Energy Strategy Report

City of Toronto
Climate, Energy & Resilience
Community Energy Planning

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Toronto, Ontario

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EXECUTIVE SUMMARY

EVNA Services was commissioned to prepare an Energy Strategy Report for the multi-residential project located at 3400 Weston Road in Toronto, as part the project's Zoning By-law Amendment (ZBA) submission per the City of Toronto's Energy Strategy Terms of Reference effective January 2018.

The proposed project is a new 36-storey mixed-use multi-residential tower consisting of 480 residential units with a Buildable Floor Area (BFA) of approximately 55,590 m², including two levels of underground parking.

In the city of Toronto, planning applications are required to meet and demonstrate compliance with Tier 1 of the Toronto Green Standard (TGS) version 3 which came into force May 01, 2018. In addition to the mandatory Tier 1, TGS v3 provides three optional performance Tiers (Tiers 2, 3 and 4), which were developed to take the building industry from today's building practices to a near-zero emissions level of performance by the year 2030 by increasing TGS performance requirements in four-year cycles (as shown in Table i).

Table i - A Pathway to Zero Emissions Buildings

2018	2022	2026	2030
V3 Tier 1	--	--	--
V3 Tier 2	V4 Tier 1	--	--
V3 Tier 3	V4 Tier 2	V5 Tier 1	--
V3 Tier 4	V4 Tier 3	V5 Tier 2	V6 Tier 1

Off-site renewable energy procurement = Zero Emission Buildings

TGS v3 requires new development projects applying for Site Plan Approval to demonstrate compliance by meeting/exceeding absolute performance targets defined for each of the four performance Tiers for a specific building type (as shown in Table ii for high-rise MURB).

Table ii - TGS v3 Absolute Performance Targets

Multi-unit Residential Building (≥ 4-Storeys)	TGS v3 Absolute Performance Targets			
	Tier 1	Tier 2	Tier 3	Tier 4
Total Energy Use Intensity (ekWh/m²)	170	135	100	75
Greenhouse Gas Emissions Intensity (kg/m²)	20	15	10	5
Thermal Energy Demand Intensity (kWh/m²)	70	50	30	15

The Proposed Building is expected to achieve the mandatory performance requirements for TGS v3 Tier 1 (as summarized in Section 3.2.1), however some envelope design improvements are required. **The design team is encouraged to consider the proposed Energy Conservation Measures summarized in Section 3.2.2 and to work towards achieving the optional TGS v3 Tier 2 targets**. Successful compliance with the optional TGS v3 Tier 2 targets will be rewarded by the City through a partial development charge refund, but this reward is set to expire in 2022 when TGS v4 Tier 1 comes into force replacing the current TGS v3 Tier 2.

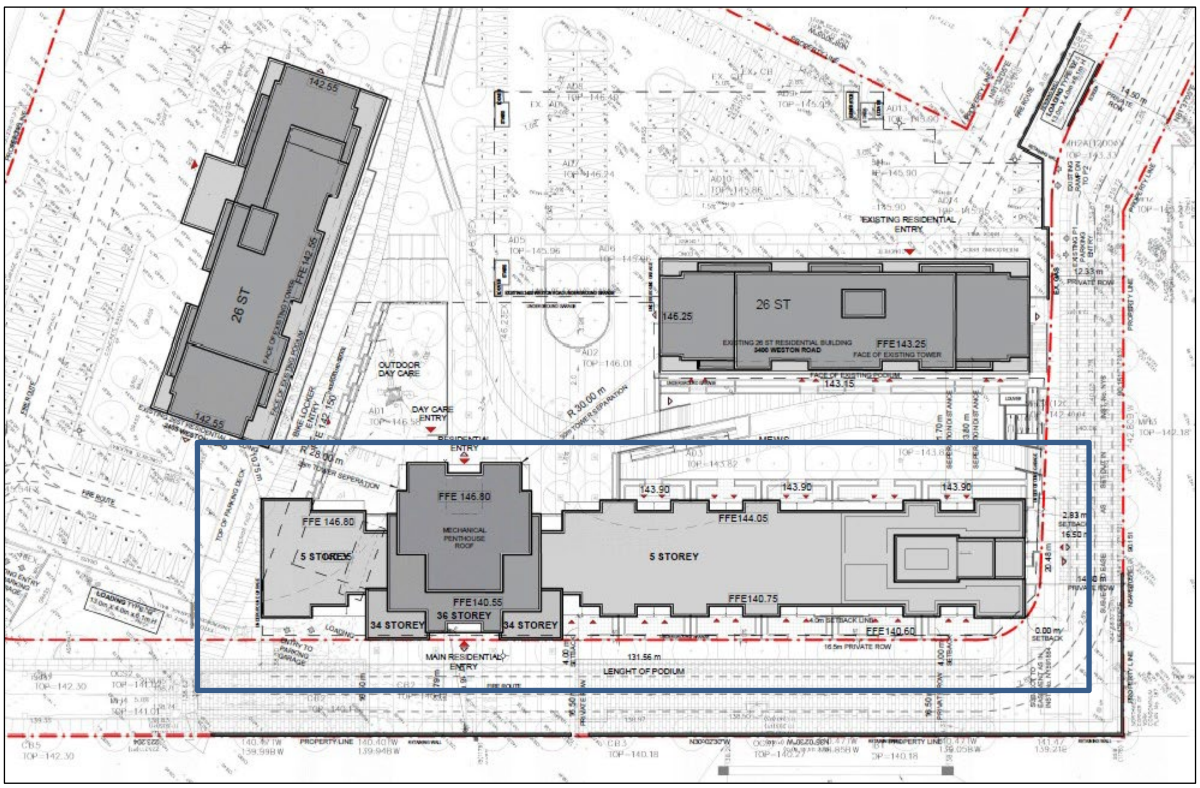
1.0 INTRODUCTION

1.1 Project Overview

The proposed project is comprised of a 36-storey mixed-use multi-residential apartment building, is located at 3400 Weston Road in Toronto, and has a Buildable Floor Area (BFA) of approximately 55,589 m² (including 2 levels of underground parking).

The Proposed Building consists of 480 residential units with a Modeled Floor Area (MFA)[1] of 37,450 m².

Figure 1 - Proposed Context Plan



The energy simulations were performed using eQUEST version 3.65. The Toronto City Center 2016 CWEC weather file was used in the simulations (CAN_ON_Toronto-City.Centre.715080_CWEC2016.bin).

Lighting Power Densities were modeled using the Space-by-Space method, per SB-10 (2016) Division 3 Chapter 3 – NECB 2015.

The building operates 24 hours per day, 7 days per week. NECB schedules Type A, B , C, G, H and K were used for this simulation.

1 **Modelled Floor Area ("MFA")** – The total enclosed floor area of the building, as reported by the energy simulation software, excluding exterior areas and parking areas. All other spaces, including semi-heated (as defined under SB-10 2017) and unconditioned spaces are included in the MFA. The MFA must be within 5% of the gross floor area from the architectural drawings, unless justification is provided demonstrating where the discrepancy arises and why the MFA should differ from the gross floor area by greater than 5%.

1.2 Energy Strategy Purpose

For buildings greater than 20,000 m^2 or within a Community Energy Plan area approved by Council, the City of Toronto introduced back in 2018 the requirement for an Energy Strategy Report at the application stage for a Plan of Subdivision, Official Plan or Zoning Bylaw Amendment. The intent of the Energy Strategy Report is to encourage project teams to:

- Take advantage of existing or proposed energy infrastructure, energy capture and/or solar orientation at the conceptual design stage.
- Consider potential energy sharing for multi-building development and/or neighbouring existing/proposed developments.
- Consider opportunities to increase resiliency such as strategic back-up power capacity (for multi-unit residential buildings).
- Identify innovative solutions to reduce energy consumption in new construction and major retrofits of existing buildings.
- Explore potential to attract private investment in energy sharing systems.

The requirement for an Energy Strategy Report stems from the City of Toronto developing a new and ambitious climate action strategy called TransformTO. The greenhouse gas reduction target set out in the TransformTO strategy is an 80% GHG reduction (based on 1990 levels) by 2050.

In order to achieve 2050 GHG reduction goal, the City has prepared a Zero Emissions Buildings Framework. The Framework comprises a full set of targets for the five most common building archetypes that require increasing levels of performance over time to achieve the 2050 goal.

The four tiers of performance incorporated in the latest Toronto Green Standard (TGS) version 3, which came into force May 01, 2018, were developed to take the building industry from today's building practices to a near-zero emissions level of performance by the year 2030 by increasing TGS performance requirements in four-year cycles.

Table 1 - A Pathway to Zero Emissions Buildings

2018	2022	2026	2030
V3 Tier 1	--	--	--
V3 Tier 2	V4 Tier 1	--	--
V3 Tier 3	V4 Tier 2	V5 Tier 1	--
V3 Tier 4	V4 Tier 3	V5 Tier 2	V6 Tier 1

Off-site renewable energy procurement = Zero Emission Buildings

At this stage of the project's design, the project team has targeted TGS v3 Tier 1 performance. The contents of this Energy Strategy Report will serve to address the energy and resiliency requirements of the Energy Strategy Terms of Reference.

2.0 DESIGN OPORTUNITIES

2.1 Passive Design Measures

The envelope of the building has not been detailed at this stage of the design. The intent of the design will be to provide an efficient building envelope design that is complemented by the mechanical systems. Fenestration systems are encouraged to be high performance with a solar heat gain coefficient selected to optimized to meet the Thermal Energy Demand requirements.

The current elevation designs suggest a window to wall ratio of approximately 82% (including spandrel glass panels) which exceeds the 40% limit defined by SB-10. The building has a predominantly rectangular floor plan throughout the 36 levels. The majority of the envelope exposure faces the North-East and South-West orientations.

As the design progresses through site plan and building permit approval, the design team should consider incorporating additional passive design measures in order to meet the new TGS v3 absolute performance requirements, including:

- High performance fenestration units with energy efficient framing material (u-PVC or Fiberglass)
- Opaque building envelope with continuous insulation (low effective U-value)
- Thermally broken balconies (to mitigate the effects of thermal bridging)
- High performance fenestration with low-e coating (includes efficient framing)
- External shading devices

2.2 Active Design Measures

The proposed mechanical system is expected to consist of 4 Pipe Fan Coils served by gas-fired condensing boilers for space heating and a water-cooled variable speed magnetic bearing centrifugal chiller for space cooling. As the design progresses towards building permit submission/approval, the analysis will be elaborated upon further to assist the design team with achieving the energy performance targets. In order to meet/exceed the new TGS performance targets, the project team is encouraged to consider the following Energy Conservation Measures in the project design:

- Condensing HW boilers with efficiency ratings ≥ 95%
- Variable Refrigerant Flow (VRF) / Heat Pump systems – high efficiency system, low carbon
- Condensing Domestic Hot Water (DHW) heaters/boilers with efficiency ratings ≥ 95%
- High efficiency gas fired Fresh Air Units (FAUs) with a rated efficiency ≥ 90%
- VFD fans on central FAUs to allow fans to reduce flows during lower occupancy
- In-suite Heat Recovery Ventilators (HRVs) or Energy Recovery Ventilators (ERVs) with a seasonal effectiveness ≥ 75% to improve ventilation quality in suites, reduced energy use
- ECM motors on terminal units to reduce fan power
- VFD controlled pumps with two-way valves to varying pump flow and reduce consumption
- Reduced corridor ventilation flows (20-30 cfm/suite) to reduce energy consumption
- High-efficiency LED lighting with controls (common area, amenities and dwelling units) – to reduce lighting energy consumption
- Low-flow plumbing fixtures to reduce water consumption and energy demand for DHW heating

2.3 Advanced Energy Solutions

2.3.1 District Energy Systems

The City of Toronto Zero Emissions Buildings Framework identifies low carbon thermal energy networks (i.e. District Energy System or DES) as key strategy for achieving the 2050 GHG reduction targets. Unlike previous versions of TGS, TGS v3 now recognizes a connection to a DES (e.g. deep lake water cooling, geo-exchange, biofuels, solar thermal, waste heat recovery, etc.…) when that system uses a low-carbon energy source, with credit reflected through the GHGI performance metric.

According to the City of Toronto, a study was conducted and identified more than 27 locations with the potential to support new District Energy Systems throughout the city. It is recommended for the design team to monitor changes in the 27 proposed district energy systems to assess any new opportunities in the future that might benefit the project.

Enwave's Deep Lake Water Cooling (DLWC) was commissioned back in 2004 and serves the City's downtown core area bordered by Bathurst St., Front St., Parliament St. and Wellesley St. Although discussions regarding DLWC or any other type of DES have not been held as of yet, the project's location is North of the 401 and is unfortunately outside the downtown core, disqualifying DLWC as a possible option to consider.

It is recommended the design team consider 'Future Proofing' the project by designing the building to be district energy-ready (DE-ready) in the event DES services become available at the project's location. DE-ready is defined as, *"Having a mechanical and building design that makes the building ready to connect to a future DES when it becomes available"*[2]. The City of Toronto suggests the following key items be incorporated into a building's design for a future district energy connection:

- Ability to supply thermal energy from the ground level
- Adequate space at or below ground level for a future energy transfer station
- An easement between the mechanical room and the property line to allow for thermal piping
- 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 will be located
- A low temperature hydronic heating system that is compatible with a district energy system in order to reduce the pipe sized and associated valves, fitting, etc.
- Appropriate thermal energy metering

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

2.3.2 Solar Photovoltaic (PV) Energy

Over the past several years, solar PV has become an economically viable strategy for small scale energy generation (e.g. at the individual building level) due to price reductions in solar panel equipment and efficiency improvements of the technology. For this reason, solar PV has become an important on-site renewable energy source used in low carbon and net zero building designs.

The are two key factors to account for when considering a Solar PV energy system. First the system requires adequate sunlight exposure and second, the real estate needed to house the panels. Typically, solar panels are installed on the building's roof. For high-rise building designs, this poses a problem given the ratio of small roof area to gross floor area. A solution to the surface area shortage on the roof would be to house additional solar panel on the building's wall areas, which would significantly increase the available surface area, however, the question then becomes whether or not this wall area would receive adequate sunlight in Toronto's downtown setting. A full analysis of solar PV energy viability is beyond the scope of this report and would be required prior to the design team making any decisions on the technology.

At a high level, given the approximate roof area of the project, it is estimated that an upward of 1,317 m² could be available for solar energy production. This would provide approximately 222 MWh of energy annually in Toronto. The following table summarizes the ratio of solar energy production versus the building's total annual energy use:

Table 2 - Solar Energy Generation

Solar Energy Generation	TGS Tier 1 Proposed Building Annual Energy	TGS Tier 2 Proposed Building Annual Energy	TGS Tier 4 Proposed Building Annual Energy
Solar Energy Generation	222,000 kWh	222,000 kWh	222,000 kWh
Total Annual Energy Use	6,327,137 ekWh	5,045,908 ekWh	2,643,498 ekWh
% of Annual Energy Use	3.5%	4.4%	8.4%

Working towards a net-zero emissions design, the solar production could provide approximately 8.4% of estimated total annual energy use. A true net-zero energy design requires 100% of the building's energy consumption to be offset, meaning that an additional 2,422 MWh of energy would need to be generated from both on-site and off-site renewable energy sources. Please refer to Section 3 below for details on the energy simulation results.

Similar to DESs noted above, in the event the design team decides that incorporating solar energy generation is not in the project's best interest at this time, it is recommended the design team consider 'Future Proofing' the project by designing the building to incorporate solar ready features, such as allowing for structural support of solar panels on the rooftop, and providing the necessary electrical conduit and space allocation in an electrical room for future solar PV equipment and infrastructure.

Please note that TGS v3 Tier 2 prescribes Solar Readiness as a core requirement, ensuring that buildings are designed to accommodate connections to solar PV or solar thermal technologies. **This means that Solar Readiness will be a mandatory TGS v4 Tier 1 requirement in 2022.**

2.3.3 Alternative Advanced Energy Solutions

While not necessarily regarded viable at this stage of the project, some of the additional advanced energy solutions described below may be examined further as the building design progresses. The design team is encouraged to review and consider the following:

- **Spectrally Selective Glazing**: is high-performance glazing that tints in response to the sun's position, solar radiation, and/or weather conditions, admitting as much daylight as possible, while mitigating as much solar heat transmission as possible. Spectrally selective glazing can significantly reduce energy consumption in buildings by maximizing use of daylight reducing the need for electric lighting, controlling solar heat gains during in summer, and preventing interior heat loss in winter.
- **Drain Water or Wastewater Heat Recovery**: Non-storage type systems consist of a copper heat exchanger that replaces a vertical section of a main waste drain. As warm/hot water flows down the waste drain (e.g. from showers, bathtubs, sinks, dishwashers, and clothes washers), incoming cold-water flows through a spiral copper tube wrapped tightly around the exterior of the copper drain. This heat transfer preheats the incoming cold water from the city prior to filling the Domestic Hot Water (DHW) storage tank, which offsets the DHW heating loads. Ideal for MURB type buildings, with multiple plumbing drains connected to a main waste drain.
- **Off-site Renewable Energy Procurement**: in addition to on-site renewable technologies, as the TGS mandatory performance targets move towards near zero emissions, development projects are expected to require procurement of some form of off-site renewable energy achieve the future Tier 1 targets.
- **Solar Air Heater**: uses the sun's energy to pre-heat ventilation air by drawing incoming air through a transpired panel, reducing the building's ventilation heating load.
- **Ground Source Heat Pump (GSHP)**: A below grade piping network which uses the ground as both a heat source and heat sink, extracting heat from the ground during the winter and rejecting heat to the ground during the summer respectively.
  - Heat pumps or VRF systems extract heat from the conditioned space during the summer and transfer it to the ground and in return supply cool air to the space.
  - In the winter, the reverse happens, heat pumps extract heat stored in the ground and transfer it to the conditioned space. Cold air extracted from the space and is transferred back to the ground to be used again during the summer.
  - This system is typically expensive, even more so in densely populated urban areas, as only the vertical loop option can be used when land area restrictions apply.
  - Another draw back of the ground-source geothermal system is the need for balance heating and cooling loads. Buildings with unbalanced heating/cooling loads due to the building's operation (e.g. schools or seasonally operated buildings, no) or due to the building's location & climate (Northern climates vs Southern climates) will eventually overtime become inefficient followed by the incapability to satisfy the building's heating or cooling loads.

- **Solar Thermal**[3]: Rooftop mounted solar collector (typically unglazed plastic collectors) predominantly used in Canada for residential pool heating. Perforated solar air collectors are used for commercial building air heating.
- **Wind Turbines**: wind turbines are typically more suited for use at a utility scale, however micro wind turbines (i.e. building-integrated wind turbines) can be suitable in urban settings at the building scale as they are designed to generate renewable electricity locally. Unfortunately, size requirements tend to limit applicability. Also, the effects of 'windshadows' produced in cities by the varying building heights, cars and roads tend to impede the laminar flow (i.e. smooth flow) of air reducing/negating the ability to generate measurable power.
- **Earth Tubes**: A passive technology that draws outdoor air through underground tubing, enabling the transfer of ground source energy to heat or cool the ventilation air supplied to the building.
    - Earth tubes are standard concrete tubes that run underground (approximately 3m deep) and precondition the temperature of incoming air before it enters the building.
    - They reduce the energy required to heat or cool the building as they can warm cold air by as much as 20°C during the winter and cool warm air by 10°C during the summer, without the need for energy consuming mechanical equipment.
    - In the summer, ground temperatures are typically cooler than outside air keeping the concrete tubes cool, which then cools the air as it passes through into the building. In the winter the reverse happens, the ground temperatures are typically warmer than the outside air which means that the tubes warm the air as it passes through.
    - When earth tubes are combined with heat recovery, they can significantly reduce the need for mechanical air tempering. In some building designs, earth tubes have been noted to allows the use of 100% fresh air within the building, without incurring large energy costs as a result.
- **Thermally Active Building Systems (TABS):** A structural element (usually a concrete slab), in which hot water and chilled water pipes are embedded. Since the pipes run through the whole slab, a large surface area of radiant heating and cooling is available. This system also takes advantage of the thermal storage capacity of concrete. With the proper controls, the system can operate in such a way to increase heat extraction/addition when high loads are anticipated, reducing the peak demand of the system.
- **Double Skin Façade:** Two layers of glass "skins" separated by an air corridor. The air corridor can be naturally or mechanically ventilated. The air space between the two facades acts as insulation against temperature extremes, winds and sounds. In cold weather, solar radiation incident on the outer skin creates a solar chimney effect, causing the warm air in the cavity to rise up and allowing for natural ventilation. In the summer, shading devices on the inner skin are often used to reduce unwanted solar heat gain.

3 https://www.nrcan.gc.ca/energy/energy-sources-distribution/renewables/solar-thermal/7301

3.0 TOWARDS ZERO EMISSIONS DEVELOPMENT

3.1 Toronto Green Standard (TGS) version 3 Absolute Energy Targets

In the City of Toronto as of May 01, 2018, planning applications are required to meet and demonstrate compliance with Tier 1 of the Toronto Green Standard (TGS) Version 3. Version 3 introduces two new 'Optional' performance Tiers; Tier 3 and Tier 4.

As of Jan 1, 2020, TGS v3 Tier 1 compliance must be demonstrated via the 'Absolute Energy Performance Targets' pathway for the five defined building type categories. All other building types shall continue to demonstrate a 15% total energy performance improvement over the OBC's SB-10 (2017) Supplementary Standard.

The intent of establishing absolute targets is to encourage all buildings of similar building type to meet the same standards of performance regardless of the building's particular design. The following summarizes the three new absolute performance targets for TGS v3:

1. **Total Energy Use Intensity (TEUI)** shall be reported in kWh/m²/year
   The sum of all energy used on site (i.e. electricity, natural gas, and district heating and cooling), minus all *Site Renewable Energy Generation*, and divided by the *Modelled Floor Area*[4].
2. **Thermal Energy Demand Intensity (TEDI)** shall be reported in kWh/m²/year
   The annual heating delivered to the building for space conditioning and conditioning of ventilation air. Measured with modelling software, this is the amount of heating energy delivered to the project that is outputted from any and all types of heating equipment, per unit of *Modelled Floor Area*. Heating equipment includes electric, gas, hot water, or DX heating coils of central air systems (e.g. make-up air units, air handling units, etc.), terminal equipment (e.g. baseboards, fan coils, heat pumps, reheat coils, etc.) or any other equipment used for the purposes of space conditioning and ventilation. Heating output of any heating equipment whose source of heat is not directly provided by a utility (electricity, gas or district) must still be counted towards the TEDI.
3. **Greenhouse Gas Intensity (GHGI)** shall be reported in kg eCO_2/m²/year
   The total greenhouse gas emissions associated with the use of all energy utilities on site on a per area basis, using the emissions factors in Section 3.3 of the TGS v3 modeling guideline.

The following table summarizes the TGS v3 Absolute Energy Performance Targets for multi-unit residential type buildings ≥ 4-Storeys:

Table 3 - TGS v3 Absolute Energy Performance Targets

Multi-unit Residential Building (≥ 4-Storeys)	TGS v3 Absolute Performance Targets			
	Tier 1	Tier 2	Tier 3	Tier 4
Total Energy Use Intensity (ekWh/m²)	170	135	100	75
Greenhouse Gas Emissions Intensity (kg/m²)	20	15	10	5
Thermal Energy Demand Intensity (kWh/m²)	70	50	30	15

4 **Modelled Floor Area ("MFA")** – The total enclosed floor area of the building, as reported by the energy simulation software, excluding exterior areas and parking areas. All other spaces, including semi-heated (as defined under SB-10 2017) and unconditioned spaces are included in the MFA. The MFA must be within 5% of the gross floor area from the architectural drawings, unless justification is provided demonstrating where the discrepancy arises and why the MFA should differ from the gross floor area by greater than 5%.

3.2 Performance Scenarios Towards Zero Emissions

3.2.1 Baseline (TGS v3 Tier 1)

The project is currently submitting the project design package to the City Planning office for Zoning By-law Amendment (ZBA) and is only expected to apply for Site Plan Approval (SPA) in 2020. Given the project's current timeline, the proposed project is required to meet/exceed the TGS v3 Tier 1 absolute performance targets.

At the time of this report, the project design was in its infancy. Only preliminary architectural plans were available showing draft versions of the proposed floor plans and building elevations.

To achieve the Tier 1 Absolute Energy Performance Targets noted in the section above, the following envelope, electrical and mechanical system design assumptions were made in the eQUEST simulation:

Building Envelope System:

- 36 storeys above grade, plus 2 levels for underground parking:
- Total Buildable Floor Area (BFA) of 55,589 m²:
  - 24,581 m² of residential, and 12,636 m² of underground parking.
- Total of 480 residential suites,
- Reduced Window to Wall Ratio (WWR) to 60% (includes vision and spandrel glass areas),
- Estimated exterior wall and slab edge U-value of U-0.049 (R-20),
- Estimated U-values: Roof U-0.027 (R-37) | Window U-value of U-0.335 (R-2.98), and
- Below grade wall and floor U-values set to SB-10 – NECB 2015 defaults.
- Building infiltration set to NECB 2015 requirement (0.25 L/s-m² | 0.05 cfm/ft²)

Mechanical & Electrical Systems:

- Central FAU w/ HW & CHW coils serving the corridors, supplying of 100 cfm/suite,
- 4 Pipe Fan Coils with ECM motors (simulated by VSD),
- Boiler Plant: 4 condensing boilers | sizing: 27 MBH/suite | efficiency: 96%,
- DHW Boiler Plant: 4 condensing boilers | sizing: 12 MBH/suite | efficiency 95%,
- In-suite heat recovery with sensible effectiveness of 55%,
- In-suite shut-off control via programmable thermostats (intermittent fan mode),
- Chiller Plant: Variable magnetic bearing centrifugal chiller | COP 6.1,
- Variable speed open cooling tower,
- Reduced domestic water load via low flow fixtures by 12.5% (reduces DHW heat load),
- Variable speed drive control on water pumps and HVAC fans,
- Internal lighting and plug loads set to SB-10 – NECB 2015 defaults,
- Three building elevators (15 kW each),
- In-suite exhaust based on ASHRAE 62.1 (50 cfm/suite) operating for 2 hours/day,
- Suite ventilation based on 100cfm/suite, and
- Parking garage exhaust based on ASHRAE 62.1 (0.75 cfm/ft²) operating for 4 hours/day.

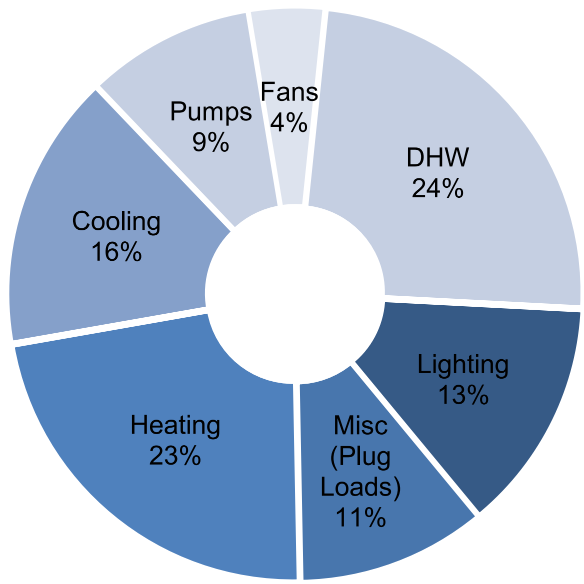
The following table summarizes the estimated energy performance values for the proposed project based on the system design assumptions noted above.

Table 4 - TGS v3 Tier 1 Performance Compliance Summary

Proposed Building	Absolute Value	Intensity	TGS v3 Tier 1 Target
Estimated Total Energy Use	22,778 GJ	168.95 kWh/m²	170.00 kWh/m²
Estimated Greenhouse Gas Emissions	699,300 kg eCO_2	18.67 kg eCO_2/m^2	20.00 kg eCO_2/m^2
Esimated Thermal Energy Demand	5,114 GJ	37.93 kWh/m²	70.00 kWh/m²

The following chart summarizes the estimated annual energy consumption for the Tier 1 compliant design grouped by building end use.

Figure 2 - TGS v3 Tier 1 End Use Breakdown



3.2.2 **Higher Performance (TGS v3 Tier 2)**

To achieve the Tier 2 Absolute Energy Performance Targets noted in Section 3.1, the following Energy Conservations Measures were added to the proposed design and simulated in the eQUEST model:

Building Envelope ECMs:

- Reduce the window to wall ratio to 50%,
- Increase roof insulation to have an assembly effective U-value of U-0.025 (R-40),
- Improve window assembly performance to an effective U-value of U-0.264 (USI-1.5),
- Reduce building infiltration by 12% (less than NECB 2015 default 0.25L/s-m²|0.05 cfm/ft²).

Mechanical & Electrical Systems:

- Reduce DHW load by a total of 40% less than NECB 2015 default (500W/per),
- Increase in-suite heat recovery sensible effectiveness to 75%, and
- Reduce suite ventilation to 50 cfm/suite (i.e. equivalent to ASHRAE 62.1 rates).

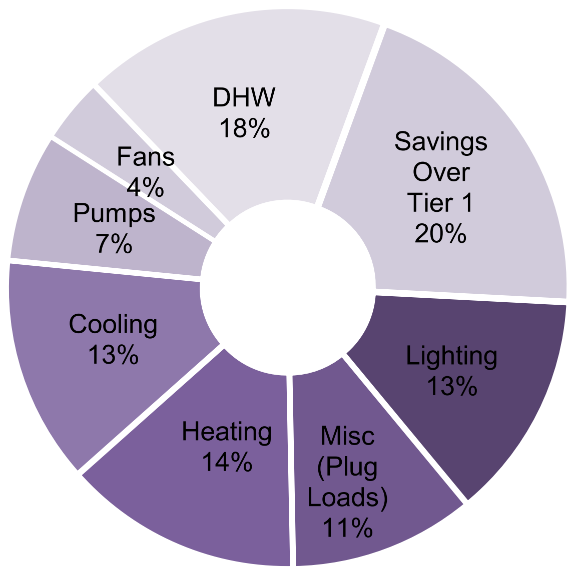
The following table summarizes the estimated energy performance values for a Tier 2 compliant design, based on the Tier 1 system design assumptions noted in Section 3.2.1 plus the Energy Conservations Measures (ECMs) noted above in this section.

Table 5 - TGS v3 Tier 2 Performance Compliance Summary

Proposed Building	Absolute Value	Intensity	TGS v3 Tier 2 Target
Estimated Total Energy Use	18,165 GJ	134.74 kWh/m²	135.00 kWh/m²
Estimated Greenhouse Gas Emissions	510,097 kg eCO_2	13.62 kg eCO_2/m^2	15.00 kg eCO_2/m^2
Esimated Thermal Energy Demand	3,134 GJ	23.25 kWh/m²	50.00 kWh/m²

The following chart summarizes the estimated annual energy consumption for the Tier 2 compliant design grouped by building end use, **showing a 20% energy savings over the Tier 1 building**.

Figure 3 - TGS v3 Tier 2 End Use Breakdown



3.2.3 Near Zero Emissions (TGS v3 Tier 4)

To achieve the Tier 4 – Near Zero Emissions Absolute Energy Performance Targets noted in Section 3.1, the following Energy Conservations Measures were added to the proposed design and simulated in the eQUEST model:

Building Envelope ECMs:

- Reduce total window to wall ratio to 40%,
- Increase exterior wall insulation to an effective U-value of U-0.04 (R-25),
- Increase thermal break at floor slab-edge/balcony with an effective U-value of U-0.04 (R-25),
- Insulate parking level P1 below grade walls with R-12 insulation (effective U-0.083), and
- Increase roof insulation to an effective U-value of U-0.02 (R-50),
- Improve window performance to an effective U-value of U-0.176 (USI-1.0),
- Reduce building infiltration by a total of 50% (less than NECB 2015 default 0.05 cfm/ft²).

Mechanical & Electrical Systems:

- Reduce DHW load by a total of 50% less than NECB 2015 default (500W/per),
- Reduce suite Lighting Power Density (LPD) by 50% (< NECB default of 5W/ft²),
- Reduce suite plug load by 25% via energy efficient appliances (< NECB default of 5W/ft²),
- Reduce building elevator motor load by 15%,

- Central FAUs serving the corridors fitted with DX cooling & HW coils served by boiler plant,
- Replace 4PFC system with air-cooled Variable Refrigerant Flow (VRF) system:
    - *System efficiencies: Cooling COP 4.7 | Heating COP 5.5,*
    - *Removed CHW loop, chiller, and associated water pumps,*
    - *Removed CW loop, cooling tower, and associated water pumps.*
- Set VRF fan power set to 0.00026263 kW/cfm per Daikin VRV iv data sheets,
- Resize Boiler Plant: 2 condensing boilers | sizing: 0.6 MBH/suite | efficiency: 96%,
- Convert DHW system to electric, with 80% of the reduced load served by electric boilers and the remaining 20% served by DHW heat pumps,
- Increase in-suite ERV effectiveness to 85%, and
- Reduce parking garage exhaust to 0.5 cfm/ft² (operating for 4 hours/day).

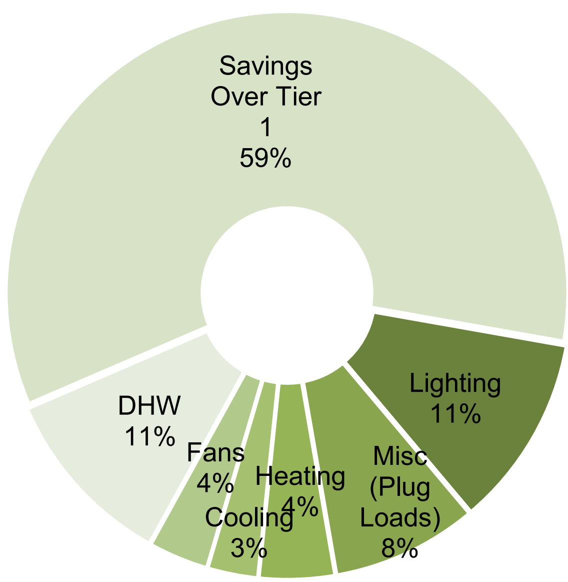
The following table summarizes the estimated energy performance values for a Tier 4 compliant design, based on the Tier 1 system design assumptions noted in Section 3.2.1 plus the Energy Conservations Measures (ECMs) noted above in this section.

Table 6 - TGS v3 Tier 4 Performance Compliance Summary

Proposed Building	Absolute Value	Intensity	TGS v3 Tier 4 Target
Estimated Total Energy Use	9,517 GJ	70.59 kWh/m²	75.00 kWh/m²
Estimated Greenhouse Gas Emissions	144,090 kg eCO_2	3.85 kg eCO_2/m^2	5.00 kg eCO_2/m^2
Esimated Thermal Energy Demand	2,021 GJ	14.99 kWh/m²	15.00 kWh/m²

The following chart summarizes the estimated annual energy consumption for the Tier 4 compliant design grouped by building end use, **showing a 59% energy savings over the Tier 1 building**.

Figure 4 - TGS v3 Tier 4 End Use Breakdown



3.3 Energy Conservation & Demand Reduction

The City of Toronto's net-zero emissions goal is based on progressively increasing the TGS energy performance targets over the next 12 years until the year 2030, at which time today's 'Optional Tier 4' performance target will become the mandatory Tier 1 performance targets.

Table 7 - TGS Absolute Performance Targets

Multi-unit Residential Building (≥ 4-Storeys)	TGS v3 Absolute Performance Targets			
	Tier 1	Tier 2	Tier 3	Tier 4
Total Energy Use Intensity (ekWh/m²)	170	135	100	75
Greenhouse Gas Emissions Intensity (kg/m²)	20	15	10	5
Thermal Energy Demand Intensity (kWh/m²)	70	50	30	15

From the simulation descriptions above, to achieve a near net zero (TGS v3 Tier 4) design, a VRF (or Daikin VRV) system had to be used. The high efficiencies achieved with this system type in combination with their electric heating components, reduces the building's energy use and GHG emissions respectively.

Supplemental heating would most likely be electric boilers as well, or at worst, high efficiency gas-fired condensing boilers. Both of these options will ultimately reduce GHG emissions compared to the water loop heat pump system initially designed. Lastly, electric DHW heaters coupled with low flow plumbing fixtures will also be used to minimize the DHW load, further reducing GHG emissions for the near net zero proposed design (i.e. TGS v3 Tier 4).

The energy efficient mechanical systems described above will however, cause a fundamental shift in the building's primary heating energy source from natural gas to electricity. This is not typical practice in today's building design for one main reason; in Ontario the electricity cost is approximately 5.8 times more than natural gas (assuming average provincial rates of \$0.15/kWh and \$0.25/m³ of natural gas).

Another factor to consider is the impact on the building's peak electrical demand during the summer and winter seasons. The following table summarizes the building demand for each of the three scenarios found in Section 3.0 above.

Table 8 - Proposed Building Demand

Building Demand	Compliant Models		
	Tier 1	Tier 2	Tier 4
Winter (kW)	699	629	1,242
Summer (kW)	754	663	616
Peak (kW)	754	663	1,242

Design teams must remain mindful that if the default approach to achieving future GHGI targets over the next 12 years is to shift the primary heating energy source from natural gas to electricity, this approach could possibly result in a power-starved electrical grid. This highlights the importance of incorporating on-site and off-site renewable energy sources in our development projects.

3.4 Low-Carbon Solutions

At this phase of the Central Park design, various low-carbon solutions are under consideration. Opting to install a VRF instead of a 4-Pipe Fan Coil system, would reduce energy use associated with space heating/cooling by taking advantage of the increased system efficiencies, and would also reduce GHG emissions as a result of the electric heating components fueled by Ontario's relatively clean electricity grid.

As mentioned above, this system change would result in a shift of primary heating energy (from natural gas to electricity), reducing overall energy consumption annually while increasing demand load on the power grid. The material drawback to this proposed system is the significant cost difference between electricity and natural gas, with the former being almost 6 times higher based on average provincial market rates (i.e. \$0.15/kWh and \$0.25/m³).

The use of high-performance condensing boilers for hot water and domestic water heating, coupled with passive load reduction strategies (e.g. improved envelope performance and low-flow plumbing fixtures respectively) can still be effective strategies for reducing carbon use.

Perhaps a hybrid approach to start might be an agreeable compromise. Assuming the design team moves forward with a water loop heat pump design, the Proposed Building could be fitted with a combination of gas-fired condensing boilers and electric boilers. The electric boilers would be reserved for 'Off-Peak' use (i.e. nights and weekends). Using the electric boilers only during Off-Peak hours would reduce associated operating costs and would contribute to reducing carbon use.

A hybrid approach would also serve well from a resilience perspective. In the event of a power outage, the back-up generator system could run the gas-fired boilers as they require little electrical power compared to an electrical boiler. This could allow for uninterrupted space heating to the dwelling units without requiring oversized generation equipment to so do. Please refer to Section 3.5 below for more details on Energy Resilience.

Alternative low-carbon solutions such as on-site/off-site renewable energy are still on the table at this stage of the design, however further analysis is required to confirm their feasibility and viability.

3.5 Energy Resilience

3.5.1 Back-up Power

With extreme weather events on the rise and area wide power outages lasting upwards of 72 hours in the Toronto area, building developers and design teams need to consider/implement advanced back-up power solutions in their designs rather than implementing the minimum code requirements for emergency power.

The difference between back-up power and emergency power, is that back-up power is provided to meet the non-life safety requirements deemed essential for occupant well-being and comfort, such that occupants (specifically in MURB type buildings) can remain in their building safely for at least a 72 period when there isn't a need for evacuation (e.g. power outage, extreme weather/storms).

Table 9 -Emergency vs. Back-up Power Requirements

	Emergency Power	Back-up Power
Purpose	Provided to meet minimum life safety requirements. Facilitate occupant evacuation and firefighter access.	Provided to meet non-life safety requirements. Considered essential for occupant well-being.
Duration	2 hours - required by code. Source: building code	At least 72 hours Source: Federal Emergency Preparedness Guide
Loads	Fire protection system (pumps, alarm system, fire elevator, stair pressurization fans)	Suite Loads (water, min. heating/cooling, emerg. power) Building Loads (elevators, common refuge area, sump-pumps)

To increase the building's resiliency, the design team could elect to forego traditional emergency power generation and select a generator system with back-up power capability in addition to emergency power. Please refer to Section 3.5.2 below for details of natural gas generator benefits.

3.5.2 Natural Gas Generators

Natural gas generators are preferred over traditional diesel generators for power back-up from a resilience perspective, as there is no need for refuelling.

Natural gas engines cost approximately 15-20% more than diesel engines, however when the all-in costs of the two systems are compared (includes diesel tank(s), piping and pumps), the total costs tend to even out as the buildings increase in height.

A factor to consider is that natural gas engines require a load management system above 400 kW, in order to meet the code-required 15 second start up time for emergency loads. Although this control equipment adds capital cost to the project, it also permits load selection. The ability to select specific loads for a given circumstance (e.g. fire pumps are required during a fire, but not during a power outage) could potentially allow for smaller gas generators to be used instead of one large diesel generator.

Another benefit with natural gas generators (given the nature of their fuel connection) is that multiple smaller engines can be installed throughout the building. This in turn reduces equipment cost in comparison to a single large generator while also providing redundancy; in the event one unit fails there is still power generation available from the remaining units.

Case studies suggest that natural gas was preferred over diesel because the engines are cleaner, quieter and simpler to operate. No refuelling means uninterrupted operation during a power outage. The ability to have multiple smaller engines provides redundancy in the event of equipment failure. The advantages far outweigh the small cost premium associated with a natural gas back-up system.

Even though the project consists of only 36 storeys, it is recommended that the design team consider fitting the proposed buildings with natural gas engines in lieu of a diesel unit, to take advantage of the benefits noted above and to add back-up power generation capability to the building.

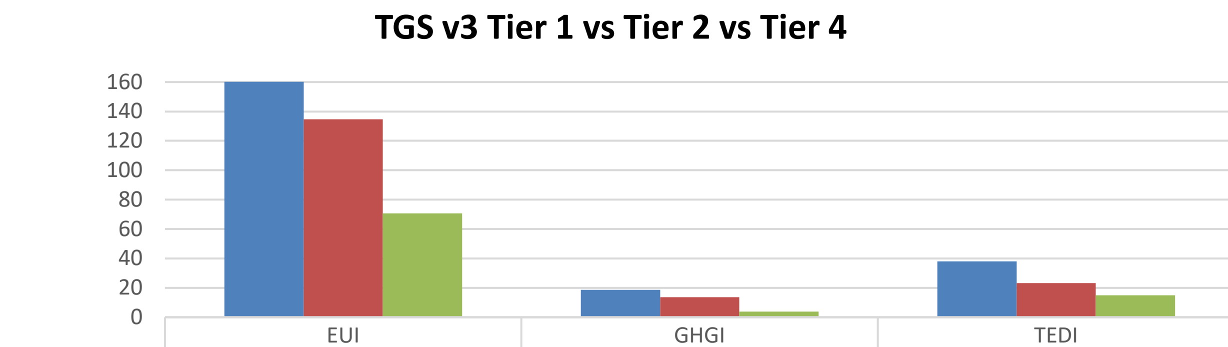
It is recommended that the design team review the City of Toronto's "Minimum Backup Power Guidelines for MURBs" (October 2016) for more detail and case studies.

4.0 ENERGY ANALYSIS

4.1 TGS Scenario Performance Comparison

The following figure 5 summarizes the Proposed Building's estimated performance, comparing the three simulated performance Tiers (Tiers 1, 2 and 4) against each other, grouped according to the respective TGS performance metric (EUI, GHGI, and TEDI).

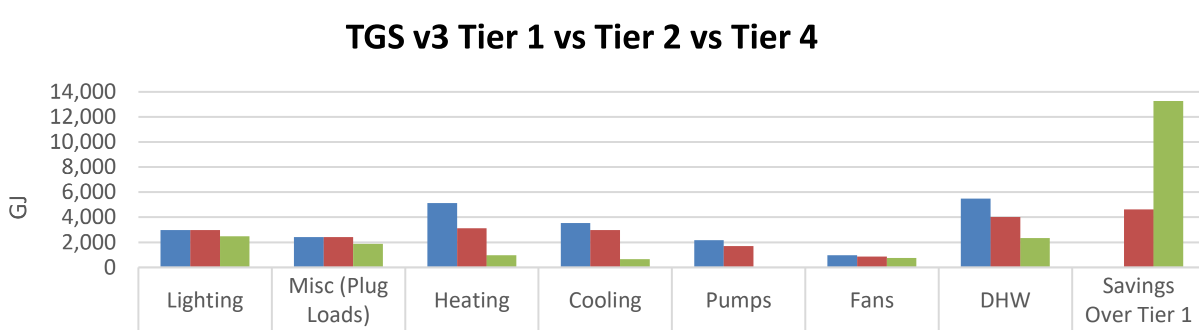
Figure 5 - TGS Performance Metric Comparison



	EUI	GHGI	TEDI
TSG v3 Tier 1	168.9 kWh/m²	18.7 kg eCO_2/m²	37.9 kWh/m²
TGS v3 Tier 2	134.7 kWh/m²	13.6 kg eCO_2/m²	23.2 kWh/m²
TGS v3 Tier 4	70.6 kWh/m²	3.8 kg eCO_2/m²	15.0 kWh/m²

Figure 6 illustrates the Proposed Building's estimated performance summarized by end use. This figure clearly highlights that compliance with TGS v3 Tier 4 requires little to no natural gas use.

Figure 6 - TGS Performance Comparison (End Use Breakdown)



	Lighting	Misc (Plug Loads)	Heating	Cooling	Pumps	Fans	DHW	Savings Over Tier 1
Tier 1 Annual Energy (GJ)	2,999	2,434	5,129	3,562	2,167	970	5,506	0
Tier 2 Annual Energy (GJ)	2,999	2,434	3,123	2,994	1,706	864	4,036	4,612
Tier 4 Annual Energy (GJ)	2,481	1,882	976	653	30	777	2,353	13,261

4.2 Preferred Project Scenario

It is recommended that the project work towards meeting the TGS v3 Tier 2 energy performance targets. This will require making improvements to key envelope components, while requiring only minor mechanical improvements when compared to a Tier 1 compliant building.

5.0 CONCLUSION / RECOMMENDATIONS

Based on the preliminary analysis of the development project, the mandatory TGS v3 Tier 1 energy performance targets are only achievable with an improved envelope design having a smaller window to wall ratio coupled with high performance mechanical equipment.

However, it is recommended that the design team consider the optional Higher Performance Tier 2 targets, as this can be achieved from passive envelope, mechanical ventilation, and heat recovery efficiency improvements. An improved envelope design and reduced ventilation rates would result in a reduced thermal load on the building (TEDI reduces from 37.93 to 23.25 kWh/m^2), potentially allowing a reduction in mechanical equipment, which translates to lower capital costs, and reduced operation and maintenance cost.

Through the use of a higher performing envelope with high efficiency HVAC equipment as summarized in Section 3.2.2; energy use, carbon use and peak electricity demand are all projected to meet/exceed the optional TGS v3 Tier 2 performance requirements, which happens to be incentivized by the City via a partial development charge refund.

The design team is also encouraged to consider implementing advanced measures such as district energy-ready (DE-ready required as core measure for Tier 2 compliance), solar PV or solar ready features, spectrally selective glazing and drain water heat recovery could all be undertaken on this project. Further analysis outside the scope of this report would be required.

Appendix I PROPOSED PROJECT ASSUMPTIONS

The following tables summarizes the Proposed Building's model input for the Tier 1 Baseline simulation.

For a summary of the projected energy performance, please refer to the 'Hourly Data Analysis' soft files included with this report submission.

Building Input	Baseline (TGS v3 Tier 1)
General	One mixed use multi-residential tower with 2 levels of underground parking
	36-storeys above grade
	Total MFA of 37,450 m² (excludes parking areas)
	Total of 480 residential suites.
Building Envelope	Reduced Total Window to Wall Ratio (WWR) of 60%:
	Effective exterior wall U-value of U-0.049 (R-20),
	Floor slab-edge/balcony with an effective U-value of U-0.049 (R-20)
	Un-insulated below grade walls and floors.
	Effective roof U-value of U-0.027 (R-37),
	Effective window U-value of U-0.335 (R-2.98), and
	Building infiltration set to NECB 2015 requirement (0.25 L/s-m² | 0.05 cfm/ft²)
Building Loads	Internal lighting and plug loads set to SB-10 – NECB 2015 defaults,
	Reduced domestic water load via low flow fixtures by 12.5% (reduces DHW heat load),
	Three building elevators (15 kW each),
	Corridor/Amenity ventilation based on ASHRAE 62.1 (5 cfm/person + 0.06 cfm/ft²), and
	Suite ventilation based on 100 cfm/suite.
Mechanical & Electrical	Central FAUs serving the corridors fitted with CHW & HW coils served by the boiler/chiller plant,
	4 Pipe Fan Coils Cooling: CHW coils served by chiller | Heating: HW coils served by boiler plant,
	Boilers: 4 condensing boilers | sizing: 27 MBH/suite | efficiency: 96%,
	DHW boilers: 4 condensing boilers | sizing: 12 MBH/suite | efficiency 95%,
	In-suite heat recovery with sensible effectiveness of 55%,
	Variable speed cooling tower,
	Variable speed drive control on water pumps and HVAC fans,
	In-suite shut-off control via programmable thermostats (intermittent fan mode)
	4 Pipe Fan Coils equipped with ECM motors,
	In-suite exhaust based on ASHRAE 62.1 (50 cfm/suite) operating for 2 hours/day,
	Parking garage exhaust based on ASHRAE 62.1 (0.75 cfm/ft²) operating for 4 hours/day.

The following table summarizes the Proposed Building's model input for the Tier 2 Higher Performance simulation. Energy Conservation Measures incorporated in this model version are highlighted in Green:

Building Input	High Performance Option 1 (TGS v3 Tier 2)
General	One mixed use multi-residential tower with 2 levels of underground parking
	36-storeys above grade
	Total MFA of 37,450 m² (excludes parking areas)
	Total of 480 residential suites.
Building Envelope	**Reduced Total Window to Wall Ratio (WWR) of 50%:**
	Effective exterior wall U-value of U-0.049 (R-20),
	Floor slab-edge/balcony with an effective U-value of U-0.049 (R-20)
	Un-insulated below grade walls and floors.
	Effective roof U-value of U-0.025 (R-40)
	Effective window U-value of U-0.264 (R-3.79) | Based on effective USI-1.5)
	Building envelope infiltration reduced by 12% (less than NECB 2015 default 0.05 cfm/ft²)
Building Loads	Internal lighting and plug loads set to SB-10 – NECB 2015 defaults,
	Reduced domestic water load via low flow fixtures by 40% (reduces DHW heat load),
	Three building elevators (15 kW each),
	Corridor/Amenity ventilation based on ASHRAE 62.1 (5 cfm/person + 0.06 cfm/ft²), and
	Reduce suite ventilation to 50cfm/suite (i.e. equivalent to ASHRAE 62.1 rates)
Mechanical & Electrical	Central FAUs serving the corridors fitted with CHW & HW coils served by the boiler/chiller plant,
	4 Pipe Fan Coils Cooling: CHW coils served by chiller | Heating: HW coils served by boiler plant,
	Boilers: 4 condensing boilers | sizing: 27 MBH/suite | efficiency: 96%,
	DHW boilers: 4 condensing boilers | sizing: 12 MBH/suite | efficiency 95%,
	In-suite heat recovery with sensible effectiveness of 75%,
	Variable speed cooling tower,
	Variable speed drive control on water pumps and HVAC fans,
	In-suite shut-off control via programmable thermostats (intermittent fan mode)
	4 Pipe Fan Coils equipped with ECM motors,
	In-suite exhaust based on ASHRAE 62.1 (50 cfm/suite) operating for 2 hours/day,
	Parking garage exhaust based on ASHRAE 62.1 (0.75 cfm/ft²) operating for 4 hours/day,

The following table summarizes the Proposed Building's model input for the Tier 4 Near Zero Emissions simulation. Energy Conservation Measures incorporated in this model version are highlighted in Green:

Building Input	High Performance Option 2 (TGS v3 Tier 4)
General	One mixed use multi-residential tower with 2 levels of underground parking
	36-storeys above grade
	Total MFA of 37,450 m² (excludes parking areas)
	Total of 480 residential suites.
	Blank
Building Envelope	**Reduced Total Window to Wall Ratio (WWR) of 40%:**
	Effective exterior wall U-value of U-0.040 (R-25),
	Floor slab-edge/balcony with an effective U-value of U-0.040 (R-25)
	Insulate parking level P1 walls with R-12 insulation (effective U-0.083)
	Effective roof U-value of U-0.02 (R-50)
	Effective window U-value of U-0.176 (R-5.68) | Based on effective USI-1.0
	Building envelope infiltration reduced by 50% (less than NECB 2015 default 0.05 cfm/ft²)
Building Loads	**Reduced domestic water load via low flow fixtures by 60% (reduces DHW heat load),**
	Reduced suite lighting power density (LPD) by 50% (over NECB 2015 default 5W/ft²)
	Reduced suite plug loads by 25% via energy efficient appliances (< NECB 2015 default 5W/ft²)
	Reduce building elevator load by 15%
	Corridor/Amenity ventilation based on ASHRAE 62.1 (5 cfm/person + 0.06 cfm/ft²), and
	Suite ventilation set to 50cfm/suite (i.e. equivalent to ASHRAE 62.1 rates)
Mechanical & Electrical	**Central FAUs serving the corridors fitted with DX cooling & HW coils served by the boiler plant,**
	Replace 4PFC system with air-cooled Variable Refrigerant Flow (VRF) system Cooling COP: 4.7 |Heating COP: 5.5
	Removed CHW loop, water-cooled chiller and associated water pumps
	Removed CW loop, cooling tower, and associated water pumps
	Set VRF fan power set to 0.00026263 kW/cfm per Daikin VRV iv data sheets
	VRF terminal units equipped with ECM motors,
	Resize Boiler plant: 2 condensing boilers | sizing: 0.6 MBH/suite | efficiency: 96%,
	Convert DHW system to electric, with 80% of the reduced load served by electric boilers and the remaining 20% served by DHW heat pumps
	In-suite heat recovery with sensible effectiveness of 85%,
	Variable speed drive control on water pumps and HVAC fans,
	In-suite shut-off control via programmable thermostats (intermittent fan mode)
	In-suite exhaust based on ASHRAE 62.1 (50 cfm/suite) operating for 2 hours/day,
	Reduce parking garage exhaust to 0.5 cfm/ft² (operating for 4 hours/day)