                                                                                                                                            |                              | Efficiency  | Heating COP: 3.31<br>Cooling COP: 3.29<br>ERV effectiveness: 75% sensible<br>60% latent                      |                                 | Efficiency                                                                            | Heating COP: 3.92<br>Cooling COP: 7.68<br>ERV effectiveness: 85% sensible<br>75% latent                           |
|                                        |                                | Fan Power   | Central fan: 0.9 W/cfm<br>Supply fans: 0.3 W/cfm                                                                                                                                                       |                              | Fan Power   | Central fan: 0.9 W/cfm<br>Supply fan: 0.3 W/cfm                                                              |                                 | Fan Power                                                                             | Central fan: 0.9 W/cfm<br>Supply fan: 0.3 W/cfm                                                                   |
| System Description                     | System 6<br>NECB Table 8.4.4.7 | Serving     | Corridors                                                                                                                                                                                              | Make-up air unit             | Serving     | Corridors                                                                                                    | Make-up air unit                | Serving                                                                               | Corridors                                                                                                         |
|                                        |                                | Description | Make-up air unit equipped with hot water and chilled water coils. Hydronic baseboards for auxiliary heating.                                                                                           |                              | Description | Heat pump make-up air unit for Heating and cooling.                                                          |                                 | Description                                                                           | Make-up air unit (water loop heat pump type) served by a geo-exchange loop for heating and cooling.               |
|                                        |                                | Efficiency  | Refer to hot water loop and chilled water lop                                                                                                                                                          |                              | Efficiency  | Heating COP: 3.31<br>Cooling COP: 3.29                                                                       |                                 | Efficiency                                                                            | Heating COP: 3.92<br>Cooling COP: 7.68                                                                            |
|                                        |                                | Fan Power   | Total fan power: 1 W/cfm                                                                                                                                                                               |                              | Fan Power   | Total fan power: 1 W/cfm                                                                                     |                                 | Fan Power                                                                             | Total fan power: 1 W/cfm                                                                                          |
|                                        | Electric Unit Heater           | Serving     | Storage, stairs and M&E rooms                                                                                                                                                                          | Electric Unit Heater         | Serving     | Storage, stairs and M&E rooms                                                                                | Electric Unit Heater            | Serving                                                                               | Storage, stairs and M&E rooms                                                                                     |
|                                        |                                | Description | Equipped with electric resistance coil                                                                                                                                                                 |                              | Description | Equipped with electric resistance coil                                                                       |                                 | Description                                                                           | Equipped with electric resistance coil                                                                            |
|                                        |                                | Fan Power   | 0.3 W/cfm                                                                                                                                                                                              |                              | Fan Power   | 0.3 W/cfm                                                                                                    |                                 | Fan Power                                                                             | 0.3 W/cfm                                                                                                         |
| Fan Control                            | Common Spaces                  |             | 30 cfm/door constant pressurization for Building Code Baseline<br>15 cfm/door constant pressurization for High Performance Design<br>10cfm/door constant pressurization for Net-Zero Ready Performance |                              |             |                                                                                                              |                                 |                                                                                       |                              |
|                                        | Residential suites             |             | 54.2 cfm/suite continuous with 100 cfm boost 2hrs/day<br>Zone level fan and ERV fans run together                                                                                                      |                              |             |                                                                                                              |                                 |                                                                                       |                                                                                                                   |
|                                        | Amenity Spaces                 |             | based on ASHRAE 62.1 2013 requirements                                                                                                                                                                 |                              |             |                                                                                                              |                                 |                                                                                       |                                                                                                                   |
| Indoor Design Temperature              | Space Type                     |             |                                                                                                                                                                                                        | Heating (deg. F)             |             | Cooling (deg. F)                                                                                             |                                 |  |                                                                                                                   |
|                                        |                                |             |                                                                                                                                                                                                        | Occupied                     | Unoccupied  | Occupied                                                                                                     | Unoccupied                      |                                                                                       |                                                                                                                   |
|                                        | Common Spaces and Corridors    |             |                                                                                                                                                                                                        | 64.4                         | 64.4        | 75.2                                                                                                         | 75.2                            |                                                                                       |                                                                                                                   |
|                                        | Vestibules & Remote Corridors  |             |                                                                                                                                                                                                        | 64.4                         | 64.4        | NA                                                                                                           | NA                              |                                                                                       |                                                                                                                   |
|                                        | Residential Suites             |             |                                                                                                                                                                                                        | 71.6                         | 64.4        | 75.2                                                                                                         | 75.2                            |                                                                                       |                                                                                                                   |
|                                        | Remote Storage and M&E Rooms   |             |                                                                                                                                                                                                        | 55                           | 55          | NA                                                                                                           | NA                              |                                                                                       |                                                                                                                   |
| Heating/Cooling Supply Air Temperature | Heating                        |             |                                                                                                                                                                                                        | 90°F                         |             |                                                                                                              |                                 |                                                                                       |                                                                                                                   |
|                                        | Cooling                        |             |                                                                                                                                                                                                        | 55°F                         |             |                                                                                                              |                                 |                                                                                       |                                                                                                                   |

| Central Plant                   |                                               |                                                                                                                                                                                                 |                                                        |                                        |                                        |                                                                                                                                                                            |
|---------------------------------|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|----------------------------------------|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Chilled Water Loop              | Building Code Baseline                        |                                                                                                                                                                                                 | High Performance Design                                |                                        | Net-Zero Ready Performance             |                                                                                                                                                                            |
|                                 | Description                                   | 1 Electric water cooled chiller<br>44°F supply, 56°F return<br>Primary-only loop with variable flow<br>constant speed pump- 22 W/GPM pump<br>specific power<br>Cooling Tower for heat rejection | Description                                            | NA                                     | Description                            | NA                                                                                                                                                                         |
|                                 | Efficiency                                    | Chiller COP: 5.5                                                                                                                                                                                | Efficiency                                             | NA                                     | Efficiency                             | NA                                                                                                                                                                         |
| Hot Water Loop                  | Description                                   | 1 Gas-fired condensing boiler<br>constant speed pump<br>180°F Supply, 140°F Return<br>Primary-only loop with variable flow<br>19 W/GPM pump specific power                                      | Description                                            | NA                                     | Description                            | NA                                                                                                                                                                         |
|                                 | Efficiency                                    | 90% thermal efficiency                                                                                                                                                                          | Efficiency                                             | NA                                     | Efficiency                             | NA                                                                                                                                                                         |
| Heat Transfer Loop Water Loop   | Description                                   | NA                                                                                                                                                                                              | Description                                            | NA                                     | Description                            | Ground source VRF systems tied to<br>Geothermal HX.<br>Geothermal HX pump power - 19 W/gpm<br>(variable speed). Mixed water loop pump<br>power - 19 W/gpm (variable speed) |
|                                 | Efficiency                                    | NA                                                                                                                                                                                              | Efficiency                                             | NA                                     | Efficiency                             | N/A                                                                                                                                                                        |
| Domestic Hot Water              | DHW Heater                                    | Dedicated DHW boiler:<br>80% efficient                                                                                                                                                          | DHW Heater                                             | Dedicated DHW boiler:<br>96% efficient | DHW Heater                             | Air to water heat pump DHW heaters; COP<br>3.5                                                                                                                             |
|                                 | Fixture Type                                  | As per NECB                                                                                                                                                                                     | Fixture Type                                           | Low-flow fixtures                      | Fixture Type                           | Low-flow fixtures                                                                                                                                                          |
|                                 | Lavatory<br>Faucet                            | 5.7 LPM                                                                                                                                                                                         | Lavatory<br>Faucet                                     | 1.90 LPM                               | Lavatory<br>Faucet                     | 1.90 LPM                                                                                                                                                                   |
|                                 | Shower head                                   | 7.6 LPM                                                                                                                                                                                         | Shower head                                            | 5.70 LPM                               | Shower head                            | 5.70 LPM                                                                                                                                                                   |
|                                 | Kitchen<br>Faucet                             | 8.35 LPM                                                                                                                                                                                        | Kitchen Faucet                                         | 5.70 LPM                               | Kitchen<br>Faucet                      | 5.70 LPM                                                                                                                                                                   |
| Internal Loads                  |                                               |                                                                                                                                                                                                 |                                                        |                                        |                                        |                                                                                                                                                                            |
| Lighting Power Density<br>(LPD) | Space Type                                    |                                                                                                                                                                                                 | Building Code Baseline<br>Table SB 4.2.1.6<br>LPD W/m² | High Performance Design<br>LPD W/m²    | Net-Zero Ready Performance<br>LPD W/m² |                                                                                                                                                                            |
|                                 | Common Spaces<br>(corridors, vestibules etc.) |                                                                                                                                                                                                 | 7.1                                                    | 7.1                                    | 5.68                                   |                                                                                                                                                                            |
|                                 | Residential Suites                            |                                                                                                                                                                                                 | 5                                                      | 5                                      | 4                                      |                                                                                                                                                                            |
|                                 | Lobbies                                       |                                                                                                                                                                                                 | 10.8                                                   | 10.8                                   | 8.64                                   |                                                                                                                                                                            |
|                                 | Stairs                                        |                                                                                                                                                                                                 | 6.2                                                    | 6.2                                    | 4.98                                   |                                                                                                                                                                            |
| Lighting Controls               | Same as ASHRAE 90.1-2013 Table 9.6.1          |                                                                                                                                                                                                 |                                                        |                                        |                                        |                                                                                                                                                                            |
| External Lighting               | Peak Watts                                    | 2.4 kW Table SB 4.2.3.1 for Building Code Baseline and High Performance Design, 1.2 kW for Net-Zero Ready Performance                                                                           |                                                        |                                        |                                        |                                                                                                                                                                            |
|                                 | Schedule                                      | Photocell control                                                                                                                                                                               |                                                        |                                        |                                        |                                                                                                                                                                            |
| Process Loads                   | Suites                                        | 5 W/m² for Building Code Baseline and High Performance Design, 4 W/m² for Net-Zero Ready Performance                                                                                            |                                                        |                                        |                                        |                                                                                                                                                                            |
|                                 | Other Space Types                             | As per NECB Space type internal load (Table A-8.4.3.2. (2)-B)                                                                                                                                   |                                                        |                                        |                                        |                                                                                                                                                                            |
|                                 | Elevators                                     | 3.2 kW total as per TK Elevator                                                                                                                                                                 |                                                        |                                        |                                        |                                                                                                                                                                            |
| Occupancy                       | NECB Defaults for space type                  |                                                                                                                                                                                                 |                                                        |                                        |                                        |                                                                                                                                                                            |



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