REPORT

3005 SHEPPARD EAST + 1800 PHARMACY AVENUE

ENERGY STRATEGY REPORT

PROJECT #1901321

JULY 23, 2019

SUBMITTED TO

Sheppard Pharmacy GP Inc.
150 Connie Crescent, Unit #4
Concord, ON, L4K 1L9

c/o Manny Karimi
Manny@copedevcorp.com

Cope Project Management Corp.
457A Danforth Avenue
Toronto, Ontario, M4K 1P1

SUBMITTED BY

Royston D'Souza, E.I.T
Energy Consultant
Royston.Dsouza@rwdi.com

Juan Sebastián Carrizo
Sr. Energy Consultant
Sebastian.Carrizo@rwdi.com

John Alberico, M.Sc., CCEP
Senior Project Manager / Principal
John.Alberico@rwdi.com

RWDI – Toronto Office
901 King Street West, Suite 400
Toronto, Ontario, M5V 3H5
T: 647.475.1048

EXECUTIVE SUMMARY

This report presents a summary of energy efficiency measures explored for the "2993-3011 Sheppard Avenue East, and 1800-1814 Pharmacy Avenue" project located in Scarborough, Ontario. The proposed development will be an 21 storey mixed-use development that includes residential, parking, indoor/outdoor amenity, and commercial spaces.

RWDI has explored how different energy efficiency strategies may be of benefit to the project. The intent of this exploration is to provide strategic energy options for the project, and to address the City of Toronto's "Energy Strategy Terms of Reference," dated January 2018 (Reference Link 1). The overarching goal of this energy strategy is to estimate the steps that should be explored to reduce energy use, ultimately striving towards a net-zero level of performance. But regardless of the decided target level of performance, the strategies identified in this report can act as a roadmap towards enhanced levels of performance.

The energy modelling tool IES Virtual Environment was used to develop these results. Note that "actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, energy use not covered by this standard, changes in energy rates between design of the building and occupancy, and precision of the calculation tool." [ASHRAE 90.1-2004, 11.1.4 Informative Note].
The preparation of this energy strategy has identified a number of opportunities, which will continue to be explored by the project's team. However, pursuit of energy conservation opportunities will need to be balanced carefully with the risks of implementing non-traditional solutions. Additionally, many of the benefits of the identified opportunities (e.g. reductions in CO_2e emissions) are arguably of greater importance to the City than the developers or end users. As such, the implementation of these opportunities will likely require a collaborative effort between the developers of this project and the City to de-risk and allow for the implementation of any non-traditional development solutions.

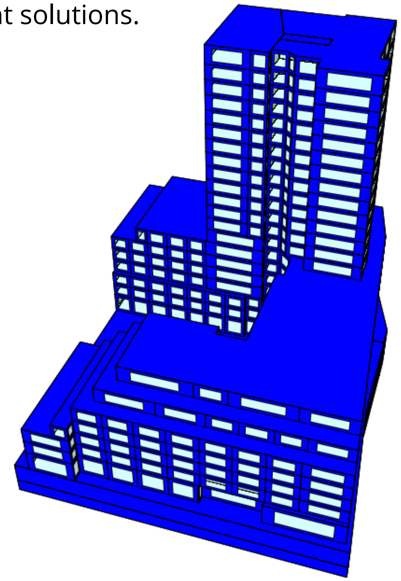

Figure 1: Preliminary Massing Used for Energy Analysis

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1. INTRODUCTION

1.1 CARBON INVENTORIES

More than ever before, climate change and greenhouse gas (GHG) emissions are a priority on the agenda at all levels of government in Canada. The graphs to the right summarize the current targets in Canada, Ontario, and Toronto. Each of these targets are stated in terms of equivalent carbon emissions (CO_2e).

For cities, provinces, and countries to operate at established 2050 target carbon budgets will require major changes in the way we all develop, operate, and live. For instance, Ontario has a target of 80% CO_2e reduction by the year 2050, which will equate to a total provincial GHG footprint of 36M tonnes of CO_2e. Compare this to Toronto's current total emissions, last reported in 2012, which equate to approximately 21M tonnes of CO_2e – close to 60% of the Province's total targeted 2050 carbon budget.

This energy strategy gives consideration to both the energy and CO_2e intensity of the development site. This is seen as not only an important responsibility, but also a step to align with Ontario's Climate Change Action Plan and potential funding that may be available through the Plan to developments of this scale.

Reference Link 2 to the Ontario Climate Change Action Plan.

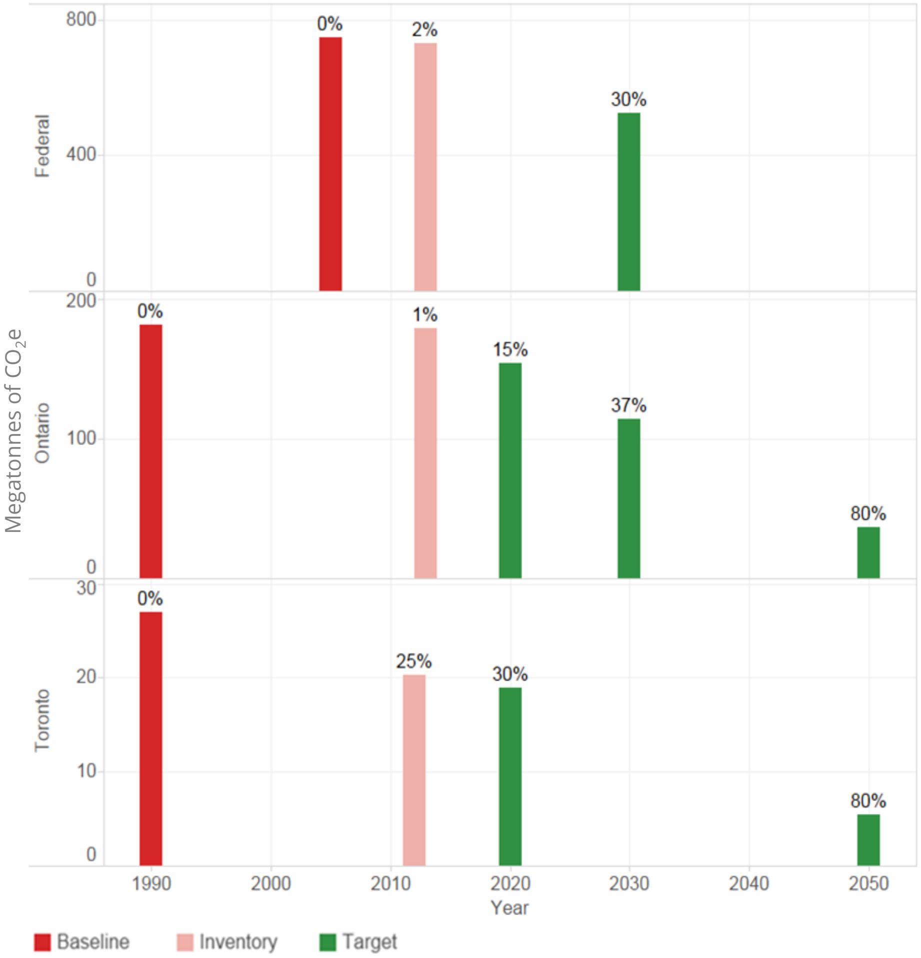


Figure 2: GHG Emission Baselines, Inventories, and Targets

1.2 ENERGY & CARBON

The link between a low-energy development and a low-carbon development is the greenhouse gas (GHG) intensity of the fuels consumed. GHG intensity is expressed in equivalent tonnes of carbon per kWh of energy consumed (CO_2e/kWh).

Primarily as a result of efforts to retire coal-fired power plants, the GHG intensity of grid-supplied electricity in Ontario has decreased 400% while the GHG intensity of natural gas has remained unchanged. This trend can be seen in the historical CO_2e intensity values for Ontario, which are reported in Canada's annual National Inventory Report, and summarized in Figure 3. (Reference Link 3)

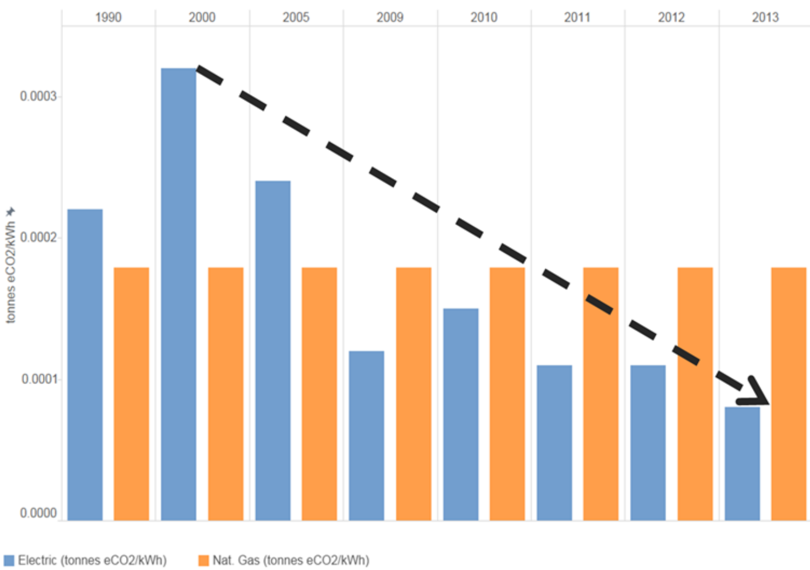


Figure 3: Historical CO_2e Intensity in Ontario for Electricity and Natural Gas

The City of Toronto's 2012 GHG inventory, report year 2013, states that buildings are responsible for 48% of the City's total GHG footprint, quantifying the important role of efforts such as this energy strategy in the development of a low-carbon future for Toronto. The inventory further notes that natural gas consumption accounts for 78% of this building-related GHG footprint.

The simple conclusion is that a low-carbon development must now consider using electricity to meet energy demands that have traditionally been met with natural gas – e.g. heating and domestic hot water. However, this conclusion over-simplifies the problem. The challenge is not a technological one – highly efficient electric heating systems exist – rather, the challenge is largely economic. The unit cost of natural gas (approximately \$0.03/kWh) is currently over 5 times less than that of electricity (approximately \$0.13/kWh) and it is expected that this trend will continue into the foreseeable future.

This development will give consideration to electric heating systems, however, these considerations will be balanced with market demands for low operating costs and purchaser demands. Any approach must reflect market realities for developments in the Toronto market.

1.3 METHODOLOGY

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

1. **Develop and utilize archetype energy models representative of the proposed project to provide an estimate of annual energy consumption of the current design;**
    - I. High-rise Residential Building,
    - II. Mid-rise Residential, and
    - III. Retail/Commercial Office
2. **Identify the top ECMs that should be considered for the project;**
3. **Quantify the impact of these Energy Conservation Measures (ECMs) using the energy models;**
4. **Evaluate site-wide results;**
5. **Determine how much renewable energy would be required to address the remaining annual energy use; and**
6. **Make recommendations based on the results of the analysis.**

This energy strategy was prepared using the preliminary density and built form concepts and statistics dated July 2019. Any characteristics that were not known at that time have been conservatively assumed to minimally comply with the requirements of the Ontario Building Code.

2. BUILDING PERFORMANCE

2.1 TORONTO GREEN STANDARD

The Toronto Green Standard (TGS) outlines the sustainable design requirements for all new developments in Toronto. All planning applications must demonstrate compliance with the Tier 1 performance measures, while Tiers 2 through 4 incentivize higher performance on a voluntary basis. TGS compliance will eventually be evaluated for this project during its Site Plan Control Application submission. At that time, a Design Development Stage Energy Efficiency Report will be provided that includes significantly more detail on the proposed design than this current rezoning phase submission.

The energy efficiency requirements of TGS version 3 Tier 1 mandate that buildings demonstrate at least a 15% energy efficiency improvement over a reference standard. In the case of this project, the proposed design will be compared to the OBC's National Energy Code of Canada for Buildings (NECB) 2015 as modified by Supplementary Standard SB-10 2017 reference building. This reference model is referred to as the "OBC Reference".

In early stages of design, a project's characteristics can be set equal to the minimum performance requirements of the reference standard used. However, one key variable that often differs is window-to-wall ratio (WWR): an OBC Reference model in Toronto will never exceed a WWR of 40%, whereas an actual design may have a higher WWR. As such, in the absence of detailed design information, an early proposed design will always consume more energy than the reference if it has a WWR higher than 40%. In these cases, this initial energy performance deficit would then be overcome by selecting architectural, mechanical and electrical components that perform better than the OBC minimum requirements.

As the planning and design phase of the project proceeds, the project will choose from an additional set of high performance strategies in order to comply with TGS Tier 1.

Figure 4: The City of Toronto Zero Emissions Buildings Framework outlines the energy efficiency, greenhouse gas emissions, and resiliency goals of the City.

2. BUILDING PERFORMANCE

2.1 TORONTO GREEN STANDARD

There are some low-cost energy conservation opportunities that have largely become best practice in Ontario, and that should be implemented by the design team for this project. These include:

1. High efficacy LED lighting in corridors, retail, and amenity areas;
2. Variable frequency drive (VFD) pumps;
3. Increased heating and domestic hot water plant performance (i.e. condensing levels of efficiency); and
4. Low-flow domestic hot water fixtures.

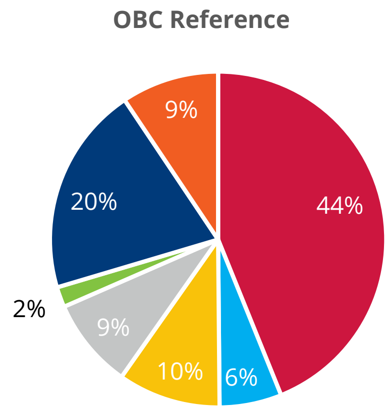
Two additional energy conservation alternatives have also been developed for consideration by the design team:

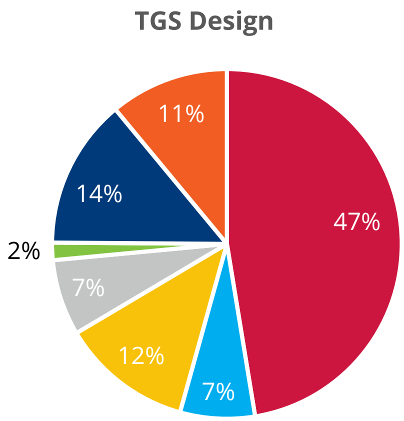
1. **Upgraded Envelope**, which includes reduced window-to-wall ratio and improved thermal performance of spandrel; and
2. **In-suite Mechanical Upgrade** including heat recovery units (HRVs) with electronically commutated (EC) motors, EC motors in fan coil units, and VFD control in fan coil units.

The assumptions used for each of these energy conservation opportunities are outlined in Appendix B. To comply with the mandatory TGS Tier 1, a combination of all of these packages (or similar packages) will be required. This energy strategy combines a selection of these measures into a "TGS Design" model, forming the starting point from which a net-zero energy design exploration will now begin.

Table 1: Site-Wide Energy Use Breakdown, OBC Reference vs. TGS Design

	OBC Reference (ekWh/m2-yr)	TGS Design (ekWh/m2-yr)	Reduction from Reference (%)
Heating	99	92	7.3%
Cooling	14	13	2.1%
Lighting	28	23	17.5%
Fans	22	14	37.6%
Pumps	4	3	30.3%
DHW	42	27	36.9%
Process	21	21	0.0%
Energy Use Intensity (ekWh/m2-yr)	**231**	**193**	**16.3%**





3. TOWARDS NET-ZERO

3.1 INTRODUCTION

The Canadian Green Building Council defines a net-zero carbon building as a "highly energy efficient building that produces on-site, or procures, carbon-free renewable energy in an amount sufficient to offset the annual carbon emissions associated with building operations" (Reference Link 4).

To achieve net-zero, a hierarchical approach to high-performance design is applied, as illustrated in the Figure to the right. This energy strategy will look at the energy performance site-wide, starting from the TGS Design, described on the previous pages. The following steps are taken to further reduce the energy consumption of the project:

1. Identify additional passive conservation strategies that should be considered to reduce external loads on the project.
2. Identify additional ways to reduce internal loads and change occupant behavior to conserve energy.
3. Identify additional active conservation strategies to address the remaining loads as efficiently as possible.
4. Make up the remaining difference with renewables.

For the purposes of this analysis, only energy consumed on-site is considered (i.e. distribution losses between the site and generation sources are not included).

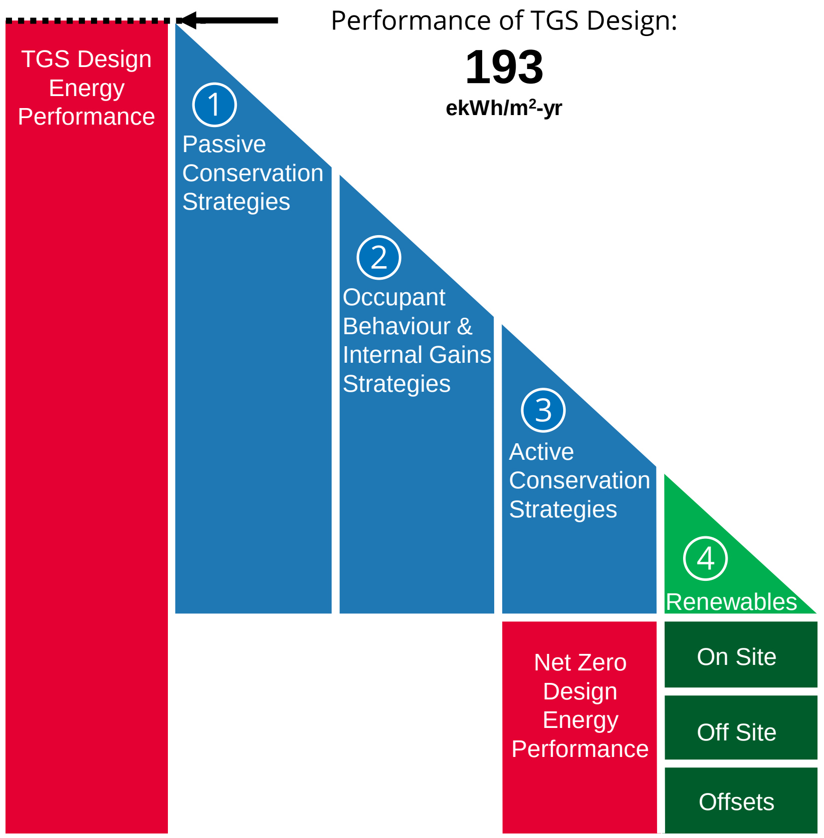


Figure 5: The path to a net-zero building

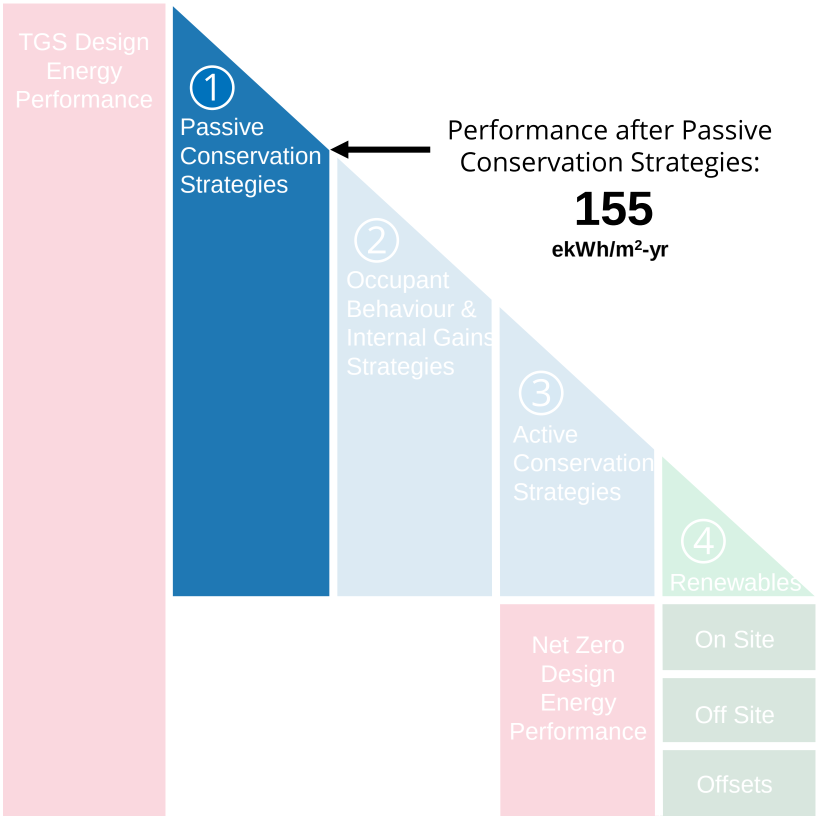
3. TOWARDS NET-ZERO

3.2 PASSIVE CONSERVATION STRATEGIES

Passive conservation strategies look to reduce the annual energy consumption of a development by reducing the external loads on the buildings (i.e. by controlling the heat gains and losses through the building envelope).

The following passive ECMs were identified as priority considerations for this project and were added to the model as passive conservation strategies:

- Glazing is upgraded to a high performance triple-glazed system;
- All podium level walls are upgraded to a steel frame wall system with 200 mm of continuous exterior insulation;
- 50 mm of exterior insulation is added to the podium roof; and
- Whole building air leakage through the envelope is reduced for the entire project to the US Army Corps of Engineer's required rate of 1.27 L/s/m^2 of envelope area at 75 Pascals.



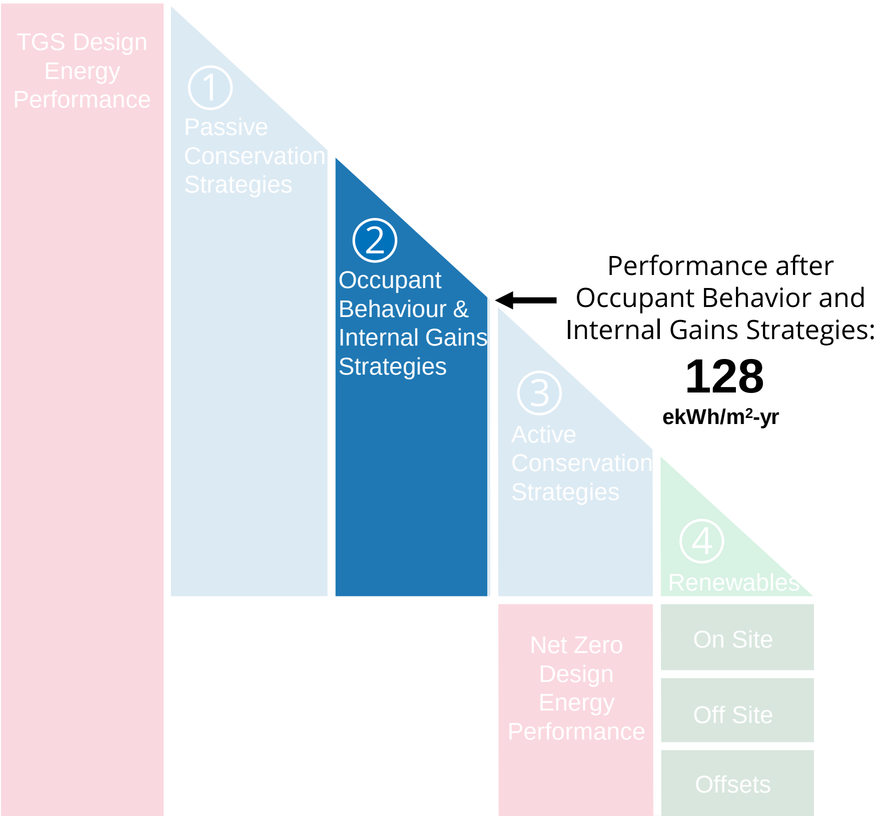
3. TOWARDS NET-ZERO

3.3 OCCUPANT BEHAVIOUR & INTERNAL LOADS STRATEGIES

Equipment and occupant loads typically come from appliances, computers, and other powered devices within the commercial areas and residential suites. These loads are difficult to influence as they are decentralized and vary widely depending on the behaviour of individual occupants. Reducing these loads requires both the application of technologies (e.g. occupancy sensors), and behavioural nudges (e.g. educational outreach).

The following ECMs were identified as priority considerations in this category and included in the model as occupant behaviour and internal gains strategies:

- Addition of smart thermostats in all residential suites, combined with suite level sub-metering of thermal energy;
- Selecting high-performance Energy Star appliances (i.e. all washers, dryers, dishwashers, and refrigerators) for the residential suites;
- Installing low flow kitchen, shower, and lavatory fixtures with flow rates of 3.8, 2.7, and 1.9 LPM, respectively in the residential areas;
- Utilizing high efficacy lighting fixtures (e.g. LEDs or compact fluorescent light bulbs) for all commercial, and common interior lighting; and
- Installing kill-switches at all suite exits to turn off all lights upon exiting.



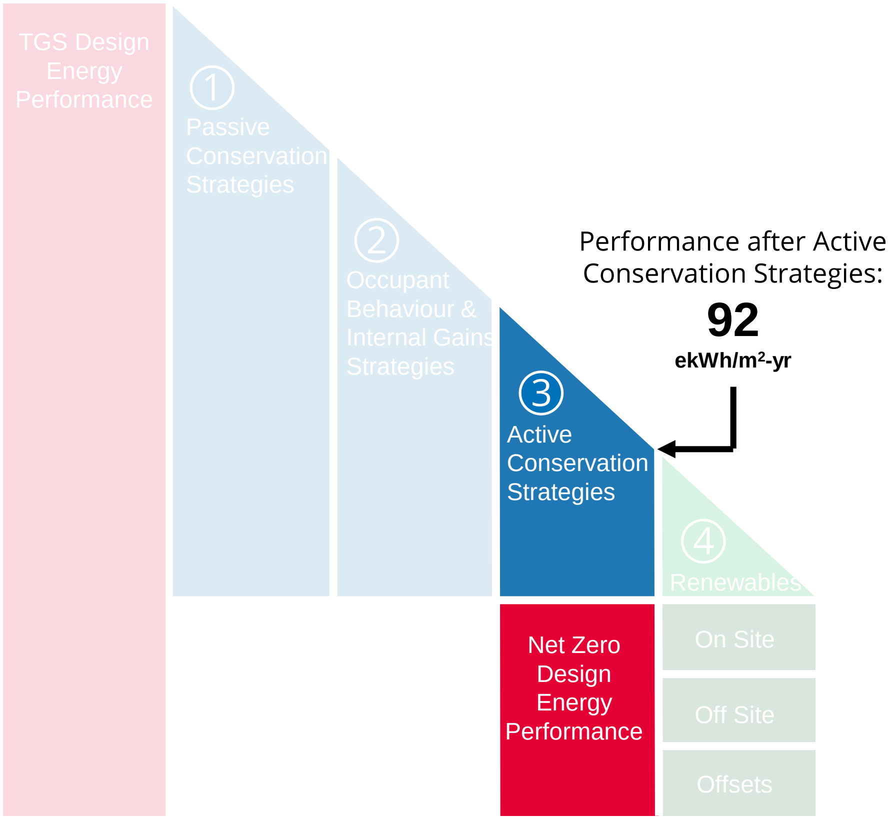
3. TOWARDS NET-ZERO

3.4 ACTIVE CONSERVATION STRATEGIES

Active systems use energy from the utility grid to meet energy demands from the building. Common active systems are lights, heaters, fans, air conditioners, and pumps. Typically, reducing the amount of energy used by these active systems is accomplished through one of two broad strategies: increasing efficiency, and reducing use. Reducing use was addressed to the extent deemed feasible in the previous two sections, "passive strategies" and "occupant behaviour and internal gains." As such, this section focuses on increasing efficiency often using enhanced technologies to deliver the same result with less energy.

The following ECMs were identified as priority considerations in this category and included as active conservation strategies:

- Upgrade residential in-suite heat recovery ventilators (HRVs) to high efficiency energy recovery ventilators (ERVs);
- Upgrade commercial energy recovery ventilators (ERVs);
- Switch commercial HVAC to dedicated outdoor air system with fan coil units;
- Utilize water-source Variable Refrigerant Flow (VRF) system for all fan coil units;
- Upgrade the residential corridor make-up air furnaces to 90% efficiency; and
- Add central drain water heat recovery to preheat all domestic hot water (DHW).



3.5 RESULTS

The results from the ECM packages discussed on the previous three pages are visualized in the below graph.

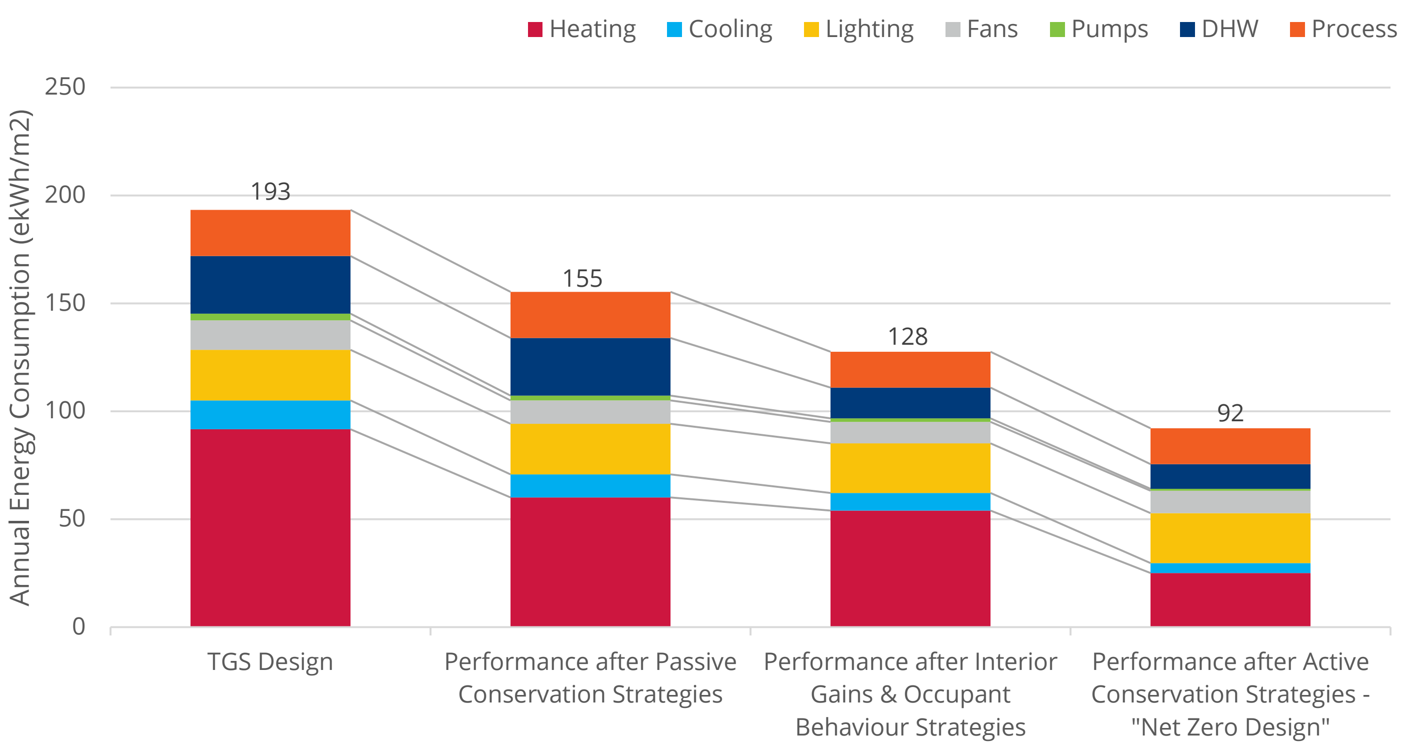


Figure 6: Results of energy conservation and demand management strategies

3. TOWARDS NET-ZERO

3.5 RESULTS

Table 2 below expresses the results in terms of four key metrics: EUI, total energy consumption, GHG emissions, and annual energy cost. The final model includes all of the strategies discussed thus far in the report, and will hereafter be referred to as the “Net Zero Design.”

The figure on the next page also breaks down these results according to the building areas.

<u>GHG Emission Factors</u>
Electricity: 0.050 kg CO_2e/kWh
Natural Gas: 0.183 kg CO_2e/kWh

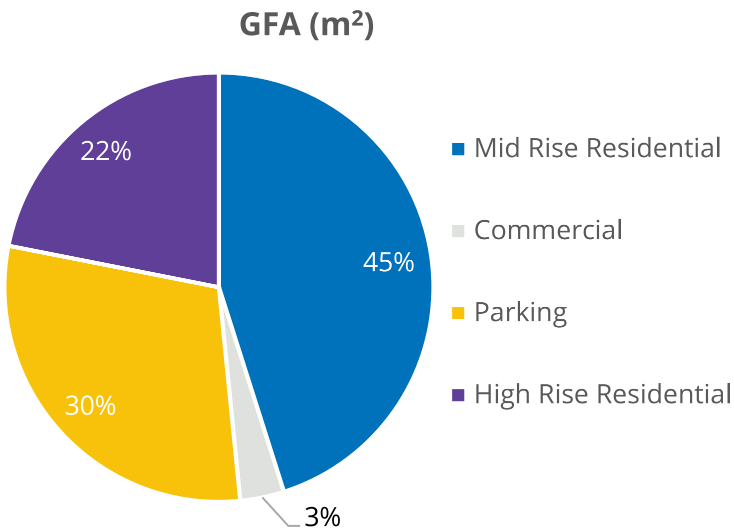
<u>Unit Energy Cost</u>
Electricity: $0.1333/kWh
Natural Gas: $0.0289/ekWh

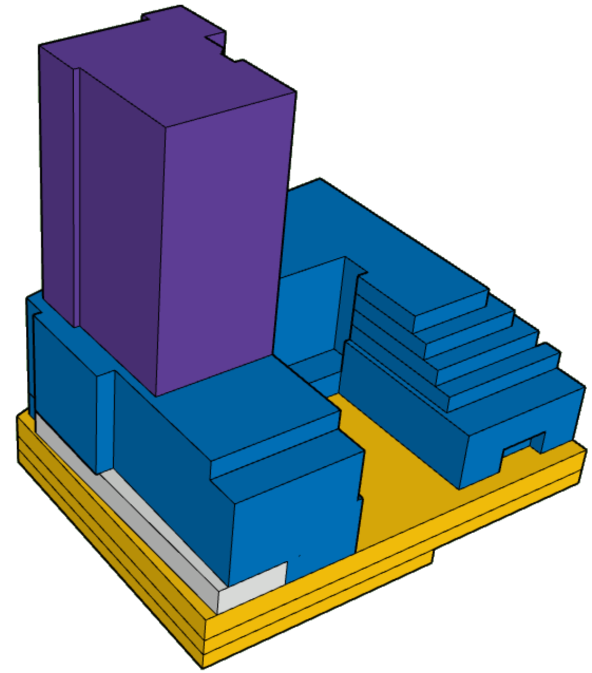
Table 2: Results of energy conservation and demand management strategies

ECM Packages	EUI (ekWh/m^2)	Total Energy (ekWh)	% Energy Reduction over Initial	GHG Emission (tonnes CO_2e)	% GHG Reduction over Initial	Energy Cost	Energy Cost Savings over Initial
TGS Design	193	5,643,700	-	700	-	$418,100	-
Performance after Passive Conservation Strategies	155	4,534,700	20%	600	14%	$364,200	13%
Performance after Interior Gains & Occupant Behaviour Strategies	128	3,726,600	34%	400	43%	$310,400	26%
Performance after Active Conservation Strategies – “Net Zero Design”	92	2,690,800	52%	300	57%	$330,600	21%

3. TOWARDS NET-ZERO

3.5 RESULTS





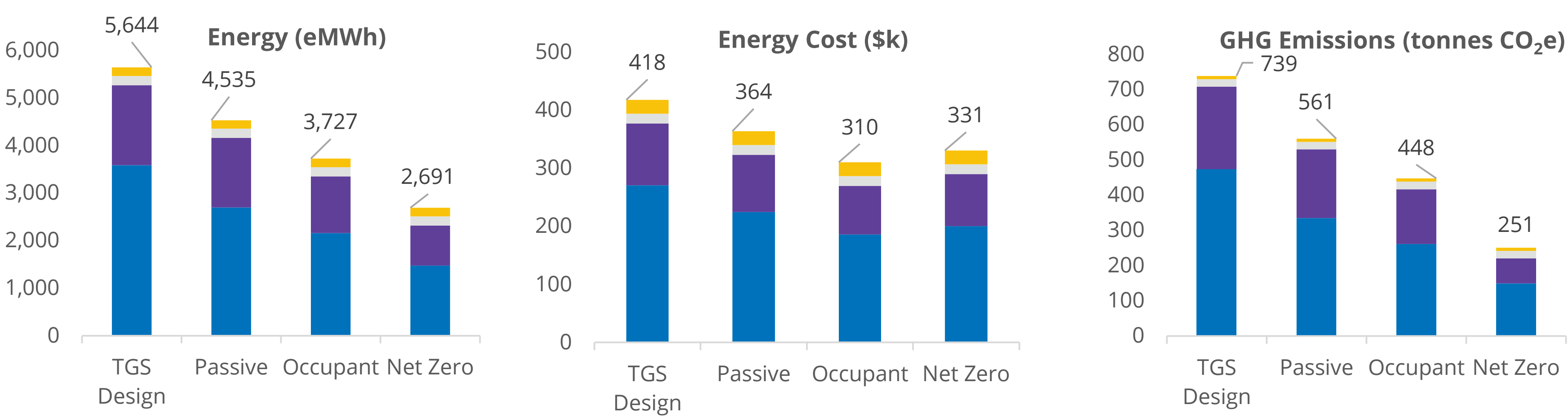


Figure 7: Results of energy conservation and demand management strategies

4. LOW-CARBON SOLUTIONS

4.1 ON-SITE RENEWABLES

After reducing the total energy consumption requirements for the site by 52% over the TGS Design, this energy strategy now considers the application of renewables to offset the remaining energy use of the Net Zero Design model.

Rooftop solar photovoltaic (PV) potential was explored using the National Renewable Energy Laboratory's (NREL) PVWatts Calculator (Reference Link 5). The dense urban context of the site does not leave much opportunity for rooftop solar access.

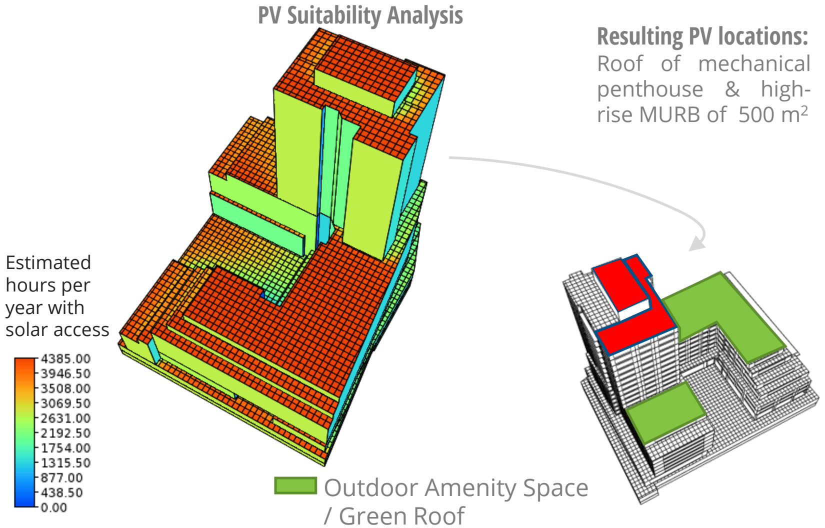
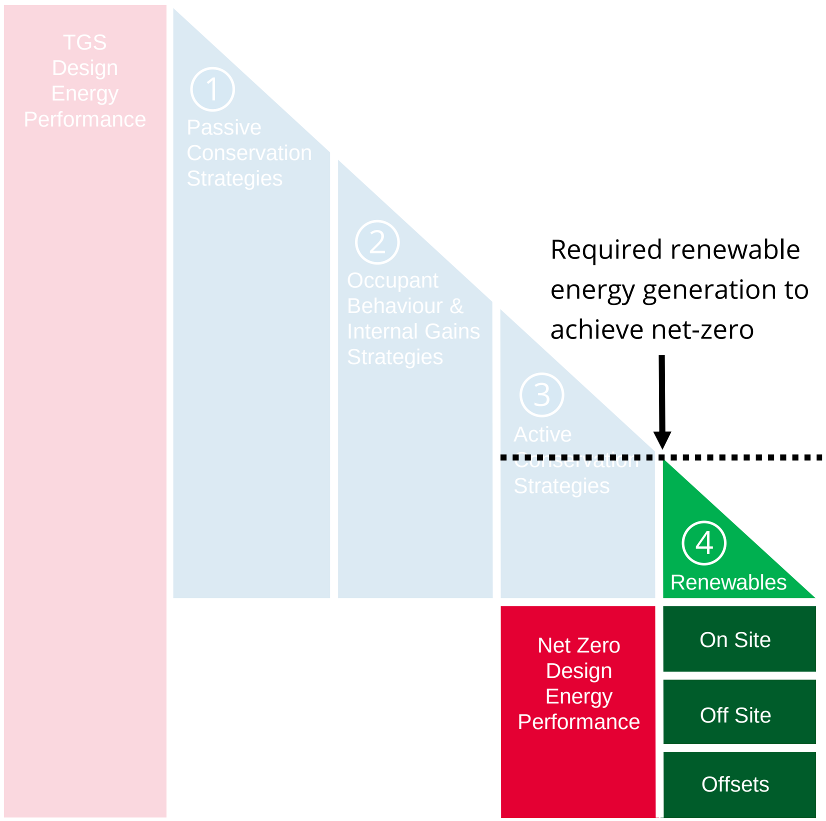


Figure 8: Solar radiation potential on the new proposed buildings



Using site-specific solar radiation information and the PVWatts calculator it was estimated that 125,000 kWh of energy could be generated on-site, annually. While not insignificant, this would only offset 4.6% of the Net Zero Design's total site energy use (2,690,800 kWh), and is therefore insufficient to reach a net-zero level of performance using on-site renewable generation.

4.2 OFF-SITE RENEWABLES

Although on-site solar PV generation will not generate sufficient energy for the development to reach a net-zero level of performance, off-site carbon offset strategies could also be considered.

The area of solar generation that would be required to fully offset the energy requirement and carbon emissions of the development can be determined by comparing the PV system size to the total energy requirement of the building.

The PVWatts calculator results for on-site solar PV suggest a generation potential of 250 kWh/m^2–year in the Toronto climate. The quantity of solar PV required to offset the remaining energy consumption of the Net Zero Design building (2,565,800 kWh) can then be calculated by dividing the energy consumption by the generation potential. This equates to a solar PV system area of 10,263 m^2.

This is not an insignificant area, and it would not likely be feasible to install this much solar capacity in downtown Toronto, yet the area is comparable to existing solar farms in rural Ontario. Developments like this could consider taking advantage of Ontario's abundant rural areas where large-scale solar farms are possible to achieve a net-zero carbon level for the project through off-site solar generation. At present, however, there are minimal incentives to encourage developments to consider such large scale strategies, making their pursuit unlikely to be feasible.

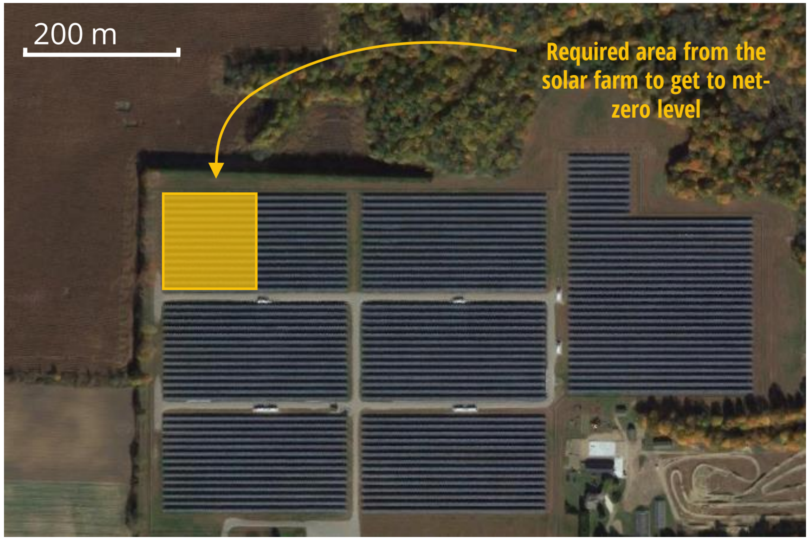


Figure 9: The area of off-site generation required by the development (yellow rectangle) overlaid on the Silvercreek Solar Park, found near Aylmer Ontario (Courtesy of GoogleEarth™).

4. LOW-CARBON SOLUTIONS

4.3 DISTRICT ENERGY & CHP

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

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

Some examples of low carbon intensity energy sources for a DES include a central geothermal field, a combined heat and power plant, deep lake water cooling, and bio-fueled boilers. Importantly, district energy should not be confused with renewable energy or low-CO_2e energy sources. Unless the fuel choice at the district central plant has a lower carbon intensity than that which is proposed at the building level, there is no CO_2e benefit to considering a district energy approach. In fact, there may be a penalty as a result of distribution losses.

The City of Toronto has a number of existing district energy systems, and encourages building developers and owners to consider collaborating with an existing district system and/or buildings that are “district energy-ready”. (Reference Link 6)

The figure below illustrates that there is no existing DES at the proposed site. However, given the scale of the 2993-3011 Sheppard Avenue East, and 1800-1814 Pharmacy Avenue development, it could also consider an on-site central energy plant, which could provide thermal energy (i.e. heating and cooling) using a common distribution loop to all areas of the building.

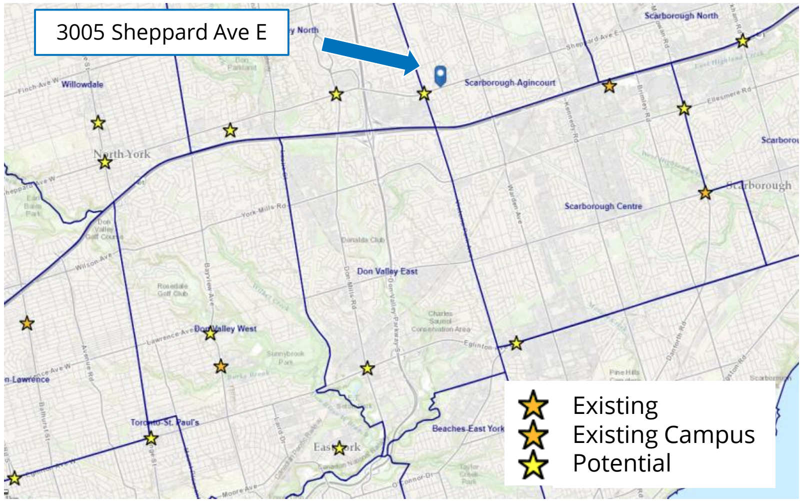


Figure 10: Nearby DES Infrastructure (Courtesy of Enwave)

5. RESILIENCY

5.1 CLIMATE CHANGE

According to the Resilient Design Institute, "resilient design" is the intentional design of buildings, landscapes, communities, and regions in order to respond to natural and man-made disasters and disturbances, as well as long-term changes resulting from climate change, including sea level rise, increased frequency of heat waves, and regional drought.
(Reference Link 7)

Figure 11: ASHRAE Climate Zones

Historically, Toronto has been considered to have a heating-dominated climate, and strategies to reduce energy requirements for heating are typically the most important. Yet, as the climate changes, reducing cooling energy will become increasingly important for Toronto buildings.

Figure 11 shows the ASHRAE Climate Zones in North America. Climate Zones are categorized based on the annual Heating Degree Days (HDDs) that are on average experienced in a given location.

While according to ASHRAE, Toronto is located in Climate Zone 6, the Ontario Building Code (OBC) considers Toronto to fall within Climate Zone 5. Further, *Toronto's Future Weather and Climate Driver Study*, found that the annual HDDs are forecasted to continue to decrease, placing Toronto in Climate Zone 4 between 2040 and 2049. (Reference Link 8)

Figure 12, on the following page, shows the historical and forecasted HDDs for Toronto, and demonstrates this shift away from ASHRAE Climate Zone 6.

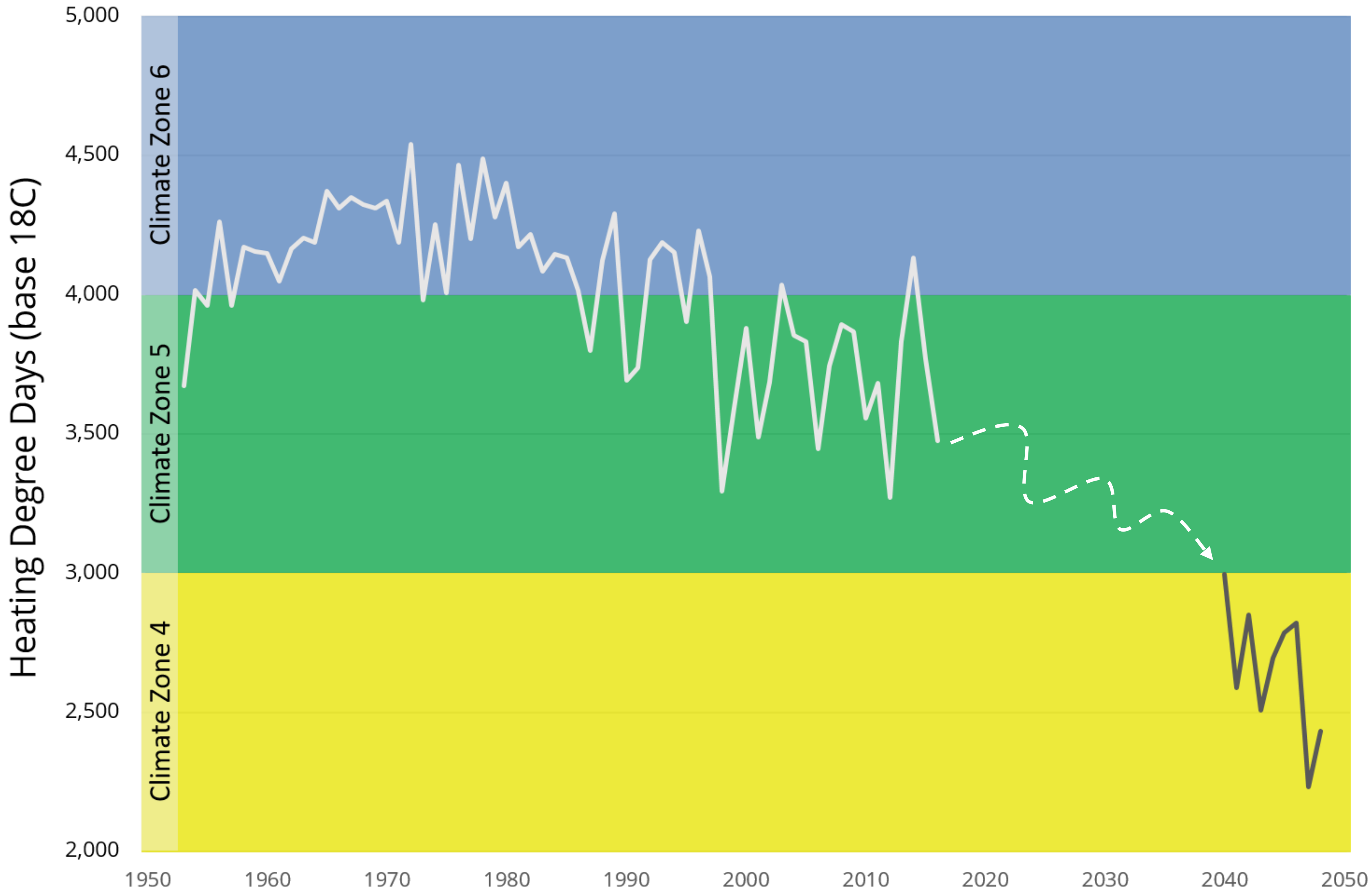


Figure 12: Historical and Forecasted Heating Degree Days at Toronto Pearson Airport
([Reference Link 9](#))

5.2 TORONTO'S FUTURE WEATHER

Other key future weather changes projected by the *Toronto's Future Weather and Climate Driver Study* include:

- Increased temperatures throughout the year;
- Increased frequency and duration of heat waves;
- Increased intensity of major rain events, major storms, and tornados; and
- Increased frequency of freeze-thaw events.

These potential weather changes suggest an increased risk of power outages and system failure at the building and infrastructure level – a trend that extreme weather events in recent years appears to support. The proposed development will take several years to be fully realized, and will likely be in operation 40+ years into the future. As such, the building design needs to be sufficiently robust to meet the needs of today, while flexible enough to adapt to the uncertain future of tomorrow.

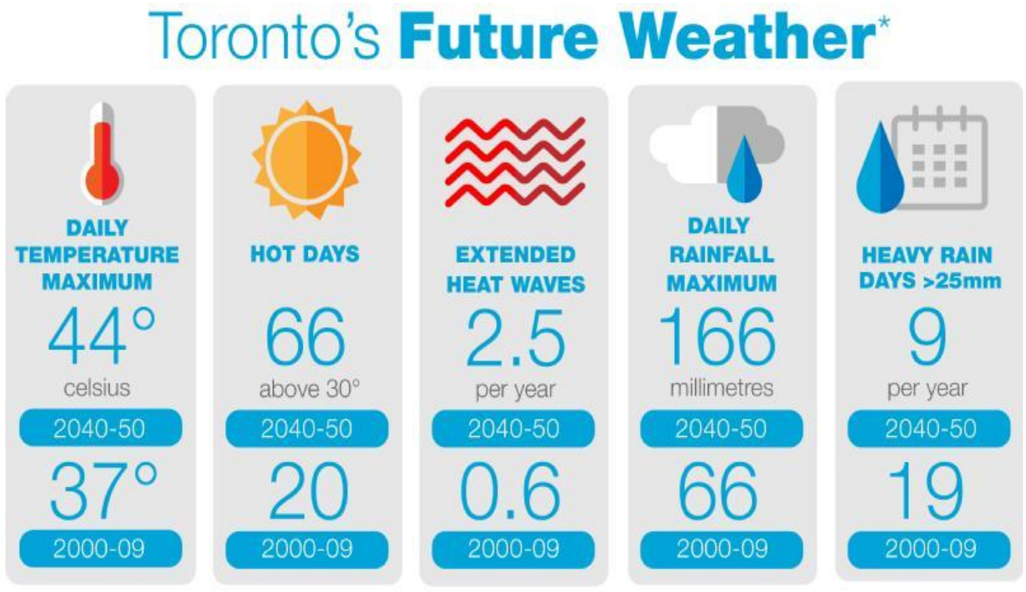


Figure 13: Key Future Weather Characteristics Projected for Toronto (Reference Link 8)

5.3 PASSIVE SURVIVABILITY TEST

"Passive survivability" is performance indicator that describes a building's ability to maintain an acceptable indoor condition despite the failure of active building systems. There are a number of factors that can influence this acceptable indoor condition: temperature, humidity, air movement, and solar radiation. If the interior temperature of a building moves beyond this acceptable range for extended periods, it can introduce health risks to occupants due to extreme heat/cold exposure.

While Toronto's future weather study focuses on increased frequency and duration of heat waves, there is still a concern for system failure during winter months, caused by sudden drops in temperature and freeze-thaw events. In addition to health risk to occupants, these extreme cold events can cause damage to building envelope, systems, and equipment.

The passive survivability of a residential building can be explored in the energy model by simulating an extended power outage, and observing the change in interior temperature. For this test, a 7-day power outage situation is simulated using historical weather that showed extreme winter conditions: from February of 2015, which broke City of Toronto records with an average daily temperature of -13°C.

Within the energy model, all active systems – heating, cooling, ventilation, domestic hot water, lighting, and receptacle – are turned off for the 7-day period, representing a full power outage with no back-up generation. The results are shown on the following page.

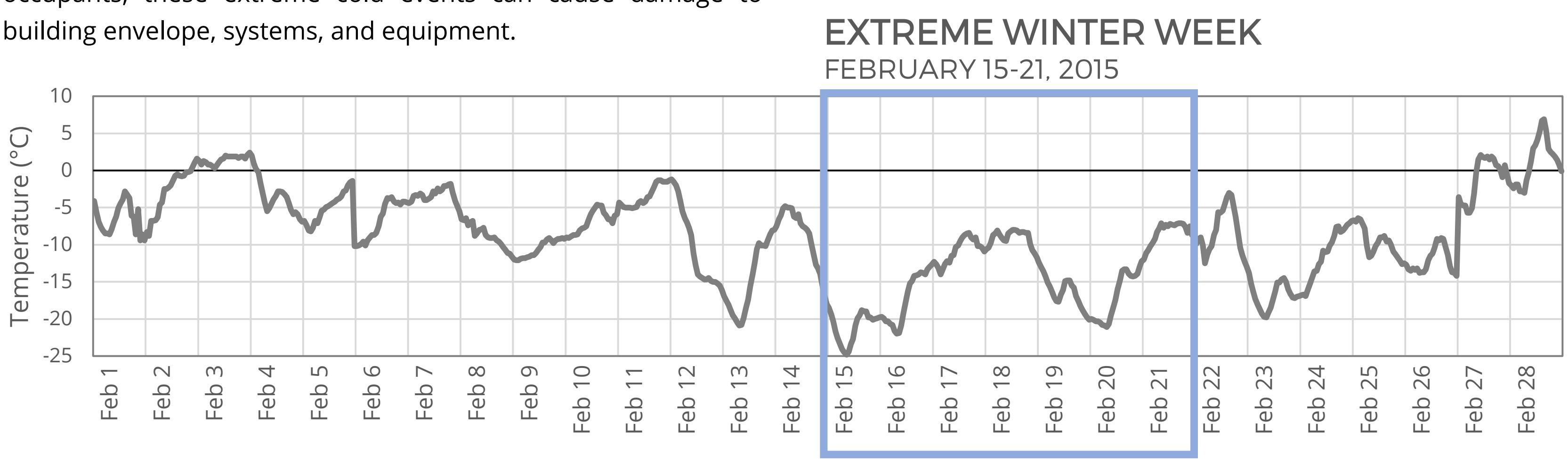


Figure 14: Extreme Winter Outdoor Air Temperatures

5.3 PASSIVE SURVIVABILITY TEST - WINTER

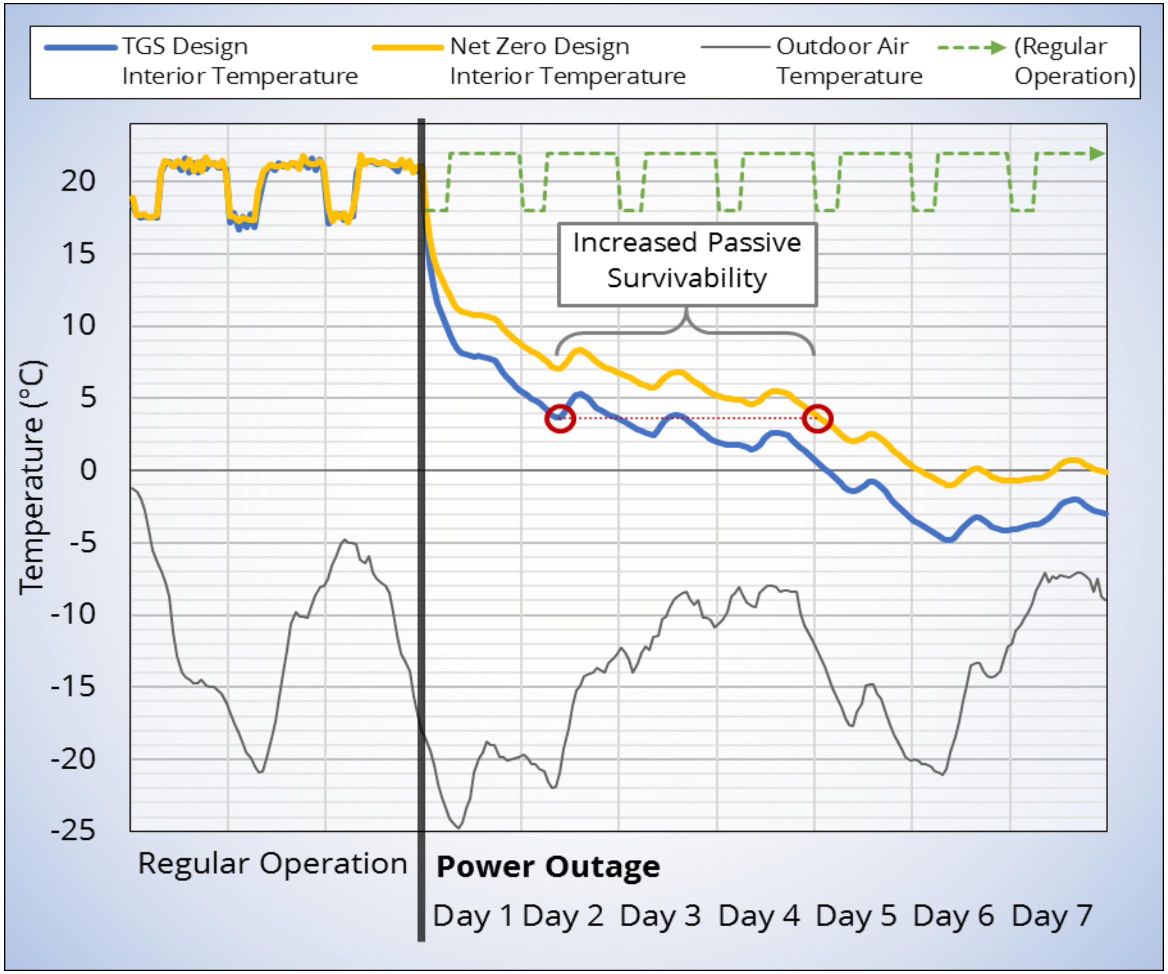


Figure 15: Winter Passive Survivability Test Results

Figure 15 presents the impact of a 7-day power outage on a north-facing suite during the coldest week of February 2015. There is limited solar heat gain opportunity for a room in this orientation, so it is considered to be the worst-case scenario.

The interior temperature of the TGS Design drops to 4°C after a day and continues to steadily decrease, falling below 0°C by the end of Day 4. Contrastingly, the Net Zero Design, which has improved building envelope performance, is better able to maintain the interior temperature and does not fall below 4°C until the end of Day 4; the Net Zero Design falls below 0°C by the end of Day 5.

By improving the building envelope to a high-performance level, the passive survivability during extreme cold events is increased dramatically.

5.4 DESIGN CONSIDERATIONS

Climate change will continue to present a new set of challenges to building developments in Toronto. Accordingly, this project's team will be encouraged to consider:

- Back-up power systems, which are suggested to provide at least 72 hours of support for: domestic water (hot & cold), elevator service, space heating, lighting and receptacle power.
- Design solutions that allow the buildings systems to be adapted to future climatic conditions. Examples could include: the ability to add shading devices at a future date, or additional system cooling capacity.
- Enclosure strategies like low window to wall ratios, thermal breaks at balconies, airtightness, and operable windows to improve the thermal comfort and passive survivability of the building.

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

- Higher perceived value because of the resilient features and the ability to market these;
- Lower operating costs (thermal envelope improvements);
- Reduced insurance premiums;
- Increased safety; and
- Easier ability to sell units on higher floors.

Figure 16: The immediate importance of resilient design was demonstrated in Toronto by the 2013 flooding of downtown streets and buildings (Courtesy of user:Eastmain / Public Domain)

6. CONCLUSIONS & RECOMMENDATIONS

1. In order to meet the Tier 1 energy efficiency requirements of TGS, the building design will need to include a combination of the best proactive measures, envelope upgrades and mechanical system upgrades (see page 8) to reach the 15% better than code performance required for TGS. A path to achieve TGS compliance is discussed in this report.

2. While the potential energy use and GHG emissions reductions are impressive and demonstrate the project's potential to contribute positively towards the City's TransformTO initiative and Province of Ontario's Climate Change Action Plan, the relatively modest energy cost reduction (especially given the significant investment that would be required to achieve these savings) highlights a key challenge to realizing low-carbon developments in Ontario, which is the cost disparity between natural gas and electricity.

3. Several of the energy conservation measures listed in this strategy have greater marketability because of their visibility and direct link to the resident's utility bills. These include suite level thermal sub-metering and kill switches near the exits. These visible measures give occupants better control of their utility bills and over the use of their space. Moreover, the energy modelling shows that these type of measures can have a significant impact on energy use.

4. While there are currently no established district energy systems at the project site, it may still prove prudent to design the new buildings to be district energy ready or even consider the additional of a new central utility plant given the scale of the development.

7. REFERENCE LINKS

1. Energy Strategy Terms of Reference: https://www.toronto.ca/wp-content/uploads/2018/01/9446-CEP-Energy-Strategy-Terms-of-Reference-Jan-2018.pdf

2. Ontario Climate Change Action Plan: https://www.ontario.ca/page/climate-change-action-plan

3. Canada's GHG Inventory: https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1

4. CaGBC Zero Carbon Framework: http://www.cagbc.org/cagbcdocs/NetZero/2016_CaGBC_Zero_Carbon_Framework_Exec_Summary.pdf

5. National Renewable Energy Lab (NREL) PVWatts Calculator: http://pvwatts.nrel.gov/

6. City of Toronto District Energy Guideline: https://www.toronto.ca/wp-content/uploads/2018/01/96ab-District-Energy-Ready-Guideline_October-2016.pdf

7. Resilient Design Institute: http://www.resilientdesign.org/

8. Toronto’s Future Weather and Climate Driver Study: https://www.toronto.ca/legdocs/mmis/2012/pe/bgrd/backgroundfile-51653.pdf

9. RWDI White Paper “Modelling Weather Futures”: https://rwdi.com/assets/factsheets/Modelling-weather-futures.pdf

APPENDIX A

SUMMARY OF ENERGY MODEL INPUTS

APPENDIX A

SUMMARY OF PRIMARY ENERGY MODEL INPUTS – HIGH-RISE RESIDENTIAL

The primary energy model inputs for the OBC Reference building, TGS Design, and final Net Zero Design model of the **high-rise residential** portions of the development are shown below:

Modelled GFA | Number of Stories	9,151 m² | Residential tower (14 storeys)
Location | Climate	Scarborough, Ontario | Toronto City CWEC
Primary Space Types	Residential, Amenities
Residential Occupancy Schedule and Set Points	Heating Set Point: 22°C, Set Back 18°C | Cooling Set Point 24°C | NECB Schedule G
Non-Residential Occupancy Schedule and Set Points	Heating Set Point: 22°C, Set Back 18°C | Cooling Set Point 24°C, Set Back to Off | NECB Schedule C
Outdoor Air Rates	Residential: 47 L/s per Suite | Non-residential: per ASHRAE 62.1-2013

	OBC Reference	TGS Design	Net Zero Design
Envelope			
Typical Exterior Wall Performance	RSI-3.6 (R-20.4)	Spandrel RSI-1.6 (R-9.0)	RSI-1.6 (R-9.0)
Typical Roof Performance	RSI-6.4 (R-36.4)	RSI-6.4 (R-36.4)	RSI-6.4 (R-36.4)
Gross Window to Wall Ratio	40%	50%	50%
Glazing Performance	USI-1.9 (U-0.33) | SHGC 0.40	USI-2.46 (U-0.43) | SHGC 0.31	USI-1.57 (U-0.28) | SHGC 0.27
Infiltration Rate	0.25 L/s-m² of façade	0.25 L/s-m² of façade	0.22 L/s-m² of façade
System Level – Residential			
Primary HVAC Type	4-pipe fan coil	4-pipe fan coil	Variable Refrigerant Flow (VRF)
Airside Heat Recovery	None	In-suite HRVs, 65% sensible	In-suite ERVs, 75% sensible|65% latent
Heating	Hydronic	Hydronic	VRF - Seasonal COP 3.0
Cooling	Hydronic	Hydronic	VRF - Seasonal COP 4.2
System Level – Non-Residential			
Primary HVAC Type	Packaged Single Zone	Packaged Single Zone	Packaged Single Zone
Airside Heat Recovery	None	None	85% sensible, 65% latent
Heating	MAU Furnace: 80% | Hydronic Radiators	MAU Furnace: 80% | Hydronic Radiators	MAU Furnace: 90% | Hydronic Radiators
Cooling	DX Cooling	DX Cooling	DX Cooling
Plant Level			
Space Heating Efficiency	Natural draft boilers: 90%	Condensing boiler: 92% seasonal	VRF
Space Cooling Performance	Water-Cooled Chiller: COP 6.17	Water-Cooled Chiller: COP 6.17	VRF
DHW Efficiency	90%	92%	92%
Space Level			
Equipment Load	4.4 W/m² (weighted average)	4.4 W/m² (weighted average)	3.4 W/m² (weighted average)
Lighting Power Density (W/m²)	Res: 5.0 | Non-Residential: 8.4	Res: 5.0 | Non-Residential: 6.7	Res: 4.8 | Non-Residential: 6.7
DHW Fixture Flow Rates (L/min)	Lav: 8.35 | Kitchen: 8.35 | Shower: 7.6	Lav: 3.8 | Kitchen: 5.7 | Shower: 5.7	Lav: 1.9 | Kitchen: 3.8 | Shower: 2.7

APPENDIX A

SUMMARY OF PRIMARY ENERGY MODEL INPUTS – MID-RISE RESIDENTIAL

The primary energy model inputs for the OBC Reference building, TGS Design, and final Net Zero Design model of the **mid-rise residential** portions of the development are shown below:

Modelled GFA | Number of Stories	18,741 m² | Mid-rise residential building (7 storeys) + 12,333 m²| Parking Garage (3 Storeys)
Location | Climate	Scarborough, Ontario | Toronto City CWEC
Primary Space Types	Residential, Amenities, Parking Garage
Residential Occupancy Schedule and Set Points	Heating Set Point: 22°C, Set Back 18°C | Cooling Set Point 24°C | NECB Schedule G
Non-Residential Occupancy Schedule and Set Points	Heating Set Point: 22°C, Set Back 18°C | Cooling Set Point 24°C, Set Back to Off | NECB Schedule C
Outdoor Air Rates	Residential: 47 L/s per Suite | Non-residential: per ASHRAE 62.1-2013

	OBC Reference	TGS Design	Net Zero Design
Envelope			
Typical Exterior Wall Performance	RSI-3.6 (R-20.4)	Spandrel RSI-1.1 (R-6.3)	RSI-3.4 (R-19.2)
Typical Roof Performance	RSI-6.4 (R-36.4)	RSI-6.4 (R-36.4)	RSI-6.4 (R-36.4)
Gross Window to Wall Ratio	40%	63%	45%
Glazing Performance	USI-1.9 (U-0.33) | SHGC 0.40	USI-2.46 (U-0.43) | SHGC 0.39	USI-1.50 (U-0.25) | SHGC 0.30
Infiltration Rate	0.25 L/s-m² of façade	0.25 L/s-m² of façade	0.22 L/s-m² of façade
System Level – Residential			
Primary HVAC Type	4-pipe fan coil	4-pipe fan coil	Variable Refrigerant Flow (VRF)
Airside Heat Recovery	None	In-suite HRVs, 65% sensible	In-suite ERVs, 75% sensible|65% latent
Heating	Hydronic	Hydronic	VRF - Seasonal COP 3.0
Cooling	Hydronic	Hydronic	VRF - Seasonal COP 4.2
System Level – Non-Residential			
Primary HVAC Type	Packaged Single Zone	Packaged Single Zone	Packaged Single Zone
Airside Heat Recovery	None	None	85% sensible, 65% latent
Heating	MAU Furnace: 80% | Hydronic Radiators	MAU Furnace: 80% | Hydronic Radiators	MAU Furnace: 90% | Hydronic Radiators
Cooling	DX Cooling	DX Cooling	DX Cooling
Plant Level			
Space Heating Efficiency	Natural draft boilers: 90%	Condensing boiler: 92% seasonal	VRF
Space Cooling Performance	Air-Cooled Chiller: COP 5.9	Air-Cooled Chiller: COP 2.8	VRF
DHW Efficiency	90%	92%	92%
Space Level			
Equipment Load	4.3 W/m² (weighted average)	4.3 W/m² (weighted average)	3.0 W/m² (weighted average)
Lighting Power Density (W/m²)	Res: 5.0 | Non-Residential: 8.4 | Parking 1.0	Res: 5.0 | Non-Residential: 6.7 | Parking 1.0	Res: 4.8 | Non-Residential: 6.7 | Parking 1.0
DHW Fixture Flow Rates (L/min)	Lav: 8.35 | Kitchen: 8.35 | Shower: 7.6	Lav: 3.8 | Kitchen: 5.7 | Shower: 5.7	Lav: 1.9 | Kitchen: 3.8 | Shower: 2.7

APPENDIX A

SUMMARY OF PRIMARY ENERGY MODEL INPUTS - RETAIL

The primary energy model inputs for the OBC Reference building, TGS Design, and final Net Zero Design model of the **commercial** building areas of the development are shown below:

Modelled GFA | Number of Stories	1,375 m² | 1 storey
Location | Climate	Scarborough, Ontario | Toronto City CWEC
Primary Space Types	Commercial
Occupancy Schedule and Set Points	Heating Set Point: 22°C, Set Back 18°C | Cooling Set Point 24°C, Set Back to Off | NECB Schedule A
Outdoor Air Rates	Per ASHRAE 62.1-2013

	OBC Reference	TGS Design	Net Zero Design
Envelope			
Typical Exterior Wall Performance	RSI-3.6 (R-20.4)	RSI-2.7 (R-15.6)	RSI-4.5 (R-25.3)
Typical Roof Performance	RSI-6.4 (R-36.4)	RSI-5.3 (R-30.0)	RSI-7.0 (R-39.7)
Gross Window to Wall Ratio	35%	35%	35%
Glazing Performance	USI-1.9 (U-0.33) | SHGC 0.40	USI-2.15 (U-0.38) | SHGC 0.35	USI-1.19 (U-0.21) | SHGC 0.49
Infiltration Rate	0.25 L/s-m² of façade	0.25 L/s-m² of façade	0.22 L/s-m² of façade
System Level			
Primary HVAC Type	VAV Rooftop with Reheat Coil	VAV Rooftop with Reheat Coil	DOAS Fan Coil Units with Variable Refrigerant Flow (VRF)
Airside Heat Recovery	None	ERVs, 65% sensible | 55% latent	ERVs, 89% sensible | 74% latent
Heating	Hydronic	Hydronic	VRF - Seasonal COP 1.9
Cooling	DX Cooling, COP 3.4	Hydronic	VRF - Seasonal COP 4.3
Fan Power (W/CFM)	SF 0.86 | RF 0.39	SF 1.0 | RF 1.0	ERV SF and RF 0.75 | FCU 0.3
Plant Level			
Space Heating Efficiency	Natural draft boilers: 90%	Condensing boiler: 94%	VRF
Space Cooling Performance	None	Air-Cooled Chiller: COP 4.3	VRF
DHW Efficiency	90%	94%	96%
Space Level			
Equipment Load	5.5 W/m² (weighted average)	5.5 W/m² (weighted average)	5.5 W/m² (weighted average)
Lighting Power Density	8.8 W/m² (weighted average)	6.9 W/m² (weighted average)	5.3 W/m² (weighted average)
DHW Fixture Flow Rates (L/min)	Lav: 8.35 | Kitchen: 8.35 Shower: 9.5	Lav: 3.8 | Kitchen: 8.35 Shower: 5.7	Lav: 3.8 | Kitchen: 8.35 Shower: 5.7

APPENDIX B

TGS ENERGY CONSERVATION MEASURES

APPENDIX B
TGS ENERGY CONSERVATION MEASURES

The following assumptions were used to explore a path to compliance with the mandatory Tier 1 of the Toronto Green Standard for the building:

“Low Cost Measure” Package

- LED lights with occupancy controls installed in common, amenity, commercial, retail, and parking areas – 25% reduction of LPD
- Increased boiler and DHW heater thermal efficiency – 92% seasonal efficiency
- VFD pumps
- Low flow domestic hot water fixtures:
    - Lavatories: 3.8 LPM
    - Residential kitchen faucets: 5.7 LPM
    - Showers: 5.7 LPM

“Envelope Upgrade” Package

- Window to wall ratio reduced to 50% in high rise residential towers.
- Spandrel performance upgrade to 75 mm insulated backpan with interior spray foam insulation – RSI-1.6 m^2K/W (R-9)

“In-suite Mechanical Upgrade” Package

- In-suite heat recovery ventilation (HRV) units with 65% sensible effectiveness
- Electronically commutated (EC) motors on fan coil units – 0.3 W/CFM
- EC motors on HRV units – 0.5 W/CFM
- Variable speed fans on fan-coil units