Energy Strategy Report

The Radiator

Hullmark

Toronto, ON

July 12, 2022

Revision: 2

Issued for: Site Plan Application (SPA)

EXECUTIVE SUMMARY

Hullmark has retained EQ Building Performance (EQ) to develop an Energy Strategy Report for the The Radiator project (the "Proposed Development"). The Proposed Development is a high-rise residential development consisting of a 25-storey tower and a 21-storey tower, with 658 units, associated amenities, at grade commercial flex area, as well as below-grade parking.

For the purposes of this report, all three Tiers of the current version of the Toronto Green Standard (version 4) have been evaluated, indicated as Scenario's 1-3. A summary of predicted performance is available in Table i.

Table i - Predicted Project Performance

	Scenario 1	Scenario 2	Scenario 3
Total Energy Intensity - (ekWh/m^2)	134.6	100.0	74.3
Total Energy (eMWh)	**5,986**	**4,447**	**3,303**
% Savings vs Scenario 1	21%	41%	56%
GHG Intensity (kg CO_2e/m^2)	15.0	9.9	5.0
Total GHGs (tonnes CO_2e)	**667**	**442**	**221**
% Savings vs Scenario 1	25%	50%	75%
Thermal Energy Demand Intensity (ekWh/m^2)	48.9	29.5	15.0
Total Thermal Demand (eMWh)	**2,174**	**1,312**	**667**
% Savings vs Scenario 1	30%	58%	79%

If the development were to pursue Tier 2 or higher performance, it may be eligible for up to **$1,948,478 as a development charge refund**, using current development charge rebate rates.

This report outlines design strategies to achieve each of the presented targets. Advanced measures such as district energy systems and solar PV are recommended for further exploration, however, further detailed analysis is outside the scope of this report. Design options are also presented to provide enhanced resilience for the Proposed Development and should be evaluated further on a feasibility and cost basis.

This report is for the purposes of the rezoning submission and meets the requirements of the Energy Strategy Terms of Reference. The strategies outlined in this report should be evaluated by the design team throughout design development. Using a combination of strategies from the energy strategy report, the Proposed Development can achieve its minimum energy performance requirements.

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ACRONYMS / DEFINITIONS

Compactness Ratio – Ratio of Modelled Floor Area to exterior above-grade envelope area (window, wall, and roof). The more compact a building, the less envelope there is for heat loss.

CEDI – Cooling Energy Demand Intensity (kWh/m^2) – Total cooling demand within the building (primarily reliant on building envelope and ventilation loads and internal heat gain) divided by the Modelled Floor Area (MFA)

EUI – Energy Use Intensity (ekWh/m^2) – Total energy use within the building divided by the Modelled Floor Area (MFA). One of three energy modeling metrics within the TGS.

GFA - The total area of all floors in a building between the outside faces of the exterior walls as reported in the architectural statistics.

GHGI – Greenhouse Gas Intensity (kgCO_2/m^2) – Total carbon used within the building, calculated using carbon factors from SB-10, divided by the Modelled Floor Area (MFA). One of three energy modeling metrics within the TGS.

MFA – Modelled Floor Area – Total enclosed floor area of the building as reported in modelling software, excluding exterior areas and parking areas.

SB-10 – Supplementary Standard SB-10 – Ontario Building Code energy requirements for Part 3 buildings.

SPA – Site Plan Application

TEDI – Thermal Energy Demand Intensity (kWh/m^2) – Total heating demand within the building (primarily reliant on building envelope and ventilation load) divided by the Modelled Floor Area (MFA). One of three energy modeling metrics within the TGS.

TGS - Toronto Green Standard

1 INTRODUCTION

1.1 DEVELOPMENT SUMMARY

The Proposed Development is a high-rise residential development consisting of a 25-storey tower and a 21-storey tower, with 658 units, associated amenities, at grade commercial flex area, as well as below-grade parking. The project is currently at the rezoning and site plan application stage of development and design decisions are still fluctuating. Based on preliminary drawings and discussions with the team, this report assumes the following design attributes:

- GFA: 44,470m^2
- 658 Suites
- Window to wall ratio of approximately 40%
- High performance double glazed window assembly
- Mix of spandrel and masonry/precast opaque wall assemblies
- Compactness ratio of 50%
- High performance HVAC plant with heat recovery in suites
- Variable speed circulation pumps and fans
- Low flow plumbing fixtures
- The project is not yet committed to pursuing any voluntary higher performance standards.

Figure 1 – Proposed Development Concept Plan[1]

1.2 PURPOSE OF THIS REPORT

The purpose of the Energy Strategy Report is to identify opportunities for design excellence early in the planning phase. The City of Toronto has developed a number of sustainability policies in order to address climate change, with particular focus on net-zero development and energy resilience. For developments

[1] Development Concept Plan image taken from drawings by Sweeny & Co Architects, dated January 31, 2022

greater than 20,000 sq.m. or within a Community Energy Plan area approved by Council, the City of Toronto has introduced the requirement for an Energy Strategy Report. The intent of the report is outlined in the Energy Strategy Terms of Reference and encourages projects to:

- Take advantage of existing or planned energy infrastructure, passive design, and renewable energy
- Consider energy sharing for multi-building developments
- Consider increased resiliency such as strategic back-up power capacity
- Identify innovative solutions to reduce energy consumption
- Explore engaging private investment in energy sharing systems

While some of these are outside the scope of the developer, or the project level, they have been incorporated into this report as applicable for the benefit of the design team.

While these strategies are discussed and identified during re-zoning at high level, they can be further developed during the SPA process in combination with TGS requirements to inform design.

1.3 HOW TO READ THIS REPORT

The goal of this report is to present a roadmap of performance towards net zero by 2028 as well as additional sustainability measures that relate to energy performance. This intent of this report is not to hold developments accountable to the energy and resiliency strategies discussed within. It is worth noting that this project is in the early stages of development and that design decisions further down the line may result in the strategies in this report becoming more, or less, feasible.

Following this introduction, the report is organized into seven additional sections, each of which can be read as its own stand-alone chapter.

- SECTION 2 gives an overview of the Toronto Green Standard requirements and the energy targets evaluated within this report;
- SECTION 3 outlines the predicted energy performance of the project in steps towards a near net-zero performance;
- SECTION 4 provides an overview of the recommended design alternatives that should be considered to meet each of the scenarios reviewed;
- SECTION 5 discusses advanced design opportunities to be explored as design progresses;
- SECTION 6 explores potential financial incentives;
- SECTION 7 provides recommended next steps;
- THE APPENDICES provide additional detail on predicted performance, additional design guidance, as well as the City of Toronto Resilience Checklist.

2 TORONTO GREEN STANDARD - NEAR ZERO EMISSIONS DEVELOPMENT

Version 4 of the TGS came into effect on May 1, 2022, with energy targets aligned with the City of Toronto framework requiring near zero emissions levels for all new developments by 2028. This is done by increasing performance levels every 4 years. In all cases, Tier 1 is mandatory for all new developments in the city, while Tier 2 and above are optional increased performance levels incentivized with a development charge refund.

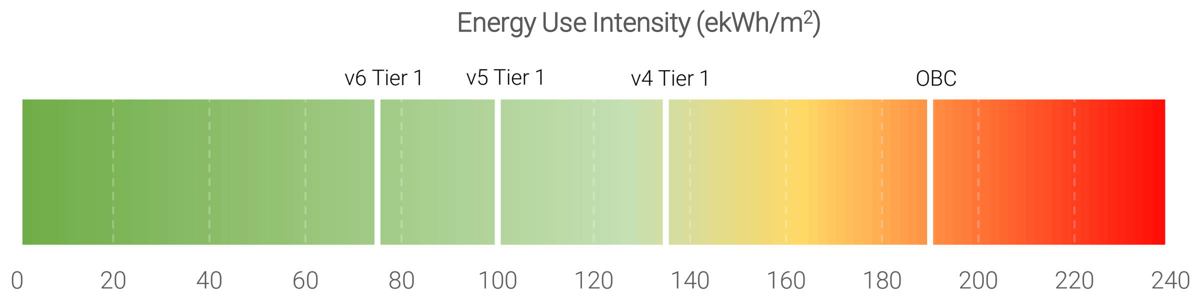
The energy requirements for Mid to High-Rise Residential & All Non-Residential development are outlined in the City of Toronto Zero Emissions Building Framework[2], and include the following three metrics:

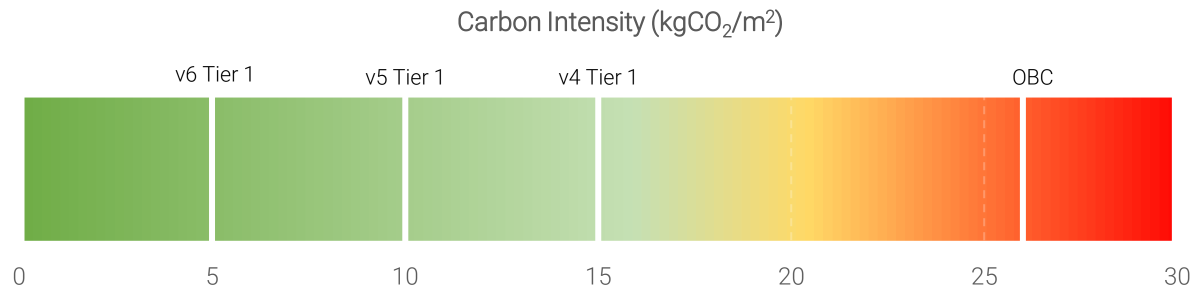
Energy Use Intensity – EUI – ekWh/m2 – Annual building energy use, divided by modelled floor area

Thermal Energy Demand Intensity – TEDI – kWh/m2 – Annual heating load, divided by the modelled floor area. TEDI excludes the effects of mechanical efficiencies (e.g. condensing boilers) but does include passive systems such as air heat recovery, solar gains, and internal gains.

Greenhouse Gas Intensity – GHGI – kgCO2e/m2 – Annual greenhouse gas emissions, divided by the modelled floor area. The annual average carbon emission factors currently listed in OBC SB-10 are used for this calculation.

It should be noted that minimum performance targets are determined by the date a development, or phase of development, submits for an initial SPA. Therefore, it is feasible that certain phases of projects submitted for rezoning today will be subject to future versions of the TGS, and therefore stricter minimum performance requirements.





[2] https://www.toronto.ca/wp-content/uploads/2017/11/9875-Zero-Emissions-Buildings-Framework-Report.pdf

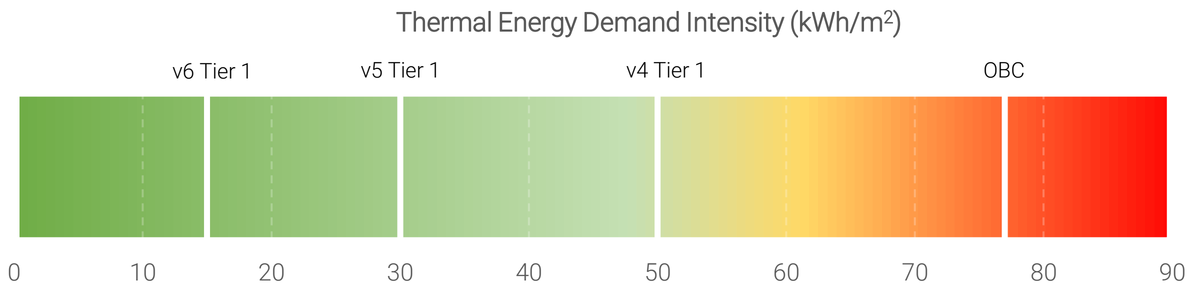


Figure 2 - TGS Performance Targets Over Time

2.1 DEVELOPMENT SPECIFIC ENERGY TARGETS

The Development team is committed to creating a high performance community and meeting the TGS minimum performance requirements at the time of the initial SPA submission. This report suggests design solutions in steps in order to achieve a *Near Zero Emissions* level of performance. This design reflects the highest level of performance, as outlined in the *Zero Emissions Buildings Framework.* To achieve full net-zero status, the remaining energy use identified in this scenario would be provided by renewable energy sources.

Table 1 - Performance Levels Analyzed

Scenario		Description
1	TGS version 4 Tier 1 (2022)	**Baseline** level of performance. Current minimum TGS performance, in effect as of May 1, 2022.
2	TGS version 5 Tier 1 (2025)	**High level** of performance. Minimum TGS performance for initial SPA beginning in 2025.
4	TGS version 6 Tier 1 (2028)	**Aspirational** performance, reflecting Near Zero Emissions. Minimum TGS performance for initial SPA beginning in 2028.

As identified in Table 1 above, these minimum performance targets are set to change on a 3-year schedule, and tied to the date of SPA submission[3]. Based on project specific timelines, the anticipated minimum performance requirements of this project are outlined in Table 2 , indicated by phase.

[3] Additional details on the transition of TGS targets are available in the Design Guidance that can be found at the end of this report.

Table 2 - Anticipated Minimum Performance Levels of the Development

Phase	Projected SPA Date	Minimum Performance Requirement
1 / A	Q3 2022	Baseline Performance (TGS v4 Tier 1)

In line with Greenhouse Gas Intensity requirement of the TGS, predicted greenhouse gas emissions as well as predicted energy use will be presented. Referencing the Ontario Building Code (OBC), a factor of **0.050 kg CO_2e/kWh** for grid supplied electricity, and **1.899 kg CO_2e/m^3** for natural gas will be applied.

Should Hullmark choose to pursue a higher tier of the Toronto Green Standard for the The Radiator project, the potential benefits include:

- A **Development Charge refund of up to $1,948,478** could be received[4];
- Increased resiliency of the building;
- Lower energy use and lower operating costs;
- Mitigated carbon pricing risk;
- Reduced infrastructure requirements;
- Additional high performance building certifications may be feasible; and
- Projects that achieve Tier 2 and above are recognized as leaders in their field

3 ENERGY ANALYSIS

The City of Toronto *Zero Emissions Building Framework* outlines sample designs that were used in setting the targets for future versions of the TGS by end use and by building type. This information has been used to predict the energy use of the building corresponding to the scenarios outlined in Table 1.

Predicted energy use and resulting carbon emissions for each of the design options is presented in Table 3.

[4] Based on Tier 2 Caps published by the City of Toronto, as well as the The Radiator Development Statistics prepared by Sweeny & Co Architects, dated 22/04/20.

Table 3 - Predicted Energy, Thermal Demand and Carbon Performance[5]

	Scenario 1	Scenario 2	Scenario 3
Total Energy Intensity - (ekWh/m^2)	**134.6**	**100.0**	**74.3**
Total Energy (eMWh)	5,986	4,447	3,303
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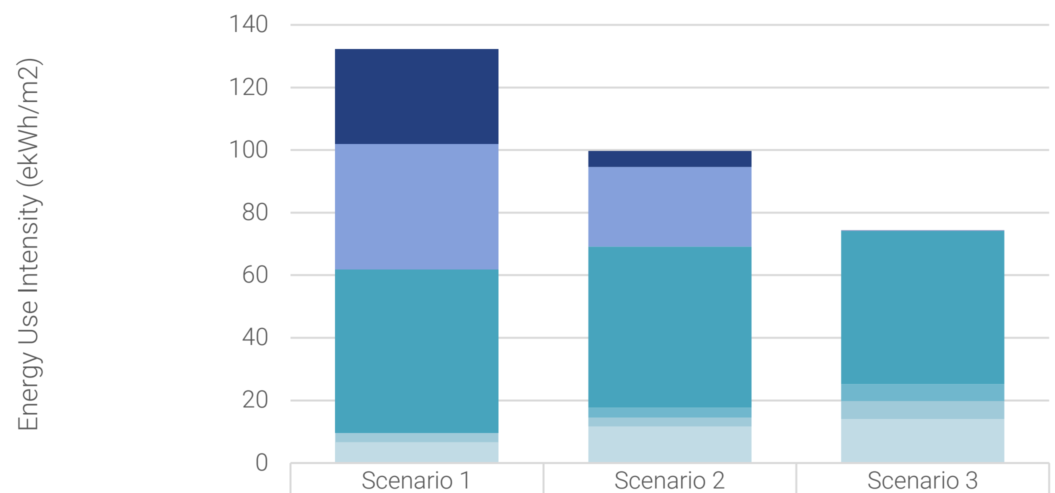


	Scenario 1	Scenario 2	Scenario 3
DHW/Base Load [Gas]	30.3	5.1	0.1
Space Heating [Gas]	40.1	25.5	0.1
Base Loads [Elec]	52.3	51.4	49
DHW Heating [Elec]	0	3.2	5.4
Space Heating [Elec]	2.9	2.8	5.8
Space Cooling [Elec]	6.7	11.7	14

Figure 3 - Predicted Energy Consumption by End-Use

[5] Detailed calculations are available in the softcopy submission in the excel file provided with submission.

4 BUILDING LEVEL DESIGN OPPORTUNITIES

To optimize building performance, passive design improvements should be prioritized to reduce the loads within the building. Once loads are reduced, the mechanical systems can then be designed to minimize the energy needed to meet those loads. Finally, renewable technology and carbon offsets can then be used to deliver net zero performance.

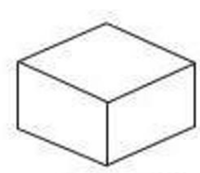
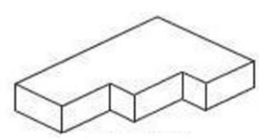
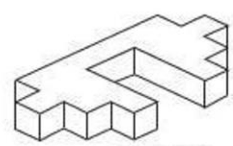
Figure 4 - Key Design Features

4.1 PASSIVE DESIGN MEASURES

Building Massing

Building form and complexity can influence energy use within a building by directly impacting building heating and cooling loads. More wall area per unit of floor area translates to more thermal loss per square meter, or TEDI, a key metric for TGS. Through internal investigation, EQ has found that a difference in a building's compactness ratio of 13% lead to influencing TEDI by more than 20%.

Table 4 – Building Compactness TEDI Impact

			
	Compact Design	Typical Design	Articulated Design
Floor area : Wall area Ratio	41%	48%	54%
TEDI (kWh/m^2)	55.8	62.5	71.7
Difference from Typical TEDI	-10%	-	+14%

Based on currently available drawings, the The Radiator project has a compactness ratio of **50%.** For comparison, the TEDI metric of the TGS was designed based on a building archetype with a compactness ratio of 40%.

Some strategies to developing a more compact building design include:

- Reduce amount of inset balconies on the building. Where present, limit depth.
- Create a simplified floor plate with reduced protrusions.
- Create larger floor plates. Tall thin towers inherently have a higher compactness ratio.

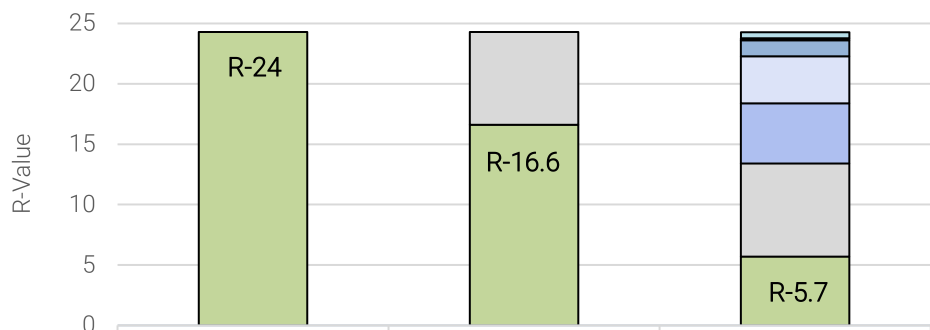
Opaque Envelope

Figure 5 below demonstrates the impact thermal bridging has on opaque envelope performance. The thermal bridging impact of repetitive elements such as structural studs and spandrel back pans have been reflected in the Building Code for several years, and greatly reduce the effective performance of the wall as seen in

Figure 5. However, poor envelope detailing at building interfaces, which traditionally have been ignored in energy performance Codes, can be seen to have an even greater sum impact.

While it is too early in design for envelope interface details or construction details to be developed, special consideration should be given to the thermal bridging impact of architectural details, which may not have been previously prioritized. These include:

- Opaque Wall and Glazing Interfaces
- Interior and Exterior Wall Interfaces
- Slab bypasses
- Balconies
- Corners
- Parapet and terrace details



	Nominal Performance	Repeated Structural Elements	All Thermal Bridging
Parapet			0.5
Terrace			0.2
Balconies			1.3
Slab Edges			3.9
Window Perimeters			5.0
Studs, Back-pans, etc.		7.7	7.7
Modelled Performance	24.3	16.6	5.7

Figure 5 - Impact of Thermal Bridging on Opaque Envelope Performance[6]

Three key strategies to improving the opaque building envelope performance and their relative priority are:

Reduce the number of thermal bridges – The best way to lessen the impact of thermal bridging on the opaque wall is to reduce the number of bridges. Reducing protrusions eliminates corner intersections and allows for larger opaque wall areas. Reducing balcony areas by using cantilevered rather than inset balconies, or even eliminating balconies can significantly improve envelope performance. Using larger glazed areas reduces window perimeters which improves both the opaque and glazing performance.

Improve thermal bridge performance – Once the number of thermal bridges has been reduced, taking effort to improve the ones remaining is important. BC Hydro has developed a *Building Envelope Thermal Bridging Guide* which includes a vast library of sample architectural details ranging from poor to efficient which can be used as a guide to improving bridge details.

Improve the clear wall performance with continuous insulation – While it may seem like increasing the clear wall performance would be a priority, the building envelope is only as strong as its weakest links; namely it's thermal bridges. A poor thermal bridge will have a much more devastating effect the greater the clear wall performance is. Once the bridges have been dealt with, improving the amount of insulation, especially continuous insulation in the clear wall will truly maximize opaque wall performance.

Fenestration

In terms of glazing products, a traditional high performance double glazing assembly will likely not be acceptable for meeting minimum targets. In order to achieve the minimum requirements of TGS, increased performance double glazed double low-e coated glazing, or triple glazing will likely need to be considered. When choosing a glazing product, consideration for the solar heat gain coefficient (SHGC) must also be taken. A higher SHGC will allow for passive heating, reducing the thermal demand; while a lower SHGC will reduce over-heating in shoulder seasons and reduce cooling loads in the summer. Reduced glazing areas will also help to reduce loads within the building. A glazing to wall area ratio of 35% to 40% is often considered a 'sweet spot', and will help optimize the performance of the building envelope while maintaining occupant views, daylight access, and improved thermal comfort.

Consideration should be given to the potential changes in climate over the lifetime of the building rather than just the current climate in which the building envelope was designed. With global warming, heating loads are

[6] The nominal performance of the building envelope is the sum thermal performance of the clear wall materials in the building envelope. It does not account for any thermal bridges.

decreasing and cooling loads are increasing in our climate. One option to balance glazing performance may be electrochromic glazing (glass that tints in response to solar intensity or sun position), which can maximize daylighting and views in regularly occupied spaces as well as have a positive impact on the building cooling and heating loads.

Design Alternatives

As design progresses through Site Plan Approval and building code review, the design teams will need to consider a number of passive design measures. In Table 5 below, a number of design alternatives have been evaluated for the The Radiator project covering current and future TGS minimum performance requirements.

Table 5 - Passive Design Considerations

Energy Conservation Measures	Necessity for Compliance			Design Decision Timing
	v4 Tier 1 (2022)	V5 Tier 1 (2025)	V6 Tier 1 (2028)	
Opaque Wall				
Continuous insulation	+ + +			Design Development
Improved thermal bridging detailing	+ + +			Design Development
Massing optimization[7]	+	+ +	+ + +	Concept
Reduced and/or thermally broken balconies	+ +			Schematic Design
Increased roof insulation	+ +			Design Development
Improved air tightness	n/a[8]	+ +		Design Development
Fenestration				
Maximum 40% vision to wall ratio	+ + +			Schematic Design
High performance double glazed assembly, thermally broken aluminum frame	Likely not sufficient			Design Development
High performance double glazed, double low-e assembly, thermally broken aluminum frame	+ +			Design Development
Standard triple glazed assembly, thermally broken aluminum frame	+ + +			Design Development
High performance triple glazed assembly with fiberglass frame	+	+	+ + +	Design Development

[7] For example, may include outset rather than inset balconies, simplified floorplate geometry, reduced setbacks, and consolidating glazing to reduce framing area.
[8] Credit can't be taken at site plan approval stage as post-construction verification is required via a whole building air tightness test.

4.2 ACTIVE DESIGN MEASURES

Ventilation

Ventilation with fresh air is a significant factor contributing to building heating and cooling loads as well as building energy and carbon use. In a high-rise residential building specifically, corridor pressurization rates can vary greatly between buildings. When using lower corridor pressurization rates, ensuring a tight building envelope with reduced infiltration is required to ensure the building is properly balanced. Reducing exhaust requirements in suites will also help pressurization with lower corridor ventilation rates. Once ventilation rates have been right-sized, using high efficiency heat recovery to further reduce energy use is a key design strategy in a high performing building.

Table 6 - Ventilation Design Considerations

<table>
<tr><th rowspan="2">Energy Conservation Measures</th><th colspan="3">Necessity for Compliance</th><th rowspan="2">Design Decision Timing</th></tr>
<tr><th>v4 Tier 1 (2022)</th><th>V5 Tier 1 (2025)</th><th>V6 Tier 1 (2028)</th></tr>
<tr><td>Corridor ventilation – avg 30 cfm/suite</td><td colspan="3">Likely not sufficient</td><td>Design Development</td></tr>
<tr><td>Corridor ventilation – avg 15 cfm/suite[9]</td><td colspan="3">+ + +</td><td>Design Development</td></tr>
<tr><td>Corridor ventilation – code minimum- requires compartmentalization to remove pressurization requirements</td><td colspan="2">+</td><td>+ +</td><td>Design Development</td></tr>
<tr><td>Code minimum ventilation in other areas</td><td colspan="3">+ + +</td><td>Design Development</td></tr>
<tr><td>Recirculating range hoods</td><td>+</td><td>++</td><td>+++</td><td>Design Development</td></tr>
<tr><td>Ductless dryers</td><td>+</td><td>++</td><td>+++</td><td>Design Development</td></tr>
<tr><td>65% Efficient air side heat recovery in suites</td><td>+ +</td><td colspan="2">Likely not sufficient</td><td>Design Development</td></tr>
<tr><td>80%+ Efficient air side heat recovery in suites</td><td colspan="2">+</td><td>+ + +</td><td>Design Development</td></tr>
<tr><td>Corridor heat recovery</td><td>+</td><td>+ +</td><td>+ + +</td><td>Design Development</td></tr>
</table>

Domestic Hot Water

Domestic hot water use in high-rise residential buildings is typically one of the largest energy and carbon uses and savings need to be targeted to achieve a high performance design. While domestic hot water loads can be reduced through low flow plumbing fixtures, there are limitations to how much impact they can have. At higher performance levels, a transition to a high efficiency electric heat pump heating source, or incorporation of sewage or drain water heat recovery may need to be considered in order to meet the corresponding carbon and energy targets.

[9] In order to maintain proper building pressurization, improved air tightness in the building envelope will be required.

Table 7 – Domestic Hot Water Considerations

Energy Conservation Measures	Necessity for Compliance v4 Tier 1 (2022)	V5 Tier 1 (2025)	V6 Tier 1 (2028)	Design Decision Timing
20% reduction in plumbing fixtures flow	Likely not sufficient			Design Development
35% reduction in plumbing fixtures flow	+ + +		-	Design Development
Sewage / Drain Water Heat Recovery	+ +		+ + +	Schematic Design
Central domestic hot water heat pump	+ +		+ + +	Design Development
DHW Preheat from geothermal loop	+[10]			Schematic Design

Mechanical and Other Opportunities

As design progresses, a preliminary energy model will be developed to evaluate different design opportunities to ensure an optimized active design. As minimum requirements and design goals shift towards low-carbon targets, high efficiency systems and electrification of designs will be required.

Some advanced design measures have been highlighted in the table below, and are more thoroughly detailed in Section 5.3 - Additional Advanced Energy Solutions; of this report.

Table 8 - Active Design Considerations

Energy Conservation Measures	Necessity for Compliance v4 Tier 1 (2022)	V5 Tier 1 (2025)	V6 Tier 1 (2028)	Design Decision Timing
Mechanical System				
Fan Coil system	+/-	Likely not sufficient – some fuel switch required		Schematic Design
Water Source Heat Pump system	+			Schematic Design
Water-source VRF system	+ +			Schematic Design
Air-source heat pump / VRF system	+ +		+ + +	Schematic Design
District Energy[11]	varies[12]			Schematic Design
On-site Renewable Energy Generation	+		+ + +	Design Development
Geothermal Energy	+ + +			Schematic Design
Other Considerations				
EnergySTAR appliances	+ + +			Design Development
30% reduction in lighting power density	+++	-		Design Development
50% reduction in lighting power density[13]	+ +	+ + +		DD

[10] Heavily dependent on building load profile and balance.
[11] See Section5.1 of this report for details on district energy analysis.
[12] Impact of district energy system is highly dependent on system efficiency and carbon factors
[13] Achieving lighting reductions in this range may require design changes to ensure minimum lighting levels are achieved such as strategic window placement and light coloured interior surfaces

5 ADVANCED ENERGY SOLUTIONS

5.1 DISTRICT ENERGY POTENTIAL

The City of Toronto Zero Emissions Buildings Framework identifies low carbon thermal energy networks / district energy systems as an important strategy in their greenhouse gas emissions reduction targets. These networks may include options such as deep lake water cooling, biofuels, solar heating or waste heat recovery.

According to the City of Toronto DE node scan[14], the project is not located within 500m of a node or potential node for District Energy development. While discussions regarding district energy may have not yet taken place, the project should monitor changes in proposed district energy systems to assess any future opportunities for connection. Detailed energy models and load profiles for this site are outside of the scope of this report, however energy models will be required for SPA and will be developed at that time. These models can be used by the design team to further explore potential district energy solutions, including both development of new district energy systems, or connections to nearby existing / potential systems.

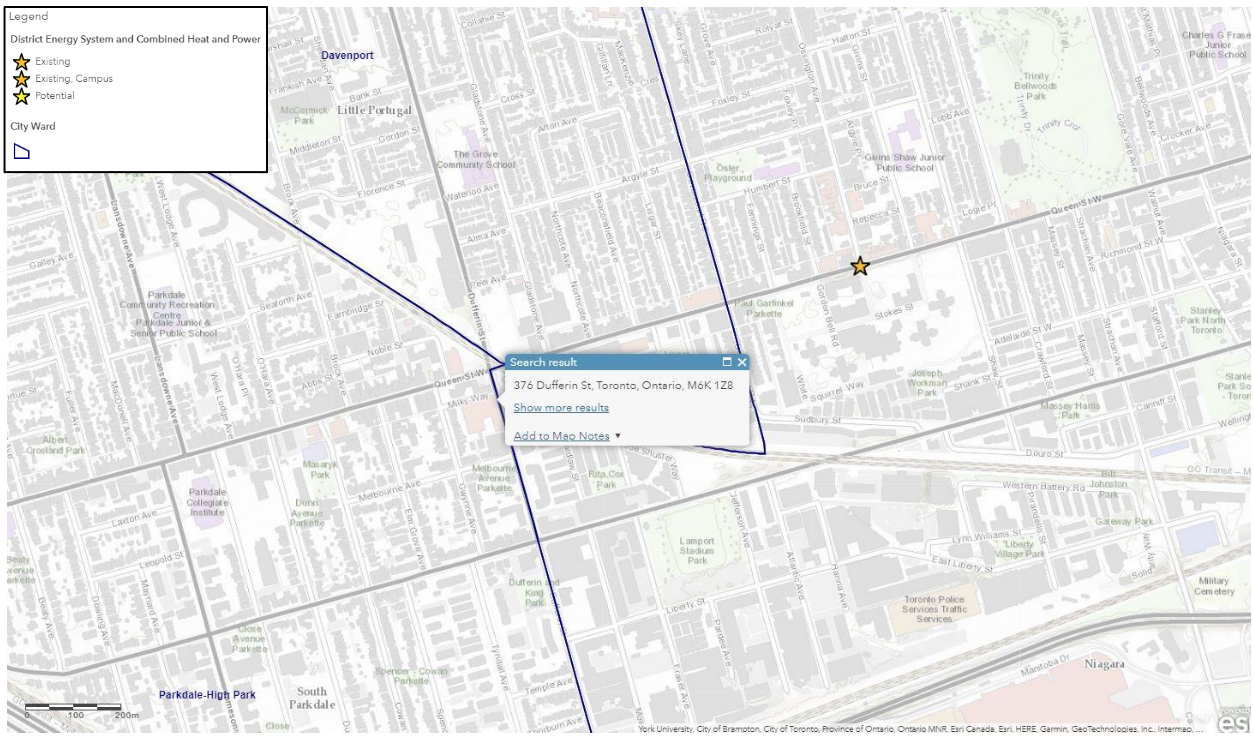


Figure 6 – City of Toronto DE Node Scan

While connecting to an existing district energy system likely isn't feasible for this project, the project team may wish to explore options for on-site district energy solutions where space allows. Benefits of this approach include:

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14 https://www.arcgis.com/home/webmap/viewer.html?webmap=4e58774223774e4c8afaf96473f99706

- Reducing the amount of space needed for in-building mechanical systems, increasing useable GFA for individual buildings.
- Improved reliability and availability of power supply, reducing dependence on the centralized grid. This allows the building to provide energy for both emergency and non-life safety requirements during power outages.
- Help to potentially achieve significant emissions reductions at a relatively low cost due to economies of scale.

At this stage, there are ways to design the building to be district energy ready. To prepare for a future district energy connection, the City of Toronto[15] suggests the following key items be incorporated into building design:

- Install heating and cooling plant equipment on the lower levels for easier integration into a future district system, or provide for a future connection points into the building's thermal piping at ground level
- Provide adequate space at or below ground level for a future energy transfer station
- Provide an easement between the mechanical room and the property line to allow for thermal piping
- Provide two-way pipes placed in the building to carry thermal energy from the district energy network to the section in the building where the future energy transfer station would be located
- Install a low temperature hydronic heating system (e.g. heat pump loop) that is compatible with a district energy system in order to reduce the pipe sizes and associated valves, fittings, etc.

5.2 RENEWABLE STRATEGIES: SOLAR PV

Solar PV is rapidly becoming an economically viable strategy for energy generation at the individual building level, thanks to the price reductions in solar panels over the last several years. As such, it is an important design consideration of low carbon and net zero buildings. Several developments of all types, including residential, institutional, and commercial have already incorporated PV into their designs or retrofitted existing buildings to take advantage of their long term economic benefits. Given the approximate total roof area of the development, it is estimated that at most 1,920 m^2 may be available for solar energy production considering shading, minimum outdoor amenity areas, and mechanical requirements, resulting in the following levels of production in Table 9. Toronto's green roof by-law provides exemptions to green roof area for roof area dedicated to solar PV.

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

Table 9 - Predicted Solar PV Production Potential

System Size (kW)	93
System Size (m^2)	1,920
Annual production (kWh)	322,000
% of energy requirement (Scenario 1)	4.3 %
% of energy requirement (Scenario 3)	9.8 %

Effective solar PV installations require access to adequate sunlight as well as the space needed to house the panels. This creates constraints for high-rise buildings, like The Radiator, which are typified by a small roof area relative to total conditioned area. Given this, on-site solar PV will not be a viable solution to see significant reductions in energy use or to offset a near zero emissions development. If the The Radiator development were to achieve the highest performance levels of the Toronto Green Standard, a minimum of 19,146 m^2 of solar PV area would be required.

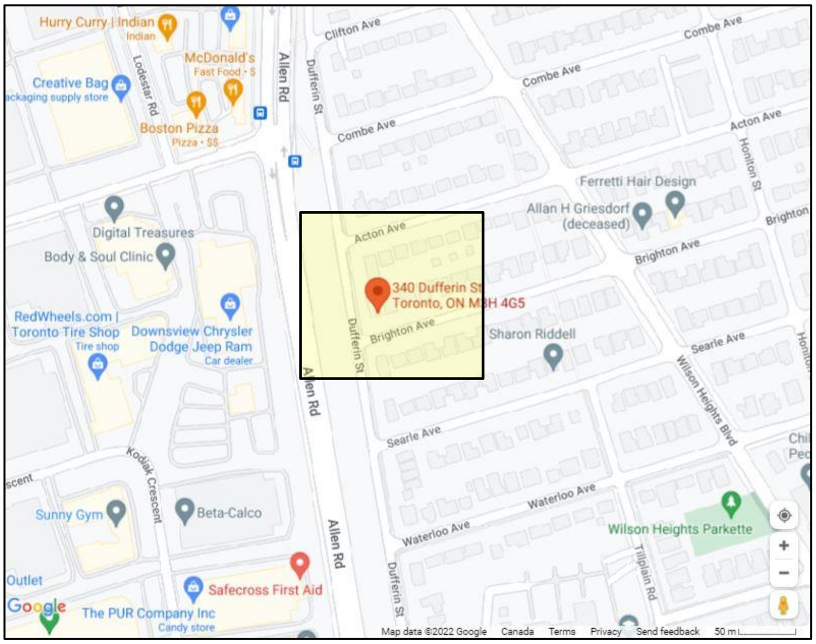


Figure 7 - Solar PV Area Required to Offset Highest Performance Energy

If this project chooses to pursue Tier 2 or higher performance levels, there are some solar related requirements that will need to be met. The site would be required to accommodate future connections to solar PV or solar thermal technologies for 1% of the total building energy. Solar ready features that should be incorporated into design include:

- Designate a portion of the roof for future solar PV and/or solar thermal
- Provide adequate structural capacity in the roof
- Install conduit to the roof from the main electrical room to accommodate future systems
- Designate wall area in the electrical rooms or future system controls
- Where possible, place HVAC or other rooftop equipment to avoid shading of future systems
- Consult NREL's Solar Ready Buildings Planning Guide

Tier 2 also encourages the use of on-site renewable energy. Providing a minimum 5% of total building energy load via renewable energy sources (or 20% through geo-exchange) can meet this optional credit's requirements.

5.3 ADDITIONAL ADVANCED ENERGY SOLUTIONS

The City of Toronto's ambitious net-zero goal for buildings has been analyzed throughout this report. The design team is encouraged to incorporate design and construction strategies in line with this goal, which are designed to reduce electrical demand, carbon emissions and conserve energy compared to a more conventional design.

In the Near Zero Emissions design option, fuel switching occurs by replacing natural gas with electric heat pump based heating and domestic hot water in order to achieve the emissions reductions requirements, as well as aggressive improvements in building envelope thermal and air tightness performance. This is reflective of the net zero emissions mandate outlined by future versions of the TGS, as well as the higher GHG intensity of natural gas compared to the relatively low-carbon electricity grid in Ontario.

Specific advanced energy solutions can be found in the Design Guidance at the end of this report.

Low Carbon Solutions

At this stage of design, low-carbon solutions are still under consideration. If a heat pump or VRF system is used, the high efficiencies achieved with these systems in combination with their electric heat pump based heating components will reduce the building's carbon use by relying on the relatively clean Ontario electricity grid. This would represent a fundamental shift in the primary heating energy source of the building and the resulting carbon impact. Back-up boilers for these systems should be high performance condensing or near-condensing technology, which will reduce carbon compared to traditional systems. Low-flow plumbing fixtures can also be used to minimize the domestic hot water boiler load, further reducing carbon use.

Additional low-carbon solutions such as renewable energy and district energy (discussed in more detail in section 5) have not yet been ruled out, and are undergoing further analysis.

6 FINANCIAL INCENTIVES

Development Charge Refund

Projects that are pursuing higher Tiers of TGS are eligible to receive a partial refund of development charges. The potential refund for this project, based on stats dated July 15, 2022, is shown in Table 10 below.

Table 10 - City of Toronto Development Charge Refund TGS Tier 2 & 3 Cap - Effective November 1, 2021[16]

Category	Amount	Project Count
Residential		
Apartment – two bedroom and larger	$3,522.40	222
Apartment – one bedroom and bachelor	$2,402.54	436
Non-Residential use (per square meter ground floor area)	$40.73	2921.63
Maximum Estimated Development Charge Refund		**$ 1,948,478**

[16]https://www.toronto.ca/wp-content/uploads/2021/10/8dda-Green-Standard-DC-Rates-Nov-1-2021.pdf

While this project is currently estimated to receive up to **$1,948,478 as a development charge refund**, this estimate is subject to change and is dependent on project statistics as well as City of Toronto approvals. The development charge refund caps have changed over time, and the project's potential refund will be based on the caps in place when fees are paid, however this may change in the future.

Sustainable Energy Plan Financing

The City of Toronto operated a Sustainable Energy Plan Financing[17] program that makes loans available to eligible projects at rates equal to the City's cost of borrowing. This financing can support engineering studies, equipment and installation costs, commissioning, and metering purchases or service fees.

Savings by Design

The Savings by Design[18] program by Enbridge is available to projects greater than 50,000 sq.ft. and offers a financial incentive of up to $15,000 for a 15% improvement in energy performance over the building code and an additional $15,000 for building commissioning. A great feature of the Savings by Design program is a mandatory IDP workshop featuring the design team and industry experts – a value of up to $35,000.

7 CONCLUSIONS/RECOMMENDATIONS

The Radiator project will achieve the minimum Toronto Green Standard version 4 Tier 1 requirements. From preliminary analysis, some design considerations the project team might want to explore include:

- Studying the built form of the development from an energy efficiency perspective, including reducing the compactness ratio
- Improving the effective performance of the opaque building envelope, including optimizing or reducing balcony use where appropriate or possible
- Maintaining a vision window to wall ratio of 40% or less
- Reducing domestic hot water natural gas consumption by using low flow fixtures
- Exploring options to de-carbonize space and domestic hot water heating by electrification and heat pump technologies

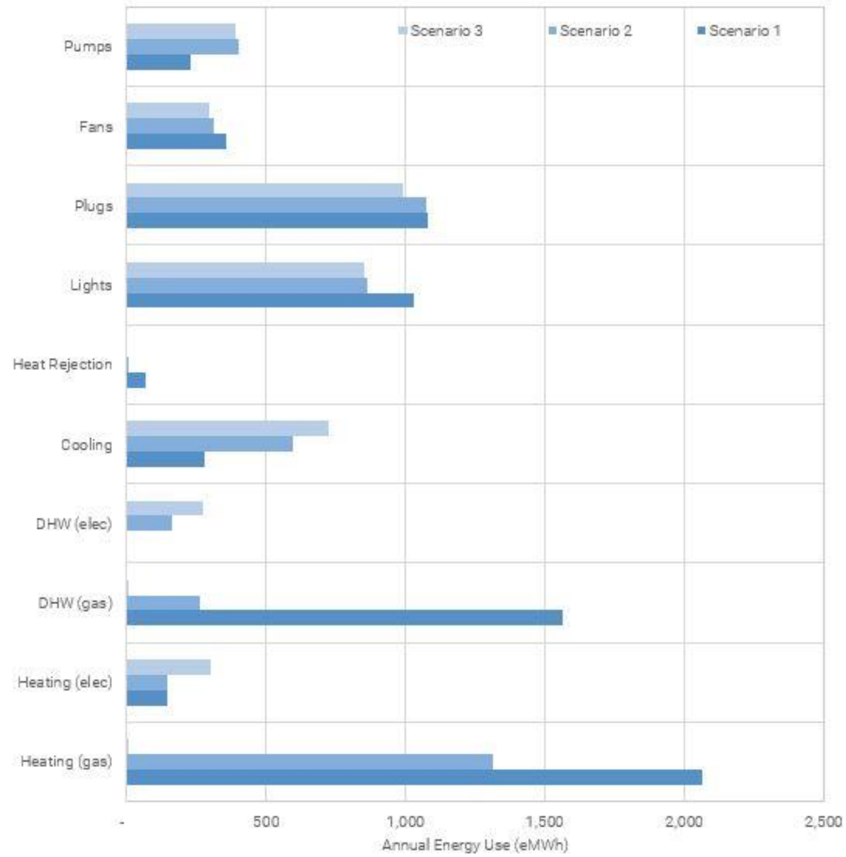
The project team is encouraged, though not required, to explore the feasibility of higher tiers of energy and carbon performance, as well as draw on the *Near Zero Emissions* building design strategies to create a truly sustainable development. The design alternatives, renewable energy, resilience, and advanced energy solutions discussed in this report are recommendations only, and decision to incorporate them into the final design is up to the discretion of the project team. These measures have been included in this report at a high level and detailed cost and feasibility analysis should be done prior to incorporation.

[17] https://www.toronto.ca/legdocs/mmis/2018/pe/bgrd/backgroundfile-117766.pdf
[18] http://www.savingsbydesign.ca/commercial/download/2020-Savings-by-Design_v7.pdf

APPENDIX A – DETAILED EXPECTED ENERGY PERFORMANCE

By Phase / Block

	The Radiator		
	Scenario 1	**Scenario 2**	**Scenario 3**
Heating Gas (ekWh/m^2)	40.1	25.5	0.1
Heating Elec (ekWh/m^2)	2.9	2.8	5.8
DHW Gas (ekWh/m^2)	30.3	5.1	0.1
DHW Elec (ekWh/m^2)	0.0	3.2	5.4
Cooling (ekWh/m^2)	5.4	11.6	14.0
Heat Rejection (ekWh/m^2)	1.4	0.1	0.0
Lights (ekWh/m^2)	20.0	16.8	16.5
Plugs (ekWh/m^2)	21.0	20.9	19.2
Fans (ekWh/m^2)	6.9	6.0	5.7
Pumps (ekWh/m^2)	4.5	7.8	7.5
Electricity - Space Cooling (ekWh/m^2)	6.7	11.7	14.0
Electricity - Space Heating (ekWh/m^2)	2.9	2.8	5.8
Electricity - DHW Heating (ekWh/m^2)	0.0	3.2	5.4
Electricity - Base loads (ekWh/m^2)	52.3	51.4	49.0
Gas - Space Heating (ekWh/m^2)	40.1	25.5	0.1
Gas - DHW / Base Loads (ekWh/m^2)	30.3	5.1	0.1
Gas Use (eMWh)	3,134	1,364	6
Gas Intensity (ekWh/m^2)	70.5	30.7	0.1
Electricity Use (MWh)	2,755	3,072	3,297
Electricity Intensity (ekWh/m^2)	62.0	69.1	74.1
Total Energy Intensity (ekWh/m^2)	**134.6**	**100.0**	**74.3**
Total Energy (eMWh)	5,986	4,447	3,303
% Savings vs Tier 1	21%	41%	56%
GHG intensity (kg CO_2e/m^2)	**15.0**	**9.9**	**5.0**
Total GHGs (tonnes CO_2e)	667	442	221
% Savings vs Tier 1	25%	50%	75%
Thermal Energy Demand Intensity (ekWh/m^2)	**48.9**	**29.5**	**15.0**
Total Thermal Demand (eMWh)	2,174	1,312	667
% Savings vs Tier 1	30%	58%	79%



APPENDIX B – DESIGN GUIDANCE

Toronto Green Standard Performance Targets

Table 11 - TGS Targets Over Time

Multi-Family Residential Buildings		EUI kWh/m^2	GHGI $kgCO_2/m^2$	TEDI kWh/m^2
TGS v4 (2022)	Tier 1	135	15	50
	Tier 2	100	10	30
	Tier 3	74.5	5	15
TGS v5 (2025)	Tier 1	100	10	30
	Tier 2	74.5	5	15
TGS v6 (2028)	Tier 1	74.5	5	15

Types of District Energy Systems

District energy system may be categorized as one of two types: **High Temperature** and **Low / Ambient Temperature**.

A **High Temperature** district energy plant provides heating and/or cooling to the building at the temperature required to meet the load, and involves using heat exchangers or coils *within* the building for distribution of heating and cooling, similar to a typical high rise design. This approach is amenable to district technologies such as Deep Lake Water Cooling (DLWC) and central steam or hot water plants, as well as central Combined Heat and Power (CHP) systems.

- Equipment in building may be minimized (boiler/chiller reduced to a heat exchanger)
- Distribution piping requires insulation
- Heating demand met by gas fired equipment or recovered waste heat
- High temperatures can be augmented by CHP / heat recovery
- Separate loops required for heating and cooling

In comparison, a **Low / Ambient Temperature** district thermal system takes its design philosophy from a water-loop heat pump (WLHP) HVAC system in a high rise residential building. The ambient temperature system relies on heat pumps or VRF units located in the space. These units connect to an ambient temperature (typically 12 to 30°C) distribution loop through which the heat pumps can reject or absorb heat. This approach is amenable to incorporating boreholes at a community level for ground source heat pump technology or low grade solar thermal.

- Heat pump equipment required in building to generate temperature for space conditioning
- No insulation needed / heat exchange with ground encouraged
- Heating demand met by terminal electric heat pump / VRF, and central gas fired or renewable sources
- Low temperatures amenable to ground loops / low grade solar thermal
- Heating and cooling provided by one loop

The decision to pursue either of these district energy options relies on several factors, including the availability of each type of system, willing partners (e.g. local public/private utilities), space constraints, and project goals.

Additional Advanced Energy Solutions

Several advanced energy design measures are listed for consideration below.

Geothermal: A piping network which takes advantage of stable earth temperatures to provide heating in the winter and cooling in the summer typically coupled with heat pumps or VRFs in the space. As geothermal developments rely on balanced load profiles, a geothermal system may need to be supplemented to meet all loads. Installing geo could result in a reduction of thermal *energy* of approximately 50%. It is also a useful technology for decarbonization as it requires a fuel switch from gas to electricity for heating/DHW; helping immensely with the GHGI target.

There are a few different options to explore when considering geothermal and these paths have differing financial implications, primarily directly financing the entire design and construction or partnering with a third party supplier. With a third party, some contracts may have both the developer and geo supplier have investment/shared ownership interest in the system which would allow the developer to have a share in cash flow. Having a third party supplier come on board to design, build, finance, and operate the field can be advantageous as it reduces the upfront building costs to the developer, and ensures the asset will be properly managed over the lifetime of the contract. The geothermal supplier will make back their invested money into the geothermal infrastructure by charging the building tenants a service fee as part of their utility costs. Additional benefit to installing a geothermal system could include:

- Elimination of plant equipment, leading to lower maintenance and reserve fund costs
- Elimination of cooling tower water/chemicals as no cooling tower is required
- Reduction of utility costs

Air Source VRF: is a high efficiency fully electric HVAC system that can operate at wider temperature ranges than a typical air source heat pump and utilize electric heating as a back-up source when required.

Sewage Heat Recovery: is a specialized water-to-water heat pump that recovers energy directly from wastewater and uses this energy to preheat domestic hot water.

Solar Thermal: Rooftop mounted solar collector for thermal energy which is typically used to offset heating of domestic hot water loads in residential buildings. Similar to the constraints listed for solar PV panels, available rooftop space may be a constraint.

Solar Air Heater: Work by drawing incoming air through a transpired solar collector for pre-heat of the central air handling unit, reducing the ventilation heating load. Integrated into the building envelope, they are typically located on mechanical penthouses for visual purposes and for proximity to the MPH. As such, available area may be limited.

Battery Storage: can be utilized in buildings to provide zero carbon backup power, and empower owners to draw from the grid at off-peak times. Paired with renewable energy, battery storage can extend the utilization of renewables promoting a renewable, resilient grid.

Earth Tubes: Work by drawing incoming air through tubing in the ground for pre-heating and cooling, reducing ventilation loads.

Off-site Renewable Energy Procurement: Aside from on-site renewable technologies, any development may procure off-site renewable energy generation credits to offset their carbon footprint.

Resilience

Resilient design is the intentional design of buildings in response to vulnerabilities to disaster and disruption of normal life. In the long term, global warming is rapidly increasing temperatures and more extreme weather events. Designs will need to accommodate these changes over the lifetime of the building. In the short term, the goal should be to keep residents in place during extreme weather events by using passive design measures, backup power, and areas of refuge.

Climate Resiliency

In 2011, the City of Toronto produced, in collaboration with SENES Consulting, the Toronto Future Weather and Climate Driver Study. Within this report, it was shown that while the Toronto climate has already changed from climate zone 6 (Ottawa) to climate zone 5 (meaning that our climate is getting warmer), this trend is expected to continue with Toronto moving to climate zone 4 (Washington DC) by the year 2040.

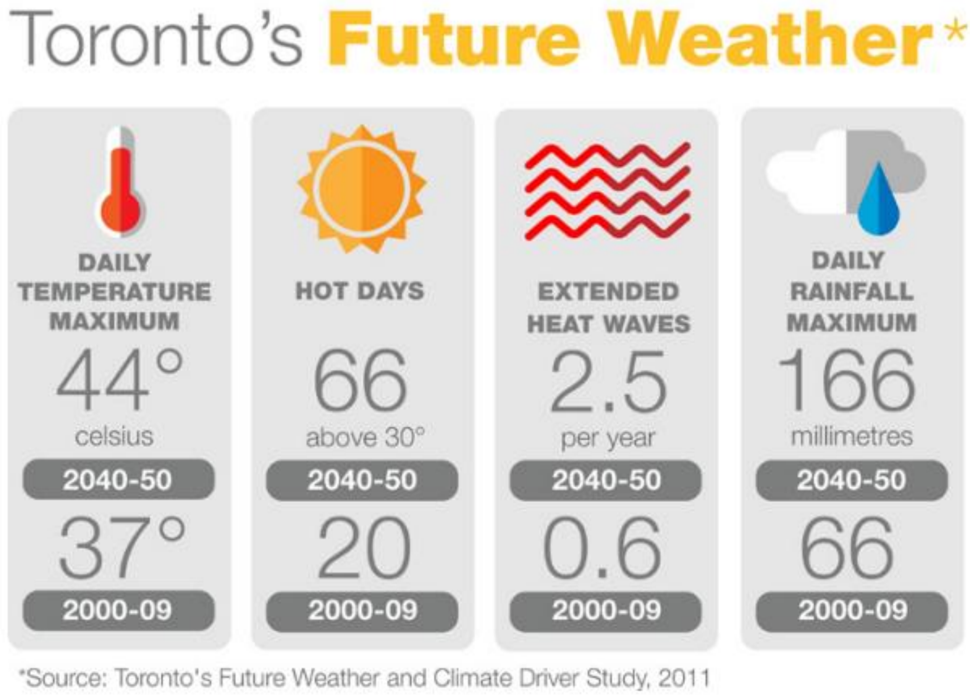


Figure 8 - Toronto Predicted Future Weather Patterns

This shift can lead to lower heating and higher cooling loads over the life of the building. Using up to date, or even predicted, weather data when doing early analysis can allow the design team to consider how the design will perform over the life of the building.

Cooling Energy Demand Intensity

Given that Toronto is in a cold climate, current passive building design practices emphasize reducing heating loads. Further investigation into the Cooling Energy Demand Intensity (CEDI), however, has revealed that buildings also have significant cooling loads that, if left unattended, can have as large an impact on thermal comfort as TEDI.

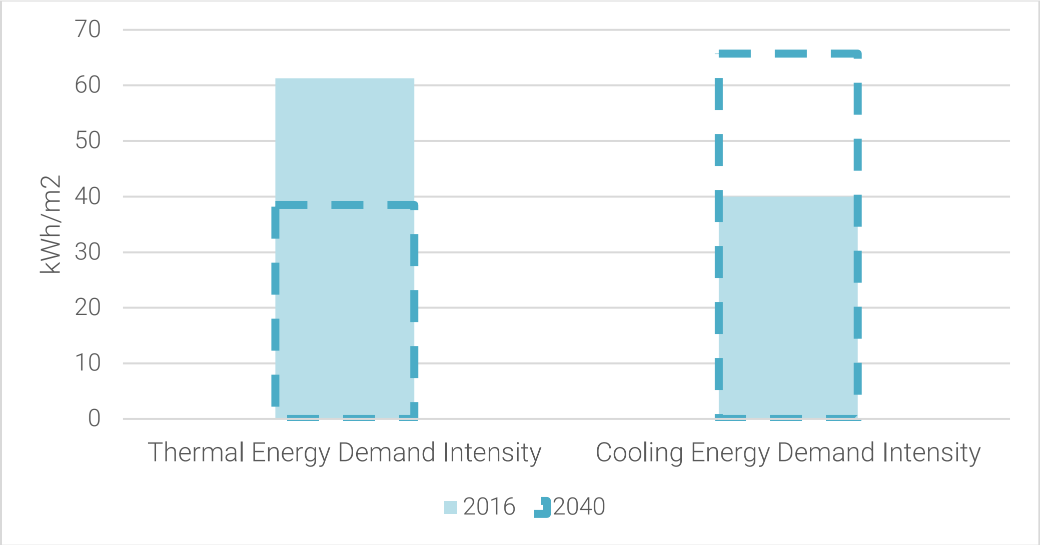


Figure 9 – Sample Comparison of Modelled Heating (Thermal) and Cooling Energy Demand Intensities over Time

EQ undertook an investigation of the impacts of TEDI and CEDI by looking at a sample set of our modelled buildings in Toronto, and comparing how the building use energy under both current weather patterns and future weather patterns anticipated for the 2040s. In doing so, it became apparent that the climate in Ontario will shift to a cooling-dominated environment. For this sample set of modelled buildings, the **TEDI decreased by 35% and CEDI increased by 70%** over the lifetime of the building. This shift indicates that heating equipment will become over-sized, potentially leading to performance issues and redundancy. Cooling equipment will conversely become undersized and require replacement sooner to increase capacity, or run the risk of potential thermal comfort issues.

Some challenges for reducing/controlling CEDI in MURBs are:

- Lighting and tenant plug-loads provide internal heat gains to the space and are typically dependent on tenant lifestyle, rather than building design and performance
- An improved opaque envelope may actually increase the cooling load of the building by trapping more heat when it's not desirable (e.g. shoulder seasons)
- Factors such as reducing the solar heat gains through glazing will simultaneously improve CEDI but negatively impact the TEDI

Although CEDI is a relatively novel metric to assess building performance, it is one that should not be overlooked as it has a notable impact on thermal comfort and will become more influential as the Toronto climate warms. When an energy model is developed for the project, the design team should consider additionally evaluating building performance using the predicted 2040 weather patterns.

Energy Conservation & Demand Reduction

With the constant stream of development within the City of Toronto, the electricity grid is becoming increasingly stressed. The electricity distribution infrastructure is already constrained in the areas anticipating the most growth, and an estimated 22% increase in electricity demand due to projects currently in approvals will pose additional challenges. Furthermore, cooling demand for buildings will increase with rising temperatures, which means that the 22% estimated increase is conservative. Broader electrification from sources such as electric cars will further increase electrical demand. The IESO has estimated the increase in peak demand shown in Figure 10, which suggests the current grid capacity will not meet future demands.

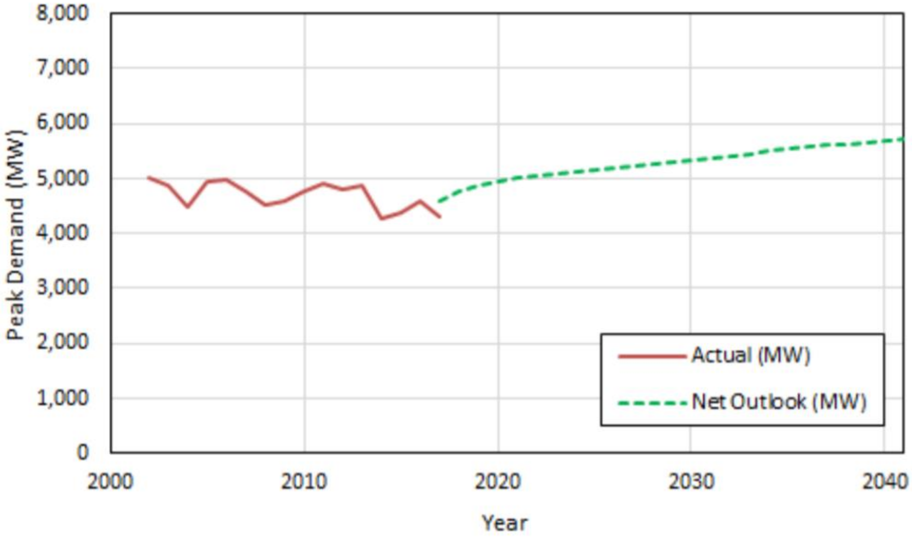


Figure 10 – Aggregated actual demand and net outlook by year[19]

With increasingly strict carbon targets, building designs will be encouraged towards electrification of heating and hot water systems, which will likely further strain the electrical grid. Consequently, energy conservation and peak demand reduction in buildings is becoming increasingly important to ensure a resilient, stable grid in the future. Some advanced strategies to reduce grid demand and energy consumption include:

- Solar photovoltaics combined with battery storage
- Local energy generation
- Connecting to district energy systems
- Heat recovery from sewage infrastructure
- Large-scale geothermal systems

Resilient Design

While increasing back-up power capabilities can improve resiliency, passive design is vital to ensuring that occupants are able to stay in the building during a power outage. The better a building is able to maintain its temperature without mechanical conditioning, the longer people will be able to remain in place. Energy modelling can be used to estimate how a building's interior temperatures will respond to an extended power failure. The *Zero Emissions Building Framework* analyzed this impact for each TGS performance tier, for a high-rise residential building. The results are summarized in Figure 11 below and show a stark difference in maintained interior temperature between the various performance tiers[20]. Indoor temperatures are analyzed at 72 hours and 2 weeks following a power outage, and show that indoor temperature drop significantly in lower performance scenarios, while the near net zero performance maintains an indoor temperature of

[19] Retrieved from: IESO Integrated Regional Resource Plan, August 9, 2019
[20]https://www.toronto.ca/311/knowledgebase/kb/docs/articles/municipal-licensing-and-standards/investigation-services/bylaw-enforcement-low-heat-no-heat-air-conditioning-air-conditioner-units-residential-properties.html#:~:text=Heating%20(Minimum%20temperatures),June%201%20of%20each%20year

18.3°C even after 2 weeks without power. While a two-week outage is likely an extreme, improved resilience will have a major effect on vulnerable populations

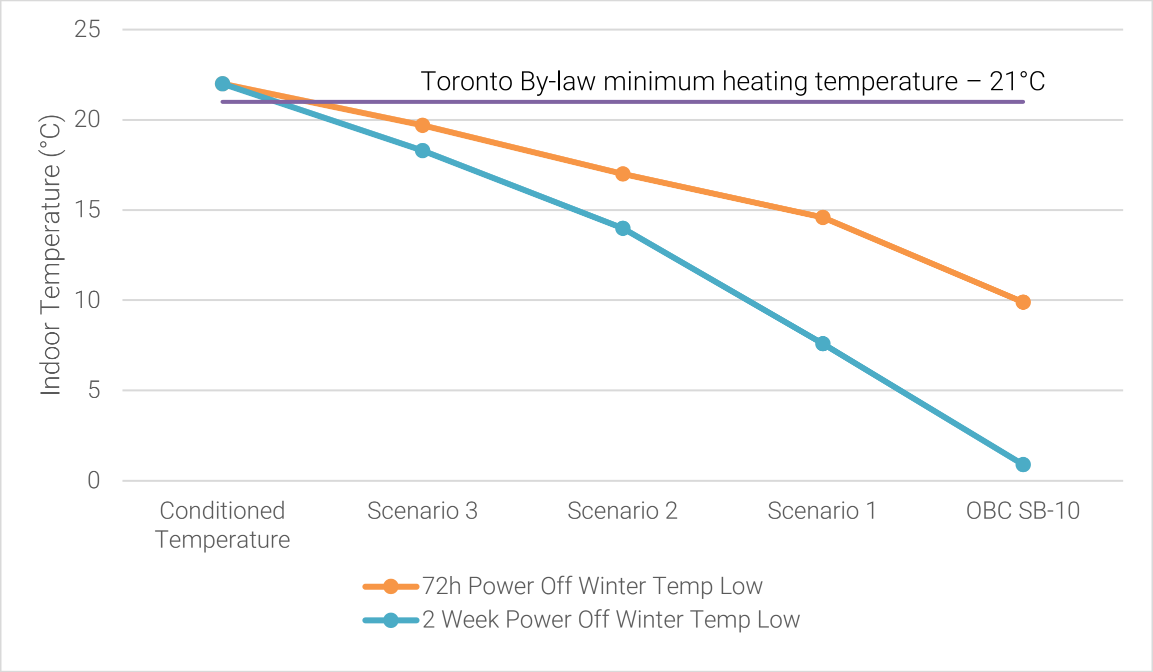


Figure 11 - Indoor Temperature in the Event of a Power Outage

The building envelope is an important factor in maintaining livable temperature in spaces during a power outage, but improved design can also allow spaces to be more comfortable during normal operations. With a poor performing envelope, the first few feet of a space adjacent to the exterior wall can be unusable due to thermal comfort issues. Additionally, as interior spaces are better able to maintain their temperature set-points, HVAC run times and system cycling can be reduced, leading to increased HVAC system life times.

Another strategy to improve resilience for residents is to provide an **area of refuge** within the building. The designated space would need to provide minimum levels of heating, cooling, lighting, potable water, and power during power outages for a minimum of 72 hours. This would allow residents to remain in the building during a power outage and to keep warm or cool, store medicine, charge communication devices and share updates. The development team is encouraged to review the *Minimum Backup Power Guidelines for Multi-Unit Residential Buildings*[21] for additional guidance.

If the development chooses to pursue Tier 2 or higher, the development will be required to fill in a Resilience Checklist[22] (See Appendix C – Resilience Checklist). While only required for higher performance scenarios, the design team is encouraged to review the checklist even if only pursuing minimal performance. While there is no obligation to incorporate any specific resiliency measures into the design, the checklist acts as a helpful tool to explore resiliency issues for the project.

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[21]https://www.toronto.ca/wp-content/uploads/2017/11/91ca-Minimum-Backup-Power-Guideline-for-MURBs-October-2016.pdf
[22]http://wx.toronto.ca/inter/clerks/fit.nsf/0/3d0af0e4d40adc8b852582e500625cd3/$File/Toronto%2BGreen%2BStandards%2BVersion%2B3.0%2BChecklist%2BResilience%2BPlanning%2BNew%2BConstruction.pdf

Back-Up Power

With increasing global temperatures, extreme weather events require designs to carefully evaluate back-up power solutions. Typical design intent is to include back-up power via a generator that will supply all emergency (life safety) requirements. Passive design measures such as a relatively low window-wall ratio, high thermal mass elements within the building, and high R-value building insulation would assist in maintaining building temperature in the event of heating/cooling system failure.

To increase building resiliency, the project could elect to include back-up power in addition to emergency power on the generator. In general, the difference between these loads is as follows:

Table 12 - Emergency vs. Back-up Power Requirements

	Emergency Power	Back-up Power
Purpose	Minimum life safety requirements (firefighter and evacuation)	Non-life-safety requirements for occupant wellbeing
Duration	2 hours – building code requirement	72 hours – based on federal emergency preparedness guidelines
Loads	Fire pumps, fire elevator, stair pressurization fans, alarm system	Water supply, minimal space heating, power to a common refuge area, domestic booster pumps, additional elevators

Including back-up power on the generator has the potential to increase costs in order to increase the size of the generator, but this can be reduced through the use of a load management system with load selection capability. When the system detects it is no longer in an emergency, it can divert generator resources to back-up power allowing tenants to remain safe and comfortable in their homes during a power outage.

Cost Implications

Utility Costs

With increasingly rigorous performance targets on a pathway to net zero construction, there are an almost infinite number of design decisions that can be made which all can have an influence on operating costs. Reducing building loads through passive measures directly reduces both equipment size and how often the mechanical systems need to operate. Pairing this with higher efficiency equipment and systems to meet these loads can reduce operation costs. Depending on the sub-metering plan for the building, utility cost savings may result in lower condo fees, or as direct savings on tenant utility bills.

Electricity prices in Ontario are currently almost five times higher than natural gas[23]. This encourages building owners to target electricity savings in order to minimize operating costs. When comparing to carbon emissions however, the opposite trend is seen with natural gas having more than three times the carbon intensity than electricity[24]. In order to meet increasingly rigorous carbon targets, a shift away from natural gas and towards electricity will inevitably be required. Depending on how the TGS targets are met, this could

[23] Approximately $36.11/GJ [$0.13/kWh] vs. $7.37/GJ [$0.28 /m3] for electricity and natural gas respectively, inclusive of the current Carbon tax.

[24] 50.22 kg CO_2e/GJ vs 13.89 kg CO_2e/GJ for natural gas and electricity respectively.

lead to relatively minor cost reductions when compared to the deep energy and carbon savings achieved. Using the modelling results indicated in the *Zero Emissions Building Framework*, energy costs have been estimated for each of the TGS v3 Tiers and compared to the energy targets in Figure 12 below.

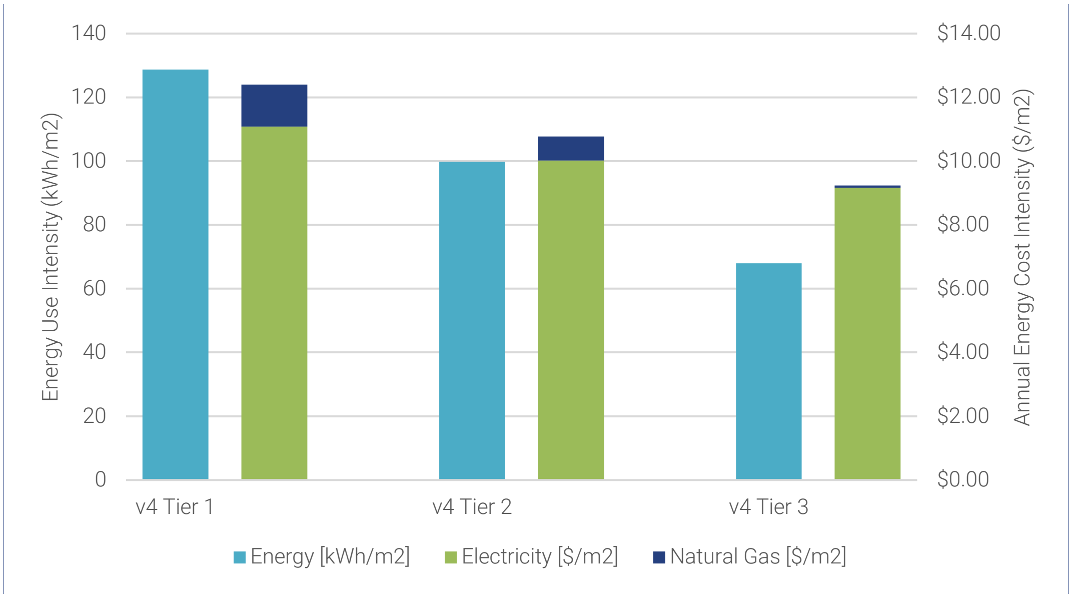

Figure 12 - Utility Cost and Energy Performance Comparison

Based on these estimates, the The Radiator project annual energy costs could range between $530,700 and $461,400. The sample compliance paths in the Framework, show that a 47% reduction in energy use results in only a 25% reduction in annual utility costs. It should be noted that this only considers one possible path to compliance. The energy model that will be developed for SPA can be a great tool to evaluate the impacts of design alternatives and explore how best to and utility cost savings. It is also worth noting that the comparison reflects current utility rates and carbon emission factors which may fluctuate over time, for example with increasing carbon pricing or changes to the fuel supply mix of the electricity grid.

Capital Costs

While some of the design decisions required to meet the TGS targets may result in direct increased costs (such as triple glazing), others like EnergySTAR appliances or low flow plumbing fixtures are often considered cost neutral. Investing costs into upgrading the building envelope can reduce loads enough that mechanical equipment could be downsized saving upfront capital costs.

Table 13 below shows the estimated cost premiums and life cycle costs from the *Zero Emissions Building Framework* as a preliminary estimate though cost premiums should be evaluated independently as part of a full feasibility study by the design team.

Table 13 - TGS Estimated Cost Premiums

Level of Performance	Total Construction Cost Premium Over Code	Estimated Envelope Cost Premium Over Code	M+E Cost Premium Over Code	Lifecycle Cost (including DC refund)[25]
Tier 1	3.5%	21.9%	13.0%	$281k
Tier 2	6.0%	24.6%	34.3%	-$2.39M
Tier 3	3.6%	28.8%	4.5%	-$873k

Achieving + Exceeded Targeted Performance

While designing the building to achieve a high level of performance is a requirement, actually achieving that high performance is neither regulated, nor guaranteed. There are many possible design solutions that can achieve the targeted level of performance and some additional strategies that can help safeguard both the initial delivery and ongoing operational performance of a high performing building.

Commissioning during and after construction

Even the best-designed buildings don't always perform as expected. Commissioning is a quality assurance process that helps convert design intent into actual building performance results. By using a combination of testing, verification, and documentation, the commissioning process can improve system and equipment operations, avoid unnecessary maintenance, and extend equipment service life, all while helping ensure the designed savings are realized. Commissioning doesn't need to, nor should it, end at occupancy. Ongoing retro-commissioning can help identify many low and no cost measures to maintain or even boost building performance.

Building Management Systems and Services

To manage day to day operations of the building, a building management software (BMS) may be desirable. Many building operators do not know how best to optimize building performance, or if they are knowledgeable, may not have time to dedicate to fine tuning operations. Using a building management software can help to ensure maintenance schedules are maintained and send alerts if equipment is acting in unusual ways or out of design ranges, allowing the building to be proactive rather than reactive to equipment operations and tenant concerns.

Energy Benchmarking

While commissioning and monitoring can help with ensuring a building performs as intended, energy benchmarking allows comparison to similar buildings to see where performance is falling short. It can also allow comparisons between buildings within a portfolio.

[25] Positive values for Lifecycle Cost Savings indicate a net savings versus the baseline, SB-10 2017. Negative values indicate a net loss.

Embodied Energy

While the energy used to operate the building is typically discussed throughout design, the energy required to extract, manufacture, and transport a building's materials, as well as the energy used during construction is often forgotten. This is known as embodied energy, and can be a significant amount of energy depending on the materials and methods used in construction. When a building is developed, the materials used (particularly for structure) are discarded in the demolition process, which results in the loss of embodied energy. As an example, typical concrete has approximately 1,984,668 MBTU/litre of embodied energy. Comparatively, gasoline has approximately 431,728 MBTU/litre of embodied energy[26]. This is equivalent to 4600 L of gasoline for every liter of concrete poured. Steel or wood both have less embodied energy than concrete and may be a better choice of material depending on the application.

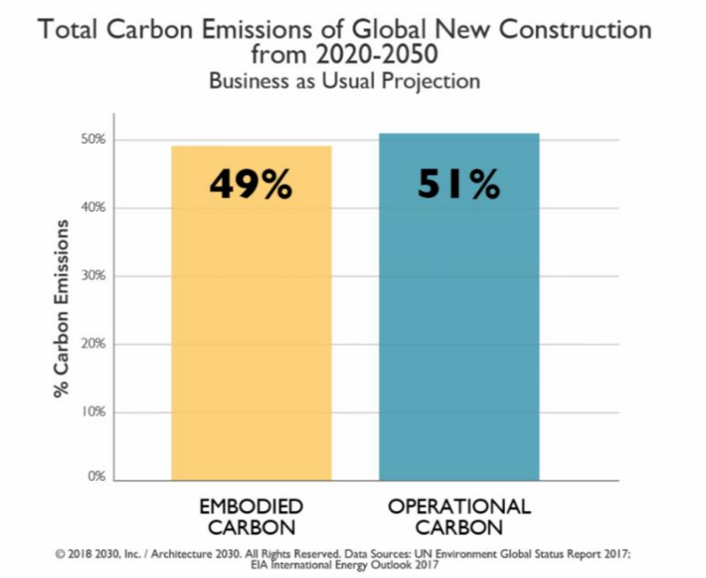

Figure 13 - Embodied versus Operational Carbon

It is important to consider a new building's materials and how the embodied energy from the existing site can be salvaged during the early stages of design. The Athena Sustainable Material Institute has produced a free software tool that allows developers, and their consulting team to track the embodied energy associated with their design[27]. Additionally, this tool can be used to improve knowledge of the embodied energy that already exists on site, and help make informed decisions on how to reduce the loss of embodied energy for the project. While outside the scope of this report, the project team is encouraged to use this software during design to stay informed about the energy involved in building the proposed development. The project team is also encouraged to reuse or recycle existing materials on site wherever it is deemed feasible.

26 https://www.go-gba.org/embodied-energy/
27 http://www.athenasmi.org/

Additional v4 Tier 2, 3, Requirements

Additional TGS v4 energy related credits that this project may consider are listed below:

Mid to High Rise Residential and Non-Residential Development

GHG 2.1 – Material Emissions Assessment (Tier 2)

The building must conduct a Material Emissions Assessment for the structure and envelope in accordance with the CaGBC Zero Carbon Building Standard v2 methodology for the Upfront Carbon lifecycle stage (A1-5). Identify low-carbon sustainable material alternatives to the proposed structure or envelope for use in the building project.

GHG 2.2 Whole Building Life Cycle Assessment (Tier 3)

Conduct a whole building life cycle assessment (LCA) of the building's structure and envelope in accordance with the CaGBC Zero Carbon Building Standard v2 methodology that demonstrates a minimum of 20% embodied carbon reduction, compared with a baseline building.

GHG 3.2 – Refuge Area and Back-Up Power Generation (Tier 2)

Residential Uses: Provide a refuge area with heating, cooling, lighting, potable water, and power available; AND Provide 72 hours of back-up power to the refuge area and to essential building systems required during an extended power outage.

GHG 4.1 – Benchmarking & Reporting (Tier 2)

Enroll the project in ENERGYSTAR® Portfolio Manager to track energy and water consumption of the new development during operations in accordance with O. Reg. 20/17 for private buildings. Provide the City of Toronto's account (CotEnergy) with read-only access to the project.

GHG 4.2 – Enhanced Commissioning (Tier 2)

Complete the commissioning process (CxP) activities for mechanical, electrical, plumbing, and renewable energy systems and assemblies in accordance with ASHRAE Guideline 0–2013 and ASHRAE Guideline 1.1–2007 for HVAC&R systems, as they relate to energy, water, indoor environmental quality, and durability, to develop the owner's project requirements and basis of design.

GHG 4.3 – Whole Building Air Leakage Testing WBALT (Tier 2)

Conduct a Whole-building Air Leakage Test to improve the quality and air tightness of the building envelope. The project must target equal to or less than 2 L/s/m2 (at 75 Pa) through whole-building air infiltration testing, as conducted in accordance with the City of Toronto Air Tightness Testing Protocol & Process Guideline.

APPENDIX C – RESILIENCE CHECKLIST

TORONTO

Checklist - Toronto Green Standards Version 3.0

Resilience Planning New Construction

Why do we need a resilience checklist?

Improving the ability of the buildings to withstand the impacts of climate change and extreme weather is an important step towards creating a more resilient city and to protecting the health, safety and economic well-being of the city's residents and businesses. The aim of this checklist is to summarize the level of resilience planning undertaken for your development project.

What responses will help improve building resilience?

The overall impact of changes in Toronto's climate on the development sector includes: higher risk of flooding events, extreme heat and cold events, and power outages. To reduce the impact of these expected changes, new developments must be constructed in such a way as to mitigate flood events, improve thermal resilience, and extend the duration of back-up power generation.

Flooding Events An increase in the overall volume of precipitation and larger individual storm events create a higher risk of flooding in certain areas of Toronto. The Toronto and Region Conservation Authority (TRCA) provides flood plain mapping resources that help identify flood-prone areas of the city. Toronto Water conducts regular servicing studies, develops and maintains the City's Wet Weather Flow Management policy and guidelines for storm water management, and institutes the City's Basement Flooding Program to ensure residents and businesses are protected from back flow and sewage disruptions.

Extreme Heat & Cold Events The risks associated with the impact of extreme heat and cold events on vulnerable populations is an increasing concern in the City of Toronto. Measures to protect at-risk residents (e.g. the elderly, socially isolated, those with pre-existing illness, and young children) and those without access to air conditioning from excessive heat will therefore be important to include into the design and operation of Toronto's buildings. Higher levels of building energy performance improve passive survivability. Buildings designed with well insulated and sealed building envelopes, lower window-to-wall ratios or other passive building design strategies help to maintain liveable indoor temperatures with less energy and for longer periods of time under power outages during winter or summer.

Power Outages The impact of a warmer climate and more extreme weather events can have an effect on the reliability of our power supply. As temperatures rise, our use of air conditioning also increases, putting stress on the ability of the power grid to deliver electricity. Periods of extreme heat are increasingly leading to brownouts and blackouts, as are events in the fall/winter such as the December 2013 ice storm. Research from past events of this nature has shown that extended back-up power, community energy systems help to reduce both the likelihood and the impact of possible power outages and help communities to recover more quickly from a disruption.

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Checklist - Toronto Green Standards Version 3.0

Resilience Planning New Construction

A. Modelling Assumptions

For expected changes in climate across the Greater Toronto Area, consult Toronto's Future Weather and Climate Driver Study

Has any enhanced modelling using future climate data been conducted for the building site?

☐ Yes ☐ No If yes, what time period was considered?

What temperature minimums/maximums were considered in building design?

Temperature Low (°C): Temperature High (°C):

What variables were assumed for extreme heat events, if any?

Temperature Max (°C): Duration of events (days):

Frequency (events/year):

What variables were assumed for extreme flooding events, if any?

Daily Rainfall Max (mm): Duration of extreme rainfall events (days):

Frequency (events/year):

Risk Assessment/modelling undertaken (Y/N), method used:

B. Thermal Resilience & Safety

For expected changes in climate across the Greater Toronto Area, consult Toronto's Future Weather and Climate Driver Study

What measures have been taken to reduce the impacts of heat waves?

Building - passive

- ☐ Higher roof R values
- ☐ Higher envelope R values
- ☐ Operable Windows
- ☐ Window films
- ☐ Cool/green roof
- ☐ High albedo envelope materials
- ☐ External window shading devices
- ☐ Triple glazed windows
- ☐ Tenant emergency preparedness guides
- ☐ Other passive ventilation strategies

Building - active

- ☐ Indoor refuge area with cooling
- ☐ Centralized air conditioning
- ☐ Ceiling fans

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Checklist - Toronto Green Standards Version 3.0

Resilience Planning New Construction

Building - site

- ☐ High albedo landscaping materials
- ☐ Soft landscaping
- ☐ External pools (eg. splash pads)
- ☐ Reduced hardscapes
- ☐ Other building shade structures
- ☐ Use of solar PV as shades
- ☐ Shade trees/shrubs
- ☐ Outdoor shaded amentiy space with seating
- ☐ High albedo hardscapes, including parking lots
- ☐ Other

Has a refuge area with cooling been provided in the building?

☐ Yes ☐ No If so, what is the total area? (m^2)

Refuge areas should be a minimum of 93 m^2 (1000 square feet), and/or 0.5m^2/occupant

What critical services are provided?

If not, what is the location of the closest emergency warming or cooling centres during an emergency?

C. Back-up Generation

Consult the City of Toronto's Minimum Backup Power Guidelines for MURBs for additional information on critical services in residential buildings.

Measures have been used to reduce the building's energy demand on the grid?

- ☐ On-site solar PV
- ☐ CHP system
- ☐ On-site solar thermal
- ☐ Ground source heat pump
- ☐ On-site battery storage
- ☐ Microgrid connected
- ☐ District energy ready
- ☐ Smart grid ready
- ☐ Building-integrated windd turbines
- ☐ Other

Describe the Back-up power/emergency generator system selected?

Is storage adequate to provide 72 hours of back-up generation? ☐ Yes ☐ No

Total storage capacity (kW): Total back-up generation fuel (units):

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Checklist - Toronto Green Standards Version 3.0

Resilience Planning New Construction

Critical services have been included into back-up power generation calculations?

- ☐ Passenger elevator(s)
- ☐ Security systems
- ☐ Unit space heating
- ☐ Unit space cooling
- ☐ Refuge area cooling
- ☐ Refuge area lighting
- ☐ Refuge area electricity
- ☐ Refuge area heating
- ☐ Sump Pumps
- ☐ Hot water boilers/pumps
- ☐ Domestic water booster pumps
- ☐ Other

D. On-site Flood Mitigation

Is the building in a known flood plain? ☐ Yes ☐ No

List any flood prevention measures used to mitigate the impact of heavy rainfall events and associated risk of flooding within the building:

- ☐ Flood proofed Electrical and HVAC Systems (located above grade or 1st floor)
- ☐ Back-up generator/fuel located above grade or 1st floor
- ☐ Ground floor electrical circuits located in ceiling
- ☐ Waste water back flow prevention
- ☐ Water tight utility conduits
- ☐ Storm water back flow prevention.

List the strategies used to accommodate heavy rainfall events under the Stormwater Retention (Water Balance) section of the TGS:

Checklist - Toronto Green Standards Version 3.0

Resilience Planning New Construction

E. Manager & Tenant Preparedness

Will building management have access to a vulnerable person's list? ☐ Yes ☐ No

If so, has building management been made aware of the location of the preparedness kit? ☐ Yes ☐ No

What additional resources for emergency preparedness have been made available to building managers, operators, and/or tenants?

Completed By:

Name (First,Last):

Position Title:

Date (yyyy-mm-dd):