PURPOSE

ENERGY STAR® Multifamily High Rise Standard Version 1.0

Technical Study

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HEALTHY · LOW CARBON · CIRCULAR

INTRODUCTION

In 2017, National Resources Canada (NRCan) partnered with EnerQuality and the Ontario home building industry to develop and launch the ENERGY STAR® Multifamily High-Rise (New Construction) Pilot (ES-MFHR) in Ontario.

This Technical Study, prepared by Purpose Building, presents a summary of the similarities and differences between this new ENERGY STAR® Multifamily Pilot program and several existing sustainable building frameworks commonly used for high-rise buildings in Ontario, including LEED (Leadership in Energy and Environmental Design), the Toronto Green Standard (TGS), and Passive House (PH).

The Study is intended for:

- Developers and owners of and investors in multifamily development interested in improving sustainability performance beyond Building Code.
- Municipalities and local Authorities Having Jurisdiction interested in developing new sustainability policies aimed at broad market adoption.
- Professionals interested in obtaining new credentials and increasing their service offering.

CONTENTS

The Study consists of:

- Qualitative comparison of key energy-related features of the reviewed Standards.
- Quantitative estimates of energy consumption, thermal energy demand, carbon emissions, annual energy costs, capital costs and administrative costs that might be expected for typical mid-rise and high-rise developments that pursue these Standards, which were determined from a combination of:
    - Iterative archetype energy modelling
    - Modelled performance of recent buildings
    - Engineering judgement
- Key Insights and recommendations for developers/investors, policy-markers and professional service providers.

Study highlights are presented here– full details and all relevant technical assumptions are presented in the Full Report.

COMPARISON OF KEY ENERGY-RELATED FEATURES OF REVIEWED STANDARDS

The table below summarizes whether the Standard includes mandatory (required) or voluntary (optional) requirements for each key energy-related feature (or if no specific requirements exist). For Standards with multiple levels of achievable performance and certification, one level was selected for this Study based on Stakeholder feedback.

Meeting the requirements of the Ontario Building Code is mandatory for all new multi-family development in Ontario (except in very rare circumstances).

All other Standards are voluntary – any requirements of those Standards therefore only apply to projects that pursue them. Toronto Green Standard v3 Tier 1 is mandatory for new development in Toronto; the energy-related features shown for Tier 2 will become mandatory in May 2022.

Though not available when this comparison was performed, the City of Ottawa recently adopted a new High Performance Development Standard (HPDS) that shares many similarities with the TGS. It will require performance reporting in 2022 and compliance with targets in 2023.

☑ Required ✋ Optional × Not Required

Feature	Ontario Building Code (SB-10 2017)	ENERGY STAR® Multifamily High Rise	Toronto Green Standard (TGS) v3 Tier 2	LEED v4 BD+C NC (Silver)	Passive House
Energy	☑	☑	☑	☑	☑
Thermal Energy Demand	×	×	☑	×	☑
Carbon	☑	×	☑	✋	×
Thermal Bridging	×	☑	☑	×	☑
Air Tightness	×	✋	✋	×	☑
Testing and Balancing	×	☑	☑	☑	☑
Appliances	×	☑	×	×	×
Motor Efficiency	☑	☑	×	×	×
Commissioning	×	☑	☑	☑	☑
Benchmarking	×	☑	☑	×	×

ESTIMATED PERFORMANCE

The table below summarizes the estimated performance ranges across four metrics: total energy use intensity (TEUI), thermal energy demand intensity (TEDI), greenhouse gas intensity (GHGI), and operational energy cost. The values shown are combined estimates for both mid-rise and high-rise buildings (in general, the higher values shown represent high-rise).

The estimates are not meant to be predictions for individual projects; rather they show directionality and how the Standards are expected to rank for most projects. TGS values shown represent targets that must be achieved; variations of up to 10% may be possible for values shown for LEED, Energy Star and Passive House due to the specific features of an individual project and due to the rules of how performance is assessed.

LEED Silver and ES-MFHR are expected to have EUI and TEDI performance comparable to TGS Tier 1. Since neither LEED nor ES-MFHR require specific carbon performance, it may be possible that some LEED and ES-MFHR projects that use electric heating achieve or surpass the TGS Tier 2 GHGI target, but it is equally likely that those same projects, if they rely solely on gas heating, result in a GHGI worse than TGS Tier 2 and possibly even TGS Tier 1.

Performance Metric	Ontario Building Code (SB-10 2017)	ENERGY STAR® Multifamily High Rise	Toronto Green Standard (TGS) v3 Tier 2	LEED v4 BD+C NC (Silver)	Passive House
Total Energy Use Intensity TEUI (kWh/m^2)	180-190	152-159	130-135	139-147	46-52
Thermal Energy Demand Intensity TEDI (kWh/m^2)	75-77	60-66	40-50	55-58	15
Greenhouse Gas Intensity GHGI ($kgCO_2/m^2$)	26-28	20-21	15	17-18	2-4
Energy Cost Intensity ECI ($/m^2)	14-15	13-14	12	13	7

EXPECTED COSTS

Achieving ENERGY STAR® Multifamily certification is expected to require a capital cost premium of approx. 1-2% relative to OBC SB-10 for both the Mid-Rise and High-Rise projects. It is possible that ES-MFHR requires lower capital costs relative to OBC SB-10.

The actual capital cost premium that a project can expect will depend on a builder's existing design and construction baseline, project proforma and the specific design elements selected for a given project to achieve compliance with the requirements.

Although not in the scope of this Study, life cycle analysis can also be completed to consider the expected cost over 20-30 years, accounting for any energy cost and operations and maintenance savings. Design strategies which may have high upfront capital costs could be attractive options over the long term and have desired co-benefits such as the improvement of occupant comfort and building resilience.

In addition to any capital costs, each of the Standards compared in this Study require the investment of soft costs. These include (where applicable):

- Program Registration and Certification fees;
- Third Party Evaluators / Certifiers;
- Consulting;
- Commissioning;
- Air-tightness testing; and
- Additional energy modelling (beyond regulatory requirements).

The ranges of the estimated soft costs account for both the mid-rise and high-rise archetypes. Additional soft costs may be required for LEED, depending on a project's credit strategy.

Soft Costs	ENERGY STAR® Multifamily High Rise	Toronto Green Standard (TGS) v3 Tier 2	LEED v4 BD+C NC (Silver)	Passive House
Potential Range	$80,000 - $100,000	$120,000- $170,000	$100,000- $130,000	$170,000 - $240,000

STUDY HIGHLIGHTS

- **ENERGY STAR® Multifamily is comparable to Toronto Green Standard v3 Tier 1**. The ENERGY STAR® Multifamily Standard can be viewed as a complimentary Standard in jurisdictions outside of Toronto. To remain progressive, the ENERGY STAR® Multifamily Standard should consider updates to the required energy performance on a 4-year schedule. While comparable to TGS v3 Tier 1 on energy performance, higher levels of performance are necessary to meet federal and global climate goals and avoid the worst effects of climate change.
- **The ENERGY STAR® Multifamily Standard aligns with approaches taken by past established Standards like LEED by focusing on energy efficiency requirements.** The performance target can be achieved through HVAC, DHW and lighting improvements, which also tends to reduce energy costs since electricity is more expensive. Focusing on relative energy efficiency improvement can mean that certain highly efficient HVAC and electrical equipment are able to achieve required performance levels while continuing to use fossil fuels. A focus on energy efficiency improvement can also overshadow an envelope that may not perform well in terms of load reduction, thermal comfort, or resilience.
- **Emerging market trends are focused on envelope performance and carbon**. Envelope performance tends to reduce peaks loads and HVAC equipment size while improving occupant comfort, while carbon is the primary driver of the climate crisis. Energy efficiency can be a complimentary performance goal, but alone is unlikely to drive the market toward passive, resilient, low-carbon solutions. The market, regulators, and investors are increasingly focused on carbon emissions. This aligns with federal, provincial, and municipal carbon reduction targets and commitments.
- **ENERGY STAR® Commissioning requirements are well-aligned with industry Standards and market trends and provide long-term benefit and asset value to developers and owners**. Commissioning help owners, developers, investors and tenants ensure they get what they paid for. Most industry Standards require commissioning, and most market leaders undertake commissioning as business as usual. Additional clarity around the process and scope of equipment included can help provide additional alignment with industry best practice. The ENERGY STAR® Multifamily Standard may consider adding an envelope commissioning requirement.
- **Airtightness represents both a current industry knowledge gap and opportunity for potentially cost-effective energy and carbon reductions**. Whole-building air tightness testing is optional in the ENERGY STAR® Multifamily Standard. Reducing air infiltration through the building envelope reduces heat loss and is a gap in most current Standards and frameworks. ENERGY STAR® Multifamily can help drive benchmarking efforts that can close the knowledge gap, accelerate increased industry skills development and bring airtightness products and services to market sooner.

STUDY HIGHLIGHTS (Cont'd)

- **The actual performance of ENERGY STAR® Certified appliances varies significantly and may not lead to reduced energy use.** An ENERGY STAR® label on appliances signals energy-efficient products but energy performance varies significantly amongst labelled appliances. The ENERGY STAR® Multifamily Standard may consider requiring savings relative to an industry average for each product category in order to increase impact in this area.
- **Licensed Professionals (LPs) may see reputational benefits and some increase in client engagement and business**. The multi-unit sector is rapidly evolving, leaders are accelerating towards even higher levels of energy and carbon performance and may not attribute significant additional value to the LP beyond what they already know about them. Additional clarity about the division of responsibilities between designers, commissioning agents, modellers and LPs is recommended to avoid potential duplication of effort.

CONDITIONS OF USE

- This Executive Summary is intended to be read along with the Full Report which includes important background context, technical details of the quantitative analysis including all assumptions and performance results.
- The work reflects Purpose Building's best judgement in light of the information reviewed at the time of preparation.
- This work does not wholly eliminate uncertainty regarding the potential for existing or future costs, hazards or losses in connection with a property.
- Applicable codes and design standards may have undergone revision since the Study was conducted.
- The work does not constitute a recommendation or guarantee of compliance with the listed Standards; compliance is wholly governed by the Authority Having Jurisdiction.
- Budget figures provided represent Purpose Building's opinion of a probable current dollar value of the work and are provided for comparative purposes only.
- For a complete list of Conditions of Use refer to the Full Report.

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GLOSSARY OF TERMS

ENERGY STAR® Multifamily High-Rise (New Construction) Pilot (ES-MFHR): A new certification program being piloted in Ontario by NRCan in partnership with EnerQuality. The certification recognizes buildings which are at least 15% more energy-efficient than those built to the Ontario energy code and requires on-site verification and testing.

Environmental, Social, and Governance (ESG): A set of standards for a company's operations that measure the sustainability and ethical impact of its impact on nature, business relationships, and internal policies.

Global Real Estate Sustainability Benchmark (GRESB): A mission-drive and industry-led organization that provides actionable and transparent environmental, social and governance (ESG) data to financial markets.

Green Building Certification Inc. Canada (GBCI): An American organization that provides third-party credentialling and verification for several rating systems relating to the built environment, including LEED.

Greenhouse Gas Intensity (GHGI): The total carbon emissions from annual building operations divided by total building gross floor area (GFA).

Leadership in Energy and Environmental Design (LEED): A green building certification program used worldwide.

National Resources Canada (NRCan): The federal government department responsible for natural resources, energy, minerals and metals, forests, earth sciences, mapping and remote sensing..

National Electrical Manufacturers Association (NEMA): An organization developed to form the technical standards for the manufacturing of electrical equipment and medical imaging equipment.

Primary Energy Renewable (PER): The amount of source energy that is used by building operations in an imagined future that maximizes regional renewable energy resources.

Thermal Energy Demand Intensity (TEDI): A measure of the amount of annual heating energy needed to maintain a building's stable interior temperature, divided by gross floor area (GFA).

Total Energy Use Intensity (TEUI): The total energy use consumption of a building, divided by its total gross floor area (GFA).

Toronto Green Standard (TGS): Toronto's sustainable design requirements for new private and City-owned developments.

INTRODUCTION

In 2017, National Resources Canada (NRCan) partnered with EnerQuality and the Ontario home building industry to develop and launch the ENERGY STAR® Multifamily High-Rise (New Construction) Pilot (ES-MFHR) in Ontario.

The purpose of this Technical Study is to present a summary of the similarities and differences between this new ENERGY STAR® Multifamily Pilot program and other commonly used and existing sustainable building frameworks for high-rise buildings in Ontario, including LEED (Leadership in Energy and Environmental Design), the Toronto Green Standard, and Passive House.

This report is intended for:

- Developers and owners of and investors in multifamily development interested in improving sustainability performance beyond Building Code.
- Municipalities and local Authorities Having Jurisdiction interested in developing new sustainability policies aimed at broad market adoption.
- Professionals interested in obtaining new credentials and increasing their service offering.

The report consists of:

- A summary of the high-level requirements of each of the surveyed Standards
- A description of the methodology used to compare the Standards in terms of energy, carbon, thermal demand, energy cost, capital cost and administrative cost performance.
- Graphical and tabular results of the comparative analysis.
- Key performance insights.
- Key findings.
- Recommendations for developers/investors, policy-markers and professional service providers.

BACKGROUND

- The ENERGY STAR® program was developed by the U.S. Environmental Protection Agency (EPA) in 1992 and managed by Natural Resources Canada (NRCan) in Canada since 2001.
- In 2017, NRCan partnered with EnerQuality and the Ontario home building industry to develop and launch the ENERGY STAR® Multifamily High-Rise (New Construction) Pilot (ES-MFHR) in Ontario
- ES-MFHR is currently being piloted in Ontario to capture lessons learned and inform a national roll-out in the near future.
- Purpose Building Inc. was one of the first Licensed Professional Firms eligible to provide Certification Management Services for this Program.

ENERGY STAR® Multifamily High-Rise (New Construction) Version 1.0 (Pilot)

- Administered in Canada under a partnership between National Resources Canada (NRCan) and EnerQuality.
- Developed for Part 3 residential projects
- Designed for broad market adoption
- Strong and familiar consumer brand
- Focused on energy
- Energy Performance is comparable to or slightly better than Toronto Green Standard (TGS) v3 Tier 1
- Provides a single set of criteria and certification level.
- Assesses energy performance relative to a baseline.
- Does not have an explicit requirements for carbon performance.

Toronto Green Standard (version 3)

- Developed and administered by the City of Toronto.
- Municipal sustainable design Standard for new private and City-owned developments in Toronto.
- Consists of tiers of performance measures with supporting guidelines that promote sustainable site and building design.
- Tier 1 is mandatory for all site planning approval.
- Tiers 2 to 4 are higher level voluntary Standards that yield financial incentives and are verified post-construction.
- Comprehensive set of environmental priorities that is similar to LEED (energy, air quality, ecology, water, waste, etc.).
- Includes performance limits for thermal energy use intensity (TEUI) and thermal energy demand intensity (TEDI).
- Includes greenhouse gas intensity (GHGI) limits.

LEED v4 Building Design + Construction (BD+C) – New Construction

- Administered by Green Building Certification Inc. Canada (GBCI) in Canada.
- Largely voluntary Standard for new construction or major retrofit projects
- Widely-recognized green building Standard with long track record and market uptake
- Comprehensive set of environmental priorities that is similar to TGS (site, transportation, energy, indoor air quality, ecology, water, waste, etc.).
- Offers flexibility in certification strategies by providing a menu of credits to choose from to earn points in addition to require prerequisites.
- Four certification levels: Certified, Silver, Gold, Platinum.
- Often used in Environmental, Social, and Governance (ESG) strategies (recognized by Global Real Estate Sustainability Benchmark (GRESB))
- Assesses energy performance relative to a baseline.
- Does not have explicit requirements for carbon performance.

Passive House

- Administered by the Passive House Institute (PHI).
- Typically voluntary Standard
- Recently gained in popularity in North America
- Focuses on energy and comfort with a reputation for being the most rigorous energy-based Standard in the building industry
- Provides universal core criteria that must be met for certification (Classic) and options for higher performance (Plus, Premium)
- Includes performance limits for energy, such as the Primary Energy Renewable (PER) metric and thermal energy demand (TEDI).
- Incorporates consideration of carbon as part of the PER metric that must be met.

Table 1 below summarizes the Ontario Building Code (SB-10 2017), ENERGY STAR® Multifamily High Rise Standard Version 1.0 (Pilot), the Toronto Green Standard version 3 Tier 2 Mid to High-rise Residential for Multi-unit Residential Buildings 4 storeys or greater, LEED v4 BD+C NC Silver Certification levels, and the Passive House Standard as they relate in their respective energy requirements. Table 1 below does not include all requirements that must be met under each Standard in order to achieve it and does not include all details related to the requirements that are listed. Please refer directly to each Standard for a full list of requirements.

Table 1: Detailed Summary of Standards

Criteria	Ontario Building Code (SB-10 2017)	ENERGY STAR® Multifamily High Rise	Toronto Green Standard (TGS) v3 Tier 2	LEED v4 BD+C NC (Silver)	Passive House
Energy	Design buildings to achieve energy efficiency levels attained by conforming to: (a) 2013 ANSI/ASHRAE/IES 90.1 and Chapter 2, (b) 2015 NECB and Chapter 3, or (c) Section 7 "Energy Efficiency" of 2014 ANSI/ASHRAE/USGBC/IES 189.1, excluding Sections 7.2.b, 7.4.7.3, 7.4.8 and 7.5.	Exceed by not less than 15% the energy efficiency levels attained by conforming to CCBFC NRCC 56191, "2015 National Energy Code of Canada for Buildings" as modified by MMA Supplementary Standard SB-10, "Energy Efficiency Requirements," Chapter 3 of Division 3. 15% better than OBC SB 10	Energy Use Intensity (EUI) must be no greater than 135 kWh/m^2 per the TGS Buildings Energy Performance measure (GHG 1.2).	A minimum improvement of 5% over an ASHRAE 90.1-2010 Appendix G baseline building must be achieved under the Minimum Energy Performance prerequisite. *Additional energy savings aren't required to achieve certification but Certified Silver projects in Ontario achieved, on average, 6 additional energy points (22% energy cost savings over ASHRAE 90.1-2007).*[1]	Total Primary Energy Renewable Demand (PER) not to exceed 60 kWh/m^2. The PER is similar to a source energy intensity value and should not be directly compared to an Energy Use Intensity (EUI).
Thermal Energy Demand Intensity (TEDI)	No requirement	No requirement	Must not exceed 50 kWh/m^2 per the requirements of the TGS measure GHG 1.2 Buildings Energy Performance.	No requirement	Must not exceed 15 kWh/m^2
Carbon	The annual CO_2e emission level from a building shall not exceed the level achieved by complying with: (a) 2013 ANSI/ASHRAE/IES 90.1 and Chapter 2, (b) 2015 NECB and Chapter 3, or (c) Section 7 "Energy Efficiency" of 2014 ANSI/ASHRAE/USGBC/IES 189.1, excluding Sections 7.2.b, 7.4.7.3, 7.4.8 and 7.5.	No requirement	Greenhouse gas emissions intensity (GHGI) must not exceed 15 kg CO_2e/m^2 per the requirements of the TGS Buildings Energy Performance measure (GHG 1.2).	No requirement	No explicit requirement (partly incl. in PER)[2]
Thermal Bridging	No requirement	Detailed thermal bridging calculations required. Significant thermal bridges are to be taken into account.	Detailed thermal bridging calculations required. Significant thermal bridges are to be taken into account.	No requirement	Detailed thermal bridging calculations required. All thermal bridges must be taken into account.
Air Tightness	No requirement	Suite/compartment airtightness testing required. Test 10% of Suites (meet Code or test another 10%). Target is 1.5 L/s*m^2 @ 75 Pa. Whole-building airtightness testing is optional. No airtightness target must be met.	Whole-building airtightness testing required per the requirements of the TGS Air Tightness Testing measure (GHG 4.3). Target is 2.0 L/s*m^2 @ 75 Pa but not currently enforced.	Only required in Residential buildings that permit smoking under the Environmental Tobacco Smoke Control prerequisite. Suites must demonstrate a maximum leakage of 1.17 L/s*m^2 @ 50 Pa.	Whole-building airtightness testing required. Pressurization test results must not exceed 0.6 air changes per hour (ACH) @ 50 Pa.
Testing and Balancing (TAB) of HVAC Systems	No requirement	All ventilation systems must undergo Testing and Balancing. A Testing and Balancing report must be completed and submitted.	No explicit requirement but Commissioning is required and Testing and Balancing results are typically required to inform the Commissioning process on new construction projects.	No explicit requirement but Commissioning is required and Testing and Balancing results are typically required to inform the Commissioning process on new construction projects.	A Testing and Balancing report which notes the adjustment of all supply and extract air valves or if not feasible, measured volume flow rates in the ventilation units (outdoor air / exhaust air) and in the principal ducts of the ventilation systems.

Table 1: Detailed Summary of Standards – cont'd

Criteria	Ontario Building Code (SB 10-2017)	ENERGY STAR® Multifamily High Rise	Toronto Green Standard (TGS) v3 Tier 2	LEED v4 BD+C NC (Silver)	Passive House
Appliances	No requirement	Common and in-suite appliances (refrigerators, dishwashers, clothes washers, ceiling fans, and vending machines) must be ENERGY STAR® certified	No requirement	No requirement	No requirement
Motor Efficiency	If an electric motor is within the scope of 2010 ANSI/ASHRAE/IES 90.1 and is regulated by an Ontario Regulation, efficiency shall be deemed to be compliant by: 1. Following requirements within Table 10.4.1A (a) of SB 10-2017. 2. CSA C390 "Test Methods, Marking Requirements, and Energy Efficiency Levels for Three-Phase Induction Motors Otherwise, electric motors shall comply with the appropriate minimum nominal efficiency requirements of Table 10.4.1.A.(a) or Table 10.4.1.A.(b)	All three-phase pump motors 1 horse-power or larger shall meet or exceed efficiency standards for National Electrical Manufacturers Association (NEMA) Premium motors.[3]	No requirement	No requirement	No requirement
Commissioning	No requirement	Commissioning is required for primary HVAC and renewable energy systems in accordance with CSA Z320, CSA Z5000 or similar. A review of cladding details during construction is required for the envelope.	Commission the building in accordance wit ASHRAE Guideline 0-2013, per the TGS Best Practice Commissioning measure (GHG 4.2). Scope must include HVAC Systems, pumps, DHW, and building automation & lighting. The inclusion of other systems is encouraged.	Commission mechanical, electrical, plumbing, and renewable energy systems and assemblies in accordance with ASHRAE Guideline 0-2005 and ASHRAE Guideline 1.1–2007 for HVAC&R Systems, as they relate to energy, water, indoor environmental quality, and durability.	HRV commissioning report required
Benchmarking	No requirement	Required to register on ENERGY STAR® Portfolio Manager	Required to register on ENERGY STAR® Portfolio Manager under the TGS Benchmarking and Reporting measure (GHG 4.1).	No requirement	No requirement

[1]Based on LEED Canada 2009 certified project information in the Canada Green Building Council's Project Database. An adequate sample size of certified LEED v4 residential projects does not currently exist in the Project Database. The estimated points reflect a target Certification target of Silver and associated energy performance.
[2]Primary Energy Renewable (PER) considers a future where energy is supplied solely by renewable energy sources, including all necessary storage facilities.
[3]Motors that are packaged as an integral component of mechanical equipment, fire pump motors, and booster pump motors are exempt from this requirement.

OVERVIEW

The quantitative analysis of the surveyed Standards was based on a combination of archetype energy modelling and precedent projects.

Two archetypes were developed, one representing a "typical" mid-rise building and one representing a "typical" high-rise building. The archetypes are based on common massing, form, density and other development characteristics found in Ontario multi-unit residential projects. Details of each archetypes are shown in Table 2.

Iterative energy modelling and design characteristics of precedent projects were then used to achieve the requirements of each of the surveyed Standards and quantify each the corresponding performance metrics.

Finally, capital costs were determined based on feedback from a Cost Consultant and precedent projects.

PERFORMANCE METRICS DEFINITIONS

Total Energy Use Intensity (TEUI) is the total energy use consumption of a building, divided by its total gross floor area (GFA). It includes all annual energy (heating, cooling, lighting etc.) from all energy sources (natural gas, electricity etc.).

Thermal Energy Demand Intensity (TEDI) quantifies the total annual space heating and ventilation heating energy demand (or load) of a building. It represents that amount of heating energy that must be added by the heating system. It is impacted by building envelope thermal performance and ventilation system performance (amount of outdoor air, heat recovery effectiveness, corridor pressurization, etc.), but is not impacted by the efficiency of the heating system. It is calculated by dividing the total annual heating demand of the building by its total GFA.

Greenhouse Gas intensity (GHGI) represents the total carbon emissions from annual building operations divided by total building GFA. It is calculated by applying average carbon emissions factors to the consumption of each fuel type at a building.

Energy Cost Intensity (ECI) represents the total energy cost of a building divided by total building GFA based on the typical market rate for each input fuel (natural gas and electricity).

ARCHETYPES

This Study considers two building archetypes representative of typical market residential development: mid-rise (5-storey), and high-rise (15-storey). Key development statistics for each development archetype are summarized in Table 2 below:

Table 2: Development Archetype Key Development Statistics

Parameter	Mid-rise	High-rise
Building Area	5,366 m^2 (57,759 ft^2)	11,329 m^2 (121,944 ft^2)
Number of Storeys	5	15
Number of Suites	67	150
Number of Occupants	160	361
Parking	2,352 m^2 (25,317 ft^2) above grade	5,284 m^2 (56,877 ft^2) below grade
Occupancy Schedule (lighting and plug loads)	NECB G for suites, NECB B for fitness. Corridor and parking lighting always on.	NECB G for suites, NECB B for fitness. Corridor and parking lighting always on.
Suite Outdoor Air	70.8 L/s (150 cfm) max (1.5 hours per day) 23.6 L/s (50 cfm) continuous (22.5 hours per day) Doubled for units bigger than 74 m^2 (800 ft^2) (2-3 bedrooms) Driven by exhaust requirements bathroom/kitchen which exceeds the ASHRAE 62.1 minimum requirement of 2.5 L/s/person (5.3 cfm/person) and 0.3 L/s/m^2 (1.52 cfm/ft^2).	
Construction	Wood-frame	Concrete

The mid-rise archetype residential building can benefit from the opportunity to use wood framing to improve envelope thermal performance and can avoid the cost and construction time associated with below-grade parking. Lower-rise residential building energy consumption may also benefit from a reduction in the amount of tempered air required for corridor pressurization to manage stack effect.

This Study assumes that all archetypes are designed with full mechanical heating and cooling.

CLIMATE ZONE

All typical design measures are based on a project located in southern Ontario and falling under climate zone 5. These typical design measures will change for projects located in colder climates. For the Standards which use a relative performance approach to assess energy (OBC SB-10, ENERGY STAR® Multifamily, LEED v4 BD+C), the minimum performance requirements of the reference building become more stringent in colder climate zones. The Standards which require fixed performance limits to be met (Toronto Green Standard, Passive House), design measures will need to increase in performance to continue meeting the fixed performance limits in a colder climate. Please note that the Toronto Green Standard only applies to the City of Toronto and does not currently span multiple climate zones.

DESIGN MEASURES APPLIED TO ACHIEVE PERFORMANCE REQUIREMENTS

Tables 3 and 4 on pages 10 and 11 present examples of key design measures which may be applied to an archetype building and achieve the performance requirements of each analyzed Standard. These measures represent one possible combination of measures. Other combinations may be used to achieve the performance requirements of each Standard. For example, increasing the thermal performance of the wall in order to reduce the performance of the windows.

The values listed in the Tables are therefore not prescriptive recommendations, rather an example of how each Standard could be achieved. None of the Standards evaluated as part of this Study prescribe building design. Each is achieved based on modelled performance of the building as a whole, either calculated as a percentage improvement compared to a baseline or compared to an absolute limit (i.e. budget for energy use, carbon emissions, etc.). For example, glazing ratio could be increased and envelope (window, wall) thermal performance could be improved to trade off energy performance and still achieve energy efficiency targets.

Developers and design teams typically perform energy modelling to obtain a suitable combination specific to the project's individual needs. The Developer and design team are able to trade off performance between design measures, provided that the overall building design continues to achieve the requirements of each Standard. Before key design decisions are confirmed, an energy model can be created to assess the impact and interaction of key design decisions. Parametric modelling (which assessed thousands of combinations of variables) or iterative modelling (which typically assesses a handful of variables) can be used to support design making and design a building that meets or exceeds minimum energy performance targets.

DETERMINATION OF COMPARATIVE PERFORMANCE METRICS

Energy Use Intensity

The current building energy code in Ontario (OBC with SB-10 2017) requires that projects either meet prescriptive requirements for each design element, or achieve an overall percentage improvements over a baseline that meets the prescriptive requirements. Most multi-family projects pursue the performance improvement pathway since it allows greater design flexibility. ENERGY STAR® Multifamily High-Rise Standard and the LEED v4 BD+C NC Rating System also use this comparative percentage improvement approach.

For the Ontario Building Code, this Study referenced the work done previously by the City of Toronto Zero Emissions Framework Report which includes both the performance metrics and one combination of design measures that can achieve them, representing a common way that past projects have achieved Code compliance. This means that the performance metrics listed should be used as an absolute performance targets in the same way that the Toronto Green Standard has absolute targets. Ultimately, the performance of a Code-compliant design will likely be close to the metrics in this Study, but will differ due to unique building characteristics and the rules that govern how OBC comparative energy modelling must be performed.

ENERGY STAR® Multifamily High Rise requires that projects achieve a 15% improvement in energy consumption over an OBC SB-10 2017 baseline based on the NECB 2015. This relative performance requirement was estimated as a TEUI equivalent by reducing the minimum energy code performance used by the Toronto Zero Emissions Framework by 15%. Archetype mid-rise (5-storey) and high-rise (15-storey) residential energy models were used to confirm that the design measures listed Tables 3 and 4 align with the TEUI performance metric established by the benchmarking process

Since TEUI for the ENERGY STAR® Multifamily archetypes was determined as a percentage reduction of the code minimum TEUI, a change in the code minimum TEUI would results in a change to the TEUI resulting from a building meeting the requirements of the ENERGY STAR® Multifamily Standard.

LEED v4 BD+C NC compares energy cost savings against an ASHRAE 90.1-2010 Appendix G baseline. Since energy points are based on cost savings, the types of energy that a building uses and saves will impact the number of points achieved. Archetype residential building models were run using the typical archetype design measures on page 10 and 11. The resulting LEED energy points fell within the ranges of this Study and the associated archetype TEUI performance is listed in Section 4 *Performance Metrics*.

Total Energy Use Intensity (Cont'd)

The Toronto Green Standard (v3) Tier 2 requires a TEUI of 135 kWh/m^2 (43 kBTU/ft^2) to be met for multi-unit residential buildings equal to or greater than 4 stories. For buildings less than 6 stories, a TEUI of 130 kWh/m^2 (41 kBTU/ft^2) must be achieved.

The Passive House Standard requires that buildings achieve a Primary Energy (PE) value of 120 kWh/m^2 (38 kBTU/ft^2) or less, or a Primary Energy Renewable (PER) value of 60 kWh/m^2 (19 kBTU/ft^2) or less. The PE and PER values are source energy metrics, which include energy losses. The PE and PER values differ by the factors that they apply to site energy consumption. PE includes factors that are intended to reflect the current grid while PER imagines in a future where 100% of energy supply is renewable. A PER value will change based on project location, end-use energy consumption, and fuel type for each end-use.

For Toronto, electricity has a PE factor of 2.6 for electricity and 1.1 for natural gas per the Passive House Planning Package (PHPP) version 9.3. These factors have been applied to estimate the TEUI for both Passive House archetypes. The 5-story building was assumed to be all-electric while 20% of the TEUI was estimated to come from natural gas use for domestic hot water in the high-rise archetype.

Thermal Energy Demand Intensity

Similar to TEUI, the Toronto Green Standard and Passive House Standard both include absolute performance metric requirements for TEDI. Code minimum, the ENERGY STAR® Multifamily Standard, and LEED v4 BD+C however do not require TEDI targets to be met. In these cases, a similar methodology to what was used to determine TEUI was also used to arrive at the archetype TEDI values listed in Section 4 *Performance Metrics*.

Greenhouse Gas Intensity

Greenhouse gas intensity (GHGI) represents the total carbon emissions from annual building operations divided by total building GFA. It is calculated by applying average carbon emissions factors to the consumption of each fuel type at a building. To calculate GHGI, an electricity emission factor of 50 g CO_2/kWh and a natural gas emission factor of 183 g CO_2/kWh as reported by SB-10 2017, were applied. These values are required to be used by the Authority Having Jurisdiction (AHJ) in the Ontario Building Code and may not reflect the most recent emissions intensities (or projections of future emissions due to changes to energy generation in Ontario).

The minimum code archetype electricity and natural gas use intensity was determined based on The City of Toronto Zero Emissions Building Framework intensities for mid-rise and high-rise MURBs.

The estimated energy use associated with electricity and natural gas in the ENERGY STAR® Multifamily and LEED models was based upon results from the archetype models, with *Key Design Measures* as listed on pages 10 and 11.

The Toronto Green Standard (v3) Tier 2 is the only Standard included in this Technical Study which includes a greenhouse gas intensity requirement. Building must achieve 15 kg CO_2e/m^2 or less under TGS (v3) Tier 2.

For the Passive House GHGI metrics, we assumed an all-electric mid-rise archetype building like the one reflected in the *Key Design Measures* section on page 10. A GHGI of approximately 2.3 kg CO_2e/m^2 was calculated using the emissions intensities listed above. For the high-rise archetype building, it was assumed that domestic hot water represents 20% of the total TEUI and is supplied by condensing natural gas boiler. The overall building emissions intensity was approximately 4.0 kg CO_2e/m^2.

Energy Cost Intensity

Energy cost Intensity represents the total energy cost of a building divided by total building GFA.

Energy cost is based on a blended electricity cost of 0.154 $/kWh and natural gas cost of 0.034 $/kWh. These energy costs are applied to electricity and natural gas intensities for each archetype and Standard. These respective electricity and natural gas intensities were determined in order to calculate the GHGI. The methodology by which they were calculated for each archetype and Standard is outlined in the Greenhouse Gas Intensity sub-section of this page.

The electricity utility rate in Ontario is currently almost 5 times higher than the natural gas rate. As a result, buildings with low fossil fuel use and a low GHGI do not have proportionally lower operational energy costs. As an example, an ENERGY STAR® Multifamily mid-rise archetype building is estimated to achieve a GHGI of kg CO_2e/m^2, which is a 30% carbon intensity savings over the code minimum archetype (estimated at 28 kg CO_2e/m^2). In part, that carbon intensity savings is a results of fuel switching away from natural gas and towards electricity. The same ENERGY STAR® Multifamily mid-rise archetype is expected to achieve 9% operational energy cost savings over the code minimum baseline. While natural gas building systems are currently more financially favourable to operate, the carbon price in Canada is expected to hit $170/tonne by 2030. Combined with the higher efficiency of electrical heat pumps, the cost of delivering a unit of heating via electricity is expected to be lower than via natural gas in less than 10 years (by 2030).

Table 3: Key Design Measures (Mid-rise Archetype)

Mid-rise Archetype					
Key Design Measure	Code Minimum OBC SB-10 2017[1]	ENERGY STAR® Multifamily High Rise	LEED v4 BD+C NC (Silver)	Toronto Green Standard (TGS) v3 Tier 2[4]	Passive House
Glazing Ratio	40%	40%	40%	35%	30%
Opaque Wall R-Value[2]	R-10	R-10	R-15	R-20	R-40
Roof R-Value[2]	R-20	R-25	R-30	R-35	R-70
Window U-Value[3]	U-0.30	U-0.32	U-0.32	U-0.27	U-0.15 (triple glazing)
Window SHGC	0.40	0.33	0.32	0.35[7]	0.27
Infiltration[5]	0.25 L/s/m^2 above-ground envelope area @ 5 Pa	0.25 L/s/m^2 above-ground envelope area @ 5 Pa	0.25 L/s/m^2 above-ground envelope area @ 5 Pa	0.19 L/s/m^2 above-ground envelope area @ 5 Pa (25% reduction)	~0.10 L/s/m^2 @ 5 Pa[8]
Heating Plant	Condensing boiler; 95%	Condensing boiler; (95%)	Condensing boiler; 95%	Condensing boiler; 95%	VRF system
Cooling Plant	Screw chiller; COP 5	Screw chiller; COP 5	Screw chiller; COP 5	Air-cooled screw chiller; COP 5	VRF system
Suite HVAC System	Fan coil units or water loop heat pumps	Fan coil units or water loop heat pumps	Fan coil units or water loop heat pumps	Fan coil units or water loop heat pumps	VRF system
Heat Recovery	None	In-suite HRVs, 55% efficient	In-suite ERVs, 65% efficient	In-suite ERVs, 70% efficient	In-suite ERVs, 85% efficient
Corridor Ventilation[7]	0.3 L/s/m2	0.3 L/s/m2	0.3 L/s/m2	0.3 L/s/m^2	0.3 L/s/m^2
Domestic Hot Water	Natural gas condensing boiler	Natural gas condensing boiler	Natural gas condensing boiler	Natural gas condensing boiler	Electric water heater
Hot Water Flow Savings	No energy savings are achieved for hot water use reduction.	30%	40%	40%	40%

[1]Code Minimum values are based on the prescriptive performance measures that would define a reference case energy model.
[2]The presented R-values represent the modelled thermal performance values that could meet the performance requirements for the archetype. The Ontario Building Code and LEED v4 BD+C do not require detailed consideration of major thermal bridges. The same envelope construction would generally be modelled with a higher R-value in these Standards, as compared to the ENERGY STAR® Multifamily, Passive House, or Toronto Green Standards.
[3]Window U-Value assumes a standard NFRC window size and includes the window frame but excludes any impacts due to the thermal bridging at the window transition.
[4]Values are based on the City of Toronto Zero Emissions Building Framework.
[5]The Standards specify both operational and building envelope air tightness tests. Building envelope testing requires that mechanical systems be excluded from the test. Passive House measures against building envelope air tightness. The Toronto Green Standard provides operational air tightness targets.
[6]Please note this flow represents code minimum ventilation requirements. No additional corridor pressurization is being considered.
[7]A higher solar heat gain co-efficient may be chosen for projects aiming to maximize solar heat gain into the space so that thermal energy demand intensity (TEDI) can be reduced to meet absolute performance targets.
[8]This is an approximation of the Passive House requirement to achieve ACH50 of no more than 0.6.

Table 4: Key Design Measures (High-rise Archetype)

High-rise Archetype					
Key Design Measure	Code Minimum OBC SB-10 2017[1]	ENERGY STAR® Multifamily High Rise	LEED v4 BD+C NC (Silver)	Toronto Green Standard v3 Tier 2[4]	Passive House
Glazing Ratio	50%	50%	45%	40%	23%
Opaque Wall R-Value[2]	R-7	R-7	R-10	R-10	R-20
Roof R-Value[2]	R-20	R-25	R-30	R-30	R-55
Window U-Value[3]	U-0.40	U-0.32	U-0.35	U-0.25	U-0.19 (triple glazing)
Window SHGC	0.40	0.32	0.30	0.40[7]	0.29
Infiltration[5]	0.25 L/s/m^2 above-ground envelope area @ 5 Pa	0.25 L/s/m^2 above-ground envelope area @ 5 Pa	0.25 L/s/m^2 above-ground envelope area @ 5 Pa	0.23 L/s/m^2 above-ground envelope area @ 5 Pa *10% reduction in infiltration over code*	~0.10 L/s/m^2 @ 5 Pa[8,9]
Heating Plant	Modulating boiler; 85%	Condensing boiler; 95%	Condensing boiler; 95%	Condensing boiler; 95%	VRF system
Cooling Plant	Screw chiller; COP 5.8	Screw chiller; COP 5.8	Screw chiller; COP 5.8	Screw chiller; COP 5.8	VRF system
Suite HVAC System	Fan coil units	Fan coil units	Water loop heat pumps	Water loop heat pumps	VRF system
Heat Recovery	In-suite ERVs, 55% efficient	In-suite ERVs, 65% efficient	In-suite ERVs, 70% efficient	In-suite ERVs, 75% efficient	Central ERV, 80% efficient
Corridor Ventilation[6]	30 CFM/Suite	30 CFM/Suite	30 CFM/Suite	15 CFM/Suite	<5 CFM/Suite (balanced ventilation)
Domestic Hot Water	Natural gas condensing boiler	Natural gas condensing boiler	Natural gas condensing boiler	Natural gas condensing boiler	Natural gas condensing boiler
Hot Water Flow Savings	No energy savings are achieved for hot water use reduction.	30%	40%	40%	40%

[1]Code Minimum values are based on the prescriptive performance measures that would define a reference case energy model.
[2]The presented R-values represent the modelled thermal performance values that could meet the performance requirements for the archetype. The Ontario Building Code and LEED v4 BD+C do not require detailed consideration of major thermal bridges. The same envelope construction would generally be modelled with a higher R-value in these Standards, as compared to the ENERGY STAR® Multifamily, Passive House, or Toronto Green Standards.
[3]Window U-Value assumes a standard NFRC window size and includes the window frame but excludes any impacts due to the thermal bridging at the window transition.
[4]Values are based on the City of Toronto Zero Emissions Building Framework.
[5]The Standards specify both operational and building envelope air tightness tests. Building envelope testing requires that mechanical systems be excluded from the test. Passive House measures against building envelope air tightness. The Toronto Green Standard provides operational air tightness targets.
[6]Please note this flow represents code minimum ventilation requirements. No additional corridor pressurization is being considered.
[7]A higher solar heat gain co-efficient may be chosen for projects aiming to maximize solar heat gain into the space so that thermal energy demand intensity (TEDI) can be reduced to meet absolute performance targets.
[8]This is an approximation of the Passive House requirement to achieve ACH50 of no more than 0.6.
[9]Tall buildings certifying under the Passive House Standard must also meet a volume leakage to envelope area ratio (q50) of 0.6 or less.

ESTIMATED PERFORMANCE METRICS

The four graphs below summarize performance requirements or estimated performance across four metrics: total energy use intensity (TEUI), thermal energy demand intensity (TEDI), greenhouse gas intensity (GHGI), and operational energy cost. A detailed explanation of each metric and methodology used to estimate performance metrics, can be found on pages 8-9. Per Section 2 *Comparison of Standards*, code minimum and each Standard have requirements that are difficult to compare side-by-side. For example, energy metrics are based on savings over various reference cases as well as different performance metrics (TEUI and PER). These graphs are intended serve as a comparison of code minimum and the four assessed Standards across common performance metrics to allow for side-by-side comparison. They are based on representative buildings and are intended to be directional. While the TGS performance value for EUI, TEDI and GHGI are absolute (projects must meet these levels of performance), variations of up to 10% may be possible for LEED, Energy Star and Passive house performance metrics due to the specific features of an individual project and due to the rules of how the OBC Baseline Building is defined relative to the proposed design. However, it is unlikely that a typical LEED Silver or ES-MFHR project would achieve the EUI and TEDI targets of TGS Tier 2 – put differently, LEED Silver and ES-MFHR are expected to have EUI and TEDI performance comparable to TGS Tier 1. Since neither LEED nor ES-MFHR require specific carbon performance, it may be possible that some LEED and ES-MFHR projects that use electric heating achieve or surpass the TGS Tier 2 GHGI target, but it is equally likely that those same projects, if they rely solely on gas heating, result in a GHGI worse than TGS Tier 2 and possibly even Tier 1.

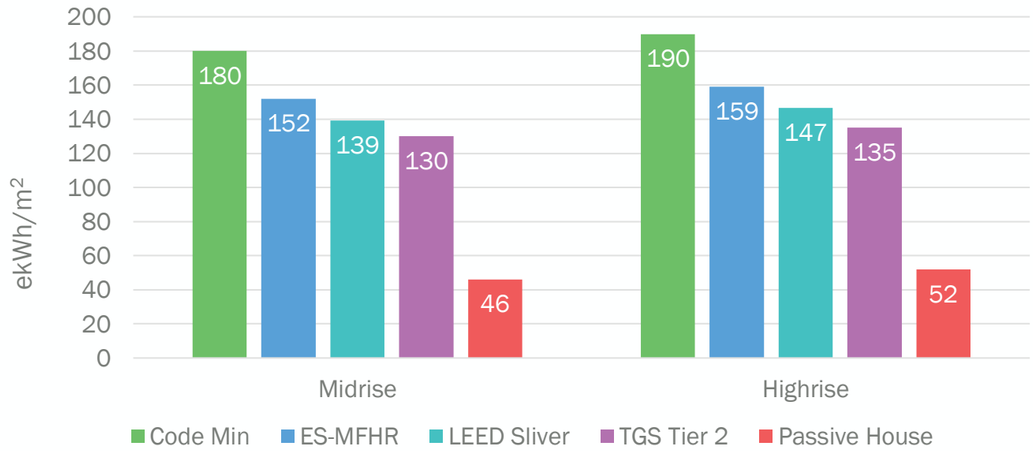

Figure 1: Summary of Total Energy Use Intensity (TEUI)

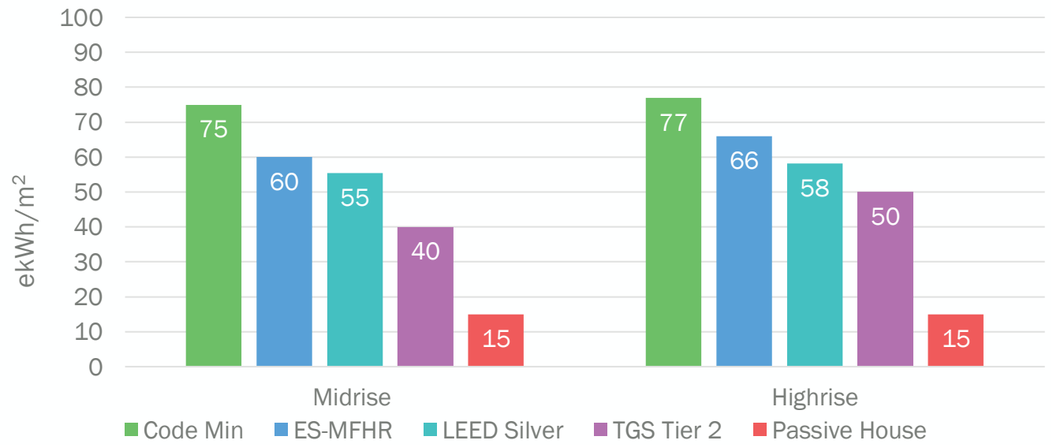

Figure 2: Summary of Thermal Energy Demand Intensity (TEDI)

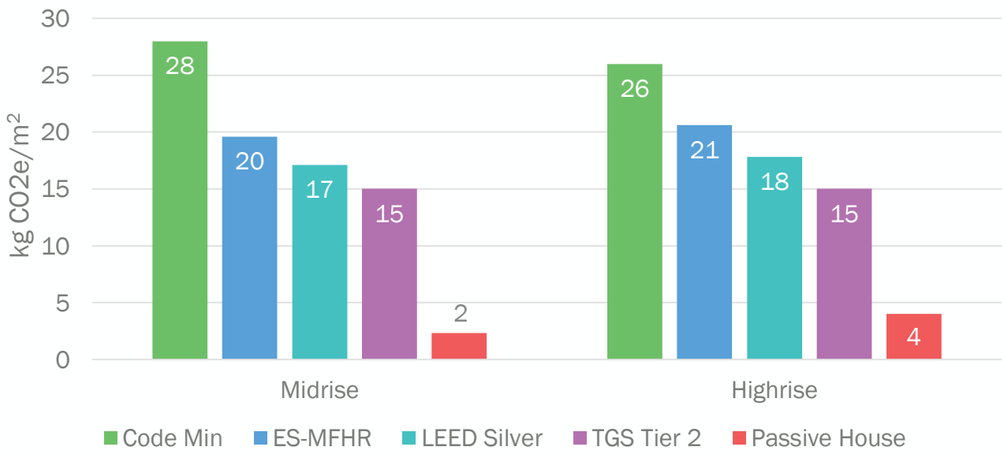

Figure 3: Summary of Greenhouse Gas Intensity (GHGI)

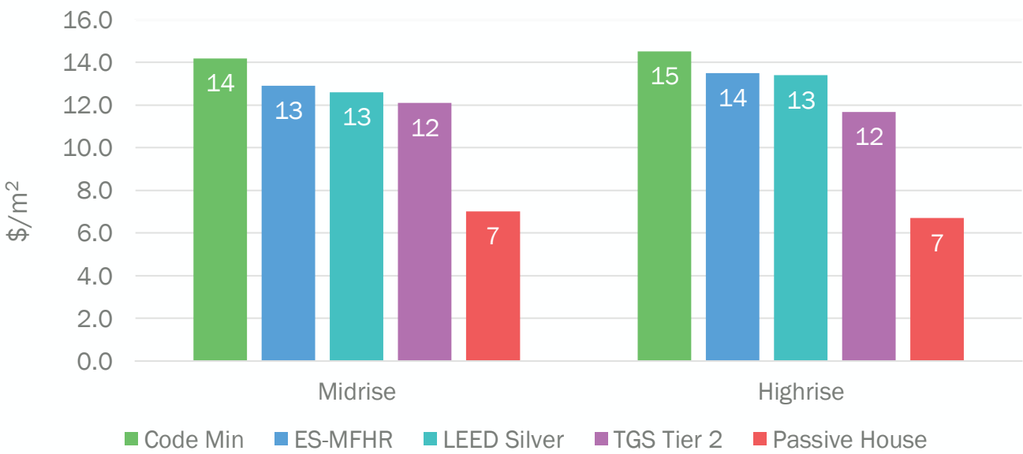

Figure 4: Summary of Energy Costs

ENERGY STAR® Multifamily is comparable to TGS v3 Tier 1.

- The ENERGY STAR® Multifamily Standard can therefore be viewed as a complimentary Standard in non-GTA jurisdictions. Projects pursuing the Standard outside of the GTA have the opportunity to relate the performance of their buildings to TGS performance metrics while also gaining the strong market recognition of the ENERGY STAR® brand.
- The Toronto Green Standard (TGS) is an evolving Standard with increasingly stringent minimum performance requirements coming into effect every 4 years or so. To remain progressive, the ENERGY STAR® Multifamily Standard should consider updates to the required energy performance on a similar schedule.
- While comparable to TGS v3 Tier 1 on energy performance, higher-performing buildings are necessary to meet federal and global climate goals and avoid the worst effects of climate change.

The ENERGY STAR® Multifamily Standard aligns with approaches taken by past established Standards like LEED by focusing on energy efficiency requirements.

- The performance target can be achieved through HVAC, DHW and lighting improvements, which also tends to reduce energy costs since electricity is more expensive.
- Focusing on relative energy efficiency improvement can mean that certain highly efficient HVAC and electrical equipment are able to achieve required performance levels while continuing to use fossil fuels.
- A focus on energy efficiency improvement can also overshadow an envelope that may not perform well in terms of load reduction, thermal comfort, or resilience. Some Standards (like TGS, Passive House) are explicitly focused on creating a high-performing enclosure to address these considerations. These Standards require TEDI performance targets be met to achieve this goal.
- Large drivers of energy use such as corridor pressurization are also ignored in the relative savings pathway since they are considered compliance-neutral loads.

Emerging market trends are focused on envelope performance and carbon.

- Envelope performance tends to reduce peaks loads and HVAC equipment size while improving occupant comfort while carbon is the primary driver of the climate crisis.
- Energy efficiency can be a complimentary performance goal, but alone is unlikely to drive the market toward passive, resilient, low-carbon solutions.
- The market, regulators, and investors are increasingly focused on building carbon emissions. This aligns with federal, provincial, and municipal carbon reduction targets and commitments. The Standards assessed in this Study address carbon emissions using different approaches and to different extents.
- The Passive House Standard does not include explicit carbon emissions targets but requires that space heating energy is significantly reduced, in turn significantly reducing operational carbon emissions. LEED has introduced new options for calculating energy points, which include a consideration of operational carbon reduction. The Toronto Green Standard sets an absolute limit on operational carbon emissions. The ENERGY STAR® Multifamily Standard does not directly address operational carbon emissions.

ENERGY STAR® Commissioning requirements are well-aligned with industry Standards and market trends and provide long-term benefit and asset value to developers and owners.

- Commissioning help owners, developers, investors and tenants ensure they get what they paid for. Most industry Standards require commissioning, and most market leaders undertake commissioning as business as usual.
- Additional clarity around the process and scope of equipment included can help provide additional alignment with industry best practice.
- The ENERGY STAR® Multifamily Standard may consider adding an envelope commissioning requirement.

Airtightness represents both a current industry knowledge gap and opportunity for potentially cost-effective energy and carbon reductions.

- Whole-building air tightness testing is now optional in the ENERGY STAR® Multifamily Standard. However, reducing air infiltration through the building envelope reduces heat loss and is a gap in most current Standards and frameworks. Airtightness performance metrics are often specified but rarely tested.
- The ENERGY STAR® Multifamily Standard allows for infiltration credit to be taken in modelling, provided that infiltration levels below code are verified with whole-building airtightness testing.
- The ENERGY STAR® Multifamily Standard continues to require that suite airtightness testing is completed for a sample of suite and a minimum airtightness measurement is achieved. Compartment air tightness is not a typical modeling input but it does provide the benefit of reducing the travel of noise and odours between suites. Well-sealed suites may result in less corridor pressurization being required for high-rise projects.
- ENERGY STAR® Multifamily can help drive benchmarking efforts that can close the knowledge gap, accelerate increased industry skills development and bring airtightness products and services to market sooner. The Standard could consider reintroducing whole-building airtightness testing in future to drive the market in this area.

The actual performance of ENERGY STAR® Certified appliances varies significantly and may not lead to reduced energy use.

- An ENERGY STAR® label on appliances signals energy-efficient products but energy performance varies significantly amongst labelled appliances. The variation is too large to overall building performance and the ENERGY STAR® Multifamily Standard may wish to require a higher level of performance within available ENERGY STAR® certified products. Projects seeking to maximize energy savings can go beyond seeking the ENERGY STAR® label on appliances and seek the most efficient option within the labelled options.
- The ENERGY STAR® Multifamily Standard may consider requiring savings relative to an industry average for each product category in order to increase impact in this area.

The capital cost of pursing ENERGY STAR® is likely minimal for most buildings and perhaps upwards of 3% for bare minimum Code-compliant designs. Soft costs are comparable with industry Standards like TGS and LEED.

- Builders have provided feedback that the pursuit of ENERGY STAR® has added minimal (<1%) cost premiums over their business-as-usual construction.
- Most builders will have a business-as-usual approach that somewhat exceeds code minimums.
- Compared to a code minimum, the capital cost premium of pursuing the ENERGY STAR® Multifamily Standard was estimated to be approximately 1% by an industry cost consultant, based on code and ENERGY STAR® example key design inputs in this Study.
- Soft costs associated with pursuing the ENERGY STAR® Multifamily Standard are estimated to be lower than those for LEED or TGS Tier 2 but not significantly.

ENERGY STAR® Multifamily certification is focused on energy efficiency and verification and testing to support quality assurance in design and construction.

- LEED is the most widely used green building rating system in the world and sometimes adopted by municipalities which wish to require new building sustainability exceeding the code minimum.
- LEED is a broad building sustainability rating system, with credit requirements ranging from water use reduction to improved indoor air quality during construction. The ENERGY STAR® Multifamily standard is focused on energy efficiency and quality assurance through verification and testing.
- While LEED targets the top quarter of the sustainability market, the ENERGY STAR® Multifamily standard is intended to be widely accessible.
- LEED does not require a higher minimum level of energy performance than ENERGY STAR® A building could achieve LEED Silver with the same or less energy savings as ENERGY STAR® but in practice and in general, LEED Silver buildings tend to target higher energy performance.

Licensed Professionals (LPs) may see reputational benefits and some increase in client engagement and business.

- The multi-unit sector is rapidly evolving, leaders are accelerating towards even higher levels of energy and carbon performance and may not attribute significant additional value to the LP beyond what they already know about them.
- In terms of program delivery, the LP model may create some confusion about division of responsibilities. The model works well with large-scale repetitive single-family homes but may create duplicate effort when it comes to the complexities and more custom nature of multi-family buildings.

CAPITAL COSTS

The actual capital cost premium that a project can expect will depend on a builder's existing construction baseline and the specific design elements chosen for a given project. For example, reducing wall thermal performance while including high-performing triple glazed windows in the design is likely a more expensive option for achieving the same modelled energy performance.

Achieving ENERGY STAR® Multifamily certification is expected to require a capital cost premium of 1-2% relative to OBC SB-10 for both the Mid-Rise and High-Rise archetypes. It is also possible that ES-MFHR require lower capital costs relative to OBC SB-10.

Although not in the scope of this Study, life cycle analysis can also be completed to consider the expected cost over 20-30 years, accounting for any energy cost and operations and maintenance savings. Design strategies which may have high upfront capital costs could be attractive options over the long term and have desired co-benefits such as the improvement of occupant comfort and building resilience.

SOFT COSTS

In addition to any capital costs, each of the Standards compared in this Study require the investment of soft costs. These include (where applicable):

- Program Registration and Certification fees;
- Third Party Evaluators / Certifiers;
- Consulting;
- Commissioning;
- Air-tightness testing; and
- Additional energy modelling (beyond regulatory requirements).

The ranges of the estimated soft costs account for both the mid-rise and high-rise archetypes. Additional soft costs may be required for LEED, depending on a project's credit strategy.

	ENERGY STAR® Multifamily	LEED v4 BD+C Silver	TGS v3 Tier 2	Passive House
Estimated Soft Cost	$80,000 - $100,000	$120,000- $170,000	$100,000- $130,000	$170,000 - $240,000

Becoming an ENERGY STAR® Multifamily High Rise Licensed Professional allows an individual to deliver and promote ES-MFHR projects and support builders who choose this program for their projects. Licensed Professionals are able to offer an additional sustainability certification option to their clients.

Under the ES-MFHR program, Licensed Professionals take responsibility for coordinating and signing off on the program submissions, which includes any work performed by sub-contractors. The program allows Licensed Professionals to appoint experts to verify compliance with requirements while retaining responsibility for overall compliance.

This allows Licensed Professionals who do not wish or are not able to deliver all ES-MFHR program requirements (Commissioning, Air Tightness Testing, Energy Modelling, etc.) to work with other providers.

The program delivery model that the ENERGY STAR® Multifamily program uses also has the benefit of offering the opportunity for more individuals to become Licensed Professionals and grow the industry.

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Appendix A: Performance Metrics Breakdown

Figure 5 shows the energy end-use breakdown of the high-rise (15-storey) energy model corresponding to each Standard. Table 5 represents the graphs in Figure 5 in a tabular format.

Heating represents the largest energy end use, followed by domestic hot water and occupant loads (lighting and plug loads). Cooling represents a relatively small end use due to the number of cooling degree days and efficiency of typical cooling equipment (cooling loads are often similar to heating loads but heating equipment considered for the majority of Standards is 4-5 times less efficient than cooling equipment).

Savings across the different Standards are mainly attributable to heating, domestic hot water, and lighting.

TGS Tier 2 and Passive House Standards require meeting absolute TEDI targets which lead to significantly better envelope and glazing systems, a more airtight building, lower glazing ratios, and higher heat recovery effectiveness. All of these factors reduce the heating demand of the building.

Both Standards also require meeting certain levels of energy use intensity which are achieved by reducing DHW consumption with lower flow fixtures, reducing lighting power densities and plug loads.

Please note that the Passive House energy end use breakdown is based on a Tier 4 archetype in the City of Toronto Zero Emissions Building Framework, which has a TEDI target that aligns with Passive House. However, please note that the Tier 4 archetype from the Framework would not necessarily meet all requirements of the Passive House Standard.

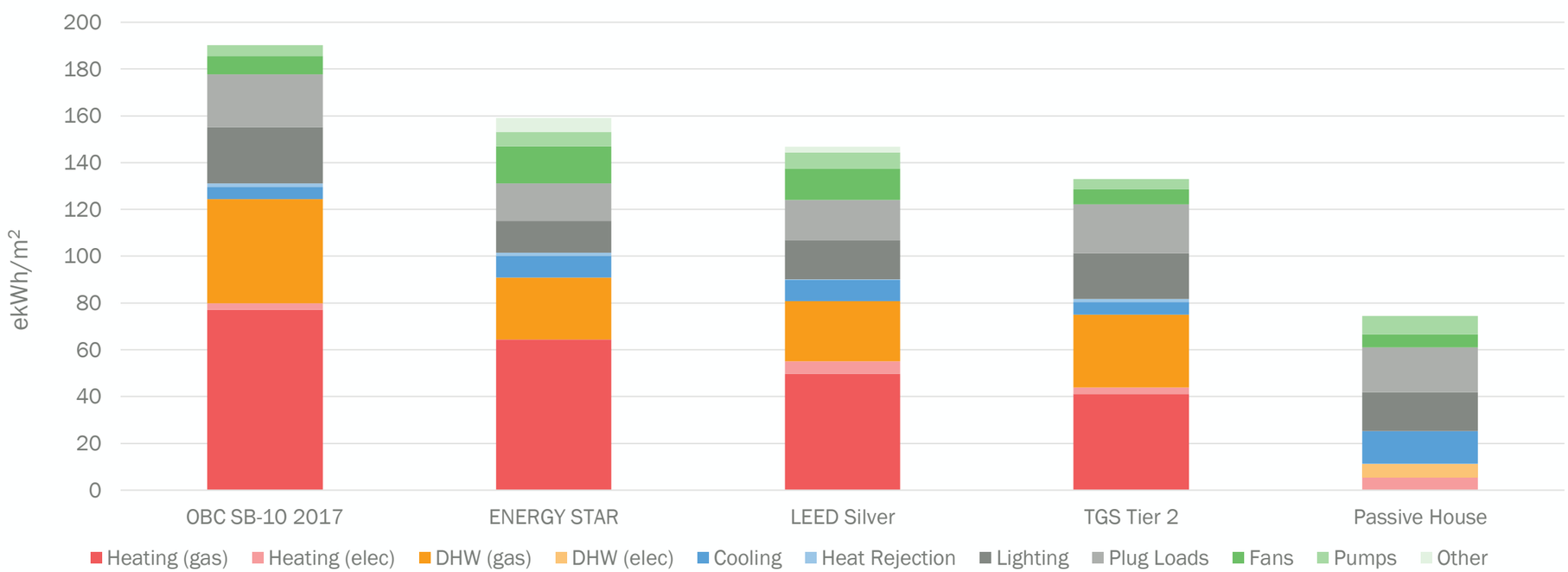

Figure 5: Energy End Use Intensity Breakdown for High-Rise Archetype

Table 5: Energy Use Intensity Breakdown for High-Rise Archetype in ekWh/m²

End Use	OBC SB-10 2017	ENERGY STAR®	LEED v4 BD+C Silver	TGS v3 Tier 2	Passive House
Heating (Gas)	77	64.4	49.6	41	0
Heating (Elec)	2.9	0.0	5.4	2.9	5.5
DHW (Gas)	44.5	26.5	25.7	31.1	0
DHW (Elec)	0	0.0	0.0	0	5.7
Cooling	5.2	9.2	9.3	5.4	14
Heat Rejection	1.5	1.3	0.1	1.3	0
Lighting	24	13.7	16.8	19.5	16.6
Plug Loads	22.6	16.0	17.1	20.9	19.2
Fans	7.8	15.8	13.5	6.6	5.7
Pumps	4.8	6.3	6.9	4.2	7.8
Other	0	5.9	2.4	0	0
TOTAL	**190.3**	**159.1**	**146.8**	**132.9**	**74.5**

Figure 6 shows the energy end-use breakdown of the mid-rise energy model corresponding to each Standard while Table 6 represents these graphs in tabular format.

As is the case for the high-rise (15-storey) archetype on the previous page, heating represents the largest energy end use, followed by domestic hot water and occupant loads (lighting and plug loads). Cooling represents a relatively small end use due to the number of cooling degree days and efficiency of typical cooling equipment (cooling loads are often similar to heating loads but heating equipment considered for the majority of Standards is 4-5 times less efficient than cooling equipment).

Savings across the different Standards are mainly attributable to heating, domestic hot water, and lighting.

As is the case with the high-rise archetypes, the TEDI targets of TGS Tier 2 and Passive House lead to reduced heating demand while TEUI targets necessitate further energy efficiency savings.

As in the high-rise case, the Passive House energy end-use breakdown is based on a Tier 4 archetype in the City of Toronto Zero Emissions Building Framework, which has a TEDI target that aligns with Passive House. However, please note that the Tier 4 archetype from the Framework would not necessarily meet all requirements of the Passive House Standard.

Figure 6: Energy End Use Intensity Breakdown for Mid-Rise Archetype

Table 6: Energy Use Intensity Breakdown for Mid-Rise Archetype in ekWh/m²

End Use	OBC SB-10 2017	ENERGY STAR®	LEED v4 BD+C Silver	TGS v3 Tier 2	Passive House
Heating (Gas)	101.6	59.7	47.3	32.7	0
Heating (Elec)	0	0	5.3	2.7	11.2
DHW (Gas)	32.8	26.5	25.9	28.7	0
DHW (Elec)	0	0	0		0
Cooling	3.8	8.8	8	5.6	11
Heat Rejection	1	1.2	0	1.2	0
Lighting	21.5	13.7	15.7	21.5	17.8
Plug Loads	20.8	16	16	19.1	17.5
Fans	13.8	13.9	12.1	12.6	5.4
Pumps	2.8	5.9	5	3.7	3.7
Other	0	5.9	4.1	0	0
TOTAL	**198.1**	**151.6**	**139.4**	**127.8**	**66.6**

Figure 7 shows the carbon end-use breakdown of the high-rise energy model corresponding to each Standard. Table 7 reflects these graphical results in a tabular format.

Heating represents the largest carbon end use, followed by domestic hot water due to the much higher emission factors associated with natural gas. All other end uses represents a relatively small carbon end use due much lower emission factor of electricity.

The only exception in this trend is the Passive House archetype which uses electricity for heating. The heating required to maintain indoor thermal comfort conditions is also greatly reduced due to the high-performing thermal envelope. As a result of the small heating load being met using electricity, all the other end uses contribute almost equally to the carbon intensity of the building with plug loads and lighting being the major contributors.

When it comes to carbon intensity, savings are typically a results of fuel switching. Electricity emission factor in Ontario as reported by SB-10 2017 is 50 g CO_2/kWh and natural gas is 183 g CO_2/kWh.

The Passive House carbon end-use breakdown is based on the model of a Tier 4 archetype found in the City of Toronto Zero Emissions Building Framework.

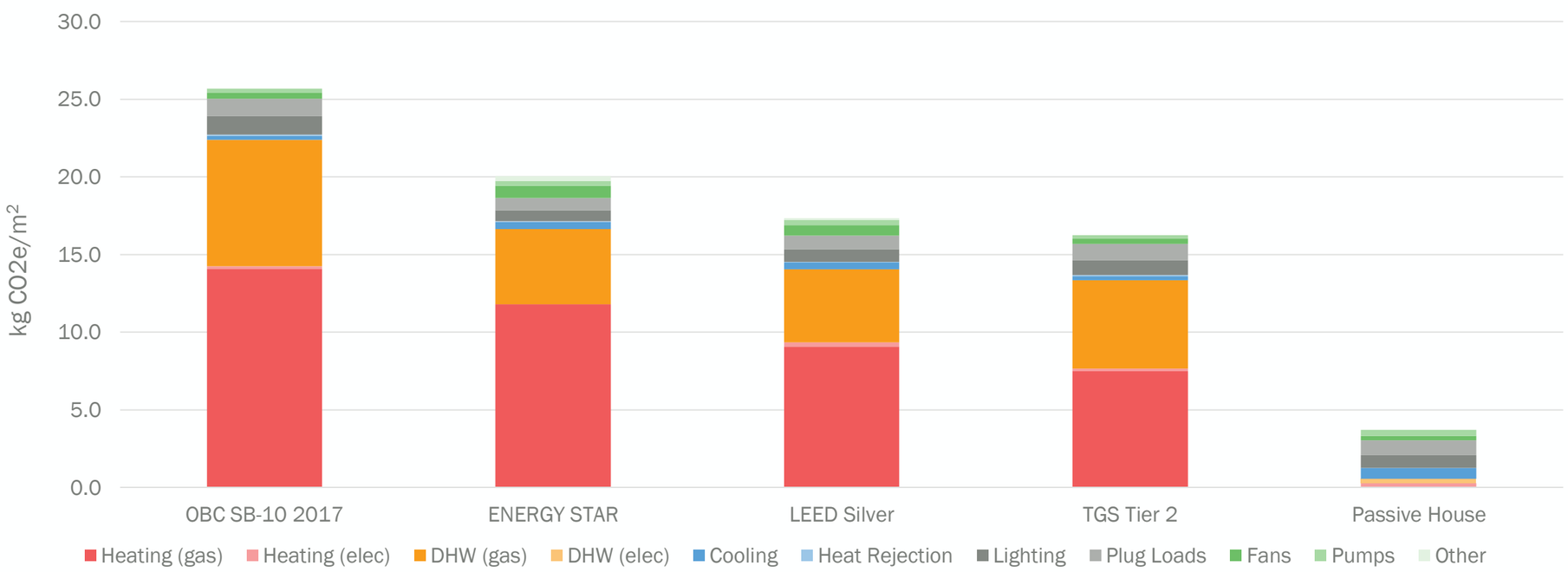

Figure 7: Carbon End Use Breakdown for High-Rise Archetype

Table 7: Carbon End Use Breakdown for High-Rise Archetype in $kgCO_2e/m^2$

End Use	OBC SB-10 2017	ENERGY STAR®	LEED v4 BD+C Silver	TGS v3 Tier 2	Passive House
Heating (Gas)	14.1	11.8	9.1	7.5	0.0
Heating (Elec)	0.1	0.0	0.3	0.1	0.3
DHW (Gas)	8.1	4.8	4.7	5.7	0.0
DHW (Elec)	0.0	0.0	0.0	0.0	0.3
Cooling	0.3	0.5	0.5	0.3	0.7
Heat Rejection	0.1	0.1	0.0	0.1	0.0
Lighting	1.2	0.7	0.8	1.0	0.8
Plug Loads	1.1	0.8	0.9	1.0	1.0
Fans	0.4	0.8	0.7	0.3	0.3
Pumps	0.2	0.3	0.3	0.2	0.4
Other	0.0	0.3	0.1	0.0	0.0
TOTAL	**25.7**	**20.0**	**17.4**	**16.2**	**3.7**

Figure 8 shows the carbon end-use breakdown of the mid-rise energy model corresponding to each Standard. Table 8 represents the graphs in Figure 8 in a tabular format.

As in the high-rise case, heating represents the largest carbon end use, followed by domestic hot water due to natural gas consumption. All other end uses represents a relatively small end use due much lower emission factor of electricity compared to natural gas.

Also as in the high-rise case, the exception in this trend is the Passive House archetype which uses electricity for heating. The heating required to maintain indoor thermal comfort conditions is also greatly reduced due to the high-performing thermal envelope. As a result of the small heating load being met using electricity, all the other end uses contribute almost equally to the carbon intensity of the building with plug loads and lighting being the major contributors.

When it comes to carbon intensity, savings are typically a results of fuel switching. Electricity emission factor in Ontario as reported by SB-10 2017 is 50 g CO_2/kWh and natural gas is 183 g CO_2/kWh.

The Passive House carbon end-use breakdown is based on the model of a Tier 4 archetype found in the City of Toronto Zero Emissions Building Framework.

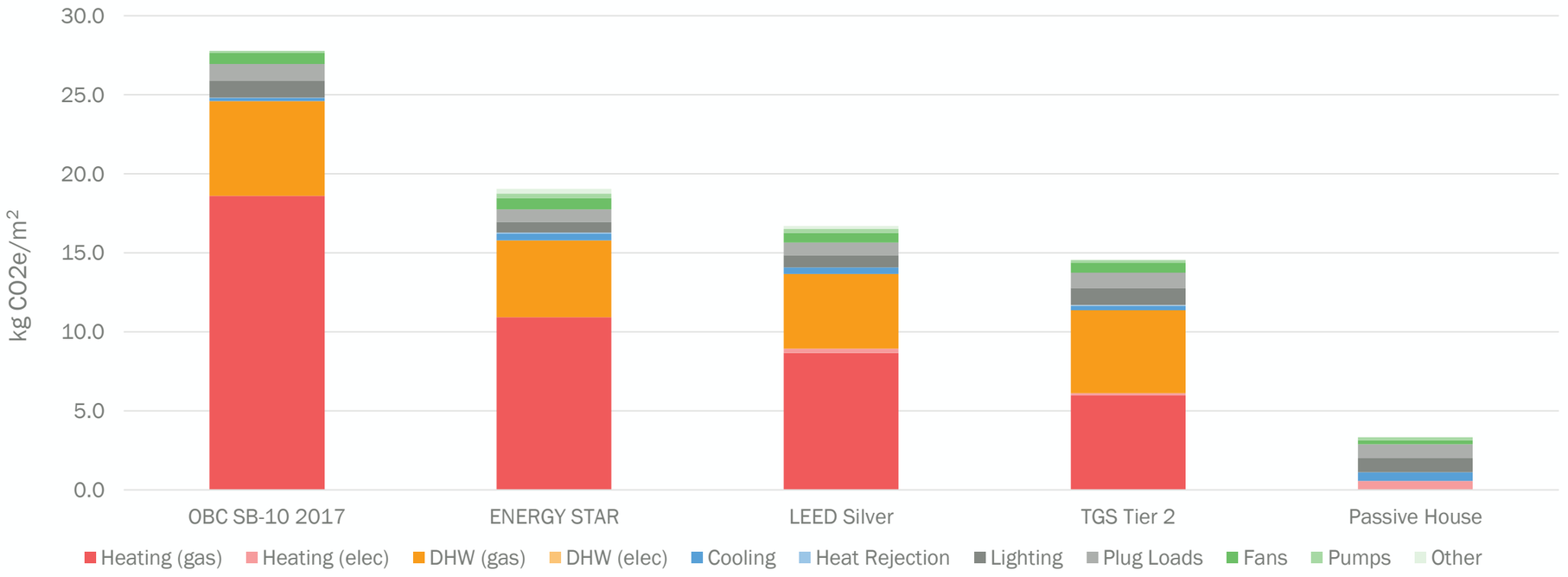

Figure 8: Carbon End Use Breakdown for Mid-Rise Archetype

Table 8: Carbon End Use Breakdown for Mid-Rise Archetype in $kgCO_2e/m^2$

End Use	OBC SB-10 2017	ENERGY STAR®	LEED v4 BD+C Silver	TGS v3 Tier 2	Passive House
Heating (Gas)	18.6	10.9	8.7	6.0	0.0
Heating (Elec)	0.0	0.0	0.3	0.1	0.6
DHW (Gas)	6.0	4.8	4.7	5.3	0.0
DHW (Elec)	0.0	0.0	0.0	0.0	0.0
Cooling	0.2	0.4	0.4	0.3	0.6
Heat Rejection	0.1	0.1	0.0	0.1	0.0
Lighting	1.1	0.7	0.8	1.1	0.9
Plug Loads	1.0	0.8	0.8	1.0	0.9
Fans	0.7	0.7	0.6	0.6	0.3
Pumps	0.1	0.3	0.3	0.2	0.2
Other	0.0	0.3	0.2	0.0	0.0
TOTAL	**27.8**	**19.0**	**16.7**	**14.6**	**3.3**

Figure 9 shows the energy cost end-use breakdown of the high-rise energy model corresponding to each Standard. Table 9 is a tabular representation of the graphical date in Figure 9.

Lighting, plug loads represent the largest energy cost end uses as the electricity rate is almost 5 times higher than the natural gas utility rate.

Cost savings, which are used to calculate LEED points, will be driven by savings in electricity end-uses (lighting, plug loads) moreso than by savings in natural gas end-uses (heating, domestic hot water) which will yield smaller cost savings.

The cost end-use breakdown for a building near Passive House levels of performance does not look significantly different from the cost end-use breakdowns of the other Standards. This is largely because the significant reduction in heating demand is often balanced (in this case) with a move to higher-cost electricity as a heating fuel.

The Passive House cost end-use breakdown is based on the model of a Tier 4 archetype found in the City of Toronto Zero Emissions Building Framework.

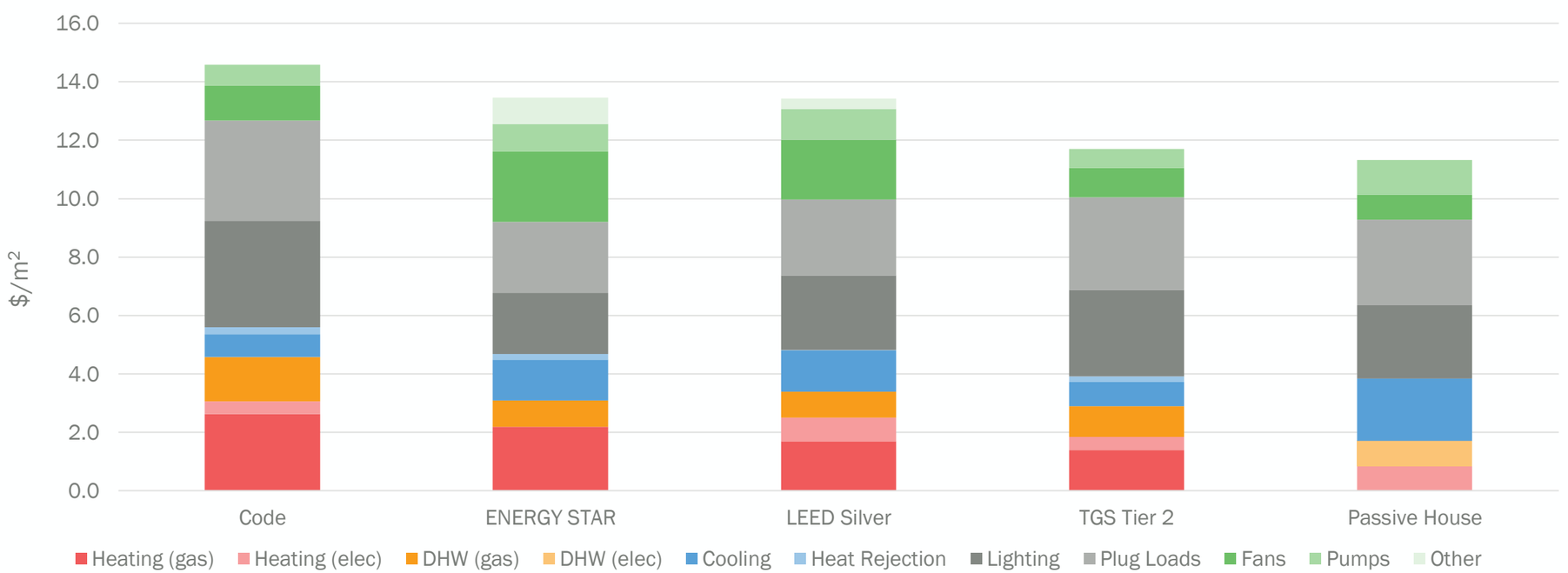

Figure 9: Energy Cost End Use Breakdown for High-Rise Archetype

Table 9: Energy Cost End Use Breakdown for High-Rise Archetype in $/m²

End Use	OBC SB-10 2017	ENERGY STAR®	LEED v4 BD+C Silver	TGS v3 Tier 2	Passive House
Heating (Gas)	2.6	2.2	1.7	1.4	0.0
Heating (Elec)	0.4	0.0	0.8	0.4	0.8
DHW (Gas)	1.5	0.9	0.9	1.1	0.0
DHW (Elec)	0.0	0.0	0.0	0.0	0.9
Cooling	0.8	1.4	1.4	0.8	2.1
Heat Rejection	0.2	0.2	0.0	0.2	0.0
Lighting	3.6	2.1	2.6	3.0	2.5
Plug Loads	3.4	2.4	2.6	3.2	2.9
Fans	1.2	2.4	2.1	1.0	0.9
Pumps	0.7	1.0	1.0	0.6	1.2
Other	0.0	0.9	0.4	0.0	0.0
TOTAL	**14.6**	**13.5**	**13.4**	**11.7**	**11.3**

Figure 10 shows the energy cost end-use breakdown of the mid-rise energy model corresponding to each Standard. Table 10 is the tabular summary of the data in Figure 10.

As in the case of the high-rise energy cost end-use breakdown on the previous page, lighting, plug loads represent the largest energy cost end uses as the electricity rate is almost 5 times higher than the natural gas utility rate.

Cost savings, which are used to calculate LEED points, continue to be driven by savings in electricity end-uses (lighting, plug loads) moreso than by savings in natural gas end-uses (heating, domestic hot water) which will yield smaller cost savings.

As in the case of the high-rise, the cost end-use breakdown for a building near Passive House levels of performance does not look significantly different from the cost end-use breakdowns of the other Standards due to the significant reduction in heating demand being balanced by the use of electricity (at a higher cost) as the heating fuel.

The Passive House cost end-use breakdown is based on the model of a Tier 4 archetype found in the City of Toronto Zero Emissions Building Framework.

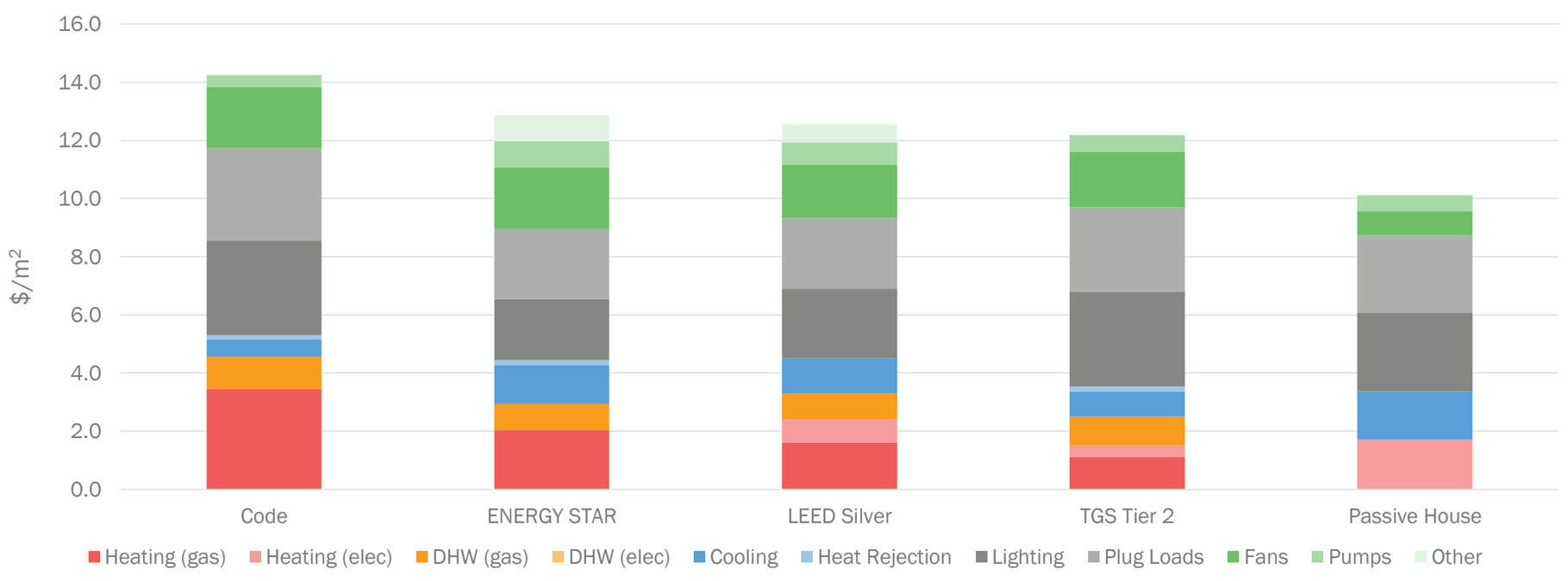

Figure 10: Energy Cost End Use Breakdown for Mid-Rise Archetype

Table 10: Energy Cost End Use Breakdown for Mid-Rise Archetype in $/m^2

End Use	OBC SB-10 2017	ENERGY STAR®	LEED v4 BD+C Silver	TGS v3 Tier 2	Passive House
Heating (Gas)	3.5	2.0	1.6	1.1	0.0
Heating (Elec)	0.0	0.0	0.8	0.4	1.7
DHW (Gas)	1.1	0.9	0.9	1.0	0.0
DHW (Elec)	0.0	0.0	0.0	0.0	0.0
Cooling	0.6	1.3	1.2	0.9	1.7
Heat Rejection	0.2	0.2	0.0	0.2	0.0
Lighting	3.3	2.1	2.4	3.3	2.7
Plug Loads	3.2	2.4	2.4	2.9	2.7
Fans	2.1	2.1	1.8	1.9	0.8
Pumps	0.4	0.9	0.8	0.6	0.6
Other	0.0	0.9	0.6	0.0	0.0
TOTAL	**14.3**	**12.9**	**12.6**	**12.2**	**10.1**

Appendix B: Conditions of Use

The scope of work and related responsibilities for this report are defined in Purpose Building's proposal and Terms and Conditions. Unless specifically recorded in the report, this scope and these responsibilities do not include:

- Physical or destructive testing to evaluate conditions that cannot be quantified by visual observation;
- Calculations or evaluations to check compliance with past or current building codes and design standards;
- Responsibility to identify errors or insufficiencies in the information obtained from the various sources;
- Responsibility for decisions made or actions taken as a result of this report unless Purpose Building are specifically advised and participate in such action, in which case the responsibility will be as agreed to at that time.
- Investigating or providing advice, about pollutants, contaminants or hazardous materials including but not limited to asbestos, mould, or other fungus.

Any user explicitly denies any right to any claim, including personal injury claims, which may arise out of pollutants, contaminants or hazardous materials.

No party other than the Client shall rely on anything in this report without Purpose Building's express written consent. Any third party user of this report specifically denies any right to any claims, whether in contract, tort and/or any other cause of action in law, against Purpose Building (including Sub-Consultants, their officers, agents and employees).

Any reliance on this report requires accepting all of the following:

- The work does not express or imply warranty as to the fitness of the property for a particular purpose or compliance with past or present regulations unless otherwise agreed in writing by Purpose Building. The work reflects Purpose Building's best judgement in light of the information reviewed at the time of preparation.
- This work does not wholly eliminate uncertainty regarding the potential for existing or future costs, hazards or losses in connection with a property.
- No portion of this report may be used as a separate entity. The report is written to be read in its entirety.
- The work does not constitute a recommendation or guarantee of compliance with the listed Standards; compliance is wholly governed by the Authority Having Jurisdiction.
- Only the specific information identified has been reviewed.
- Conditions existing, but not recorded, were not apparent given the level of study undertaken. Only conditions actually seen during examination of representative samples have been appraised and comments on the balance of the conditions are assumptions based upon extrapolation. Purpose Building can perform further investigation(s) on items of concern, if so requested.
- Applicable codes and design standards may have undergone revision since the subject property was designed and constructed and visual evaluation is not sufficient to determine if those changes affect past or current compliance.
- Budget figures provided represent Purpose Building's opinion of a probable current dollar value of the work and are provided for approximate budget purposes only. If an actual construction budget is required for some or all of the work, Purpose Building can provide an additional service to establish a scope of work and receive quotes from suitable contractors.