The City of Mississauga's Corporate Green Building Standard

Program Manual

DECEMBER 30, 2019

MISSISSAUGA

INTEGRAL GROUP

MORRISON HERSHFIELD

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1. A New Standard for Mississauga

In 2010, the City of Mississauga Council approved and adopted a LEED Silver standard of performance for all new construction and major renovations of City buildings. Requirements were adjusted according to building size: large projects with a gross floor area of 10,000 ft^2 were required to achieve LEED Silver certification, while smaller projects with a gross floor area of less than 10,000 ft^2 were required to be designed to achieve LEED Silver certification wherever possible. All projects were additionally required to achieve 15 specific credits deemed of particular importance by the City of Mississauga[1], when practical.

While the LEED Silver standard has been successful in addressing a range of environmental performance areas, it now lags behind the more ambitious targets that many cities and provinces have now set, particularly with respect to energy and emissions (Table 1).

Table 1: Federal, Provincial, Regional and Local Climate Change Targets

GHG Reduction Goals	
Government of Canada	• 17% reduction in GHG emissions below 2005 levels by 2020 • 30% reduction in GHG emissions below 2005 levels by 2030
Province of Ontario	• 30% reduction in GHG emissions below 2005 levels by 2030
Peel Region	• 80% reduction in corporate GHG emissions below 1990 levels by 2050
City of Mississauga	• 40% reduction in community and corporate GHG emissions below 1990 levels b 2030 • 80% reduction in community and corporate GHG emissions below 1990 levels by 2050

To address this gap, the City of Mississauga has adopted a more ambitious approach to environmental performance in its own buildings and facilities. **The Corporate Green Building Standard (CGB) represents a comprehensive set of environmental performance requirements that establish the City of Mississauga as a leader in sustainable buildings in Canada**, and that complement existing policies such as the *Green Building Standard for New Construction and Major Renovation*. The development of the Standard was guided by drawing on six core principles, which together ensure that the Standard will:

1. Move from a prescriptive to a performance-based approach to environmental performance that focuses on performance outcomes rather than requiring specific measures or technologies;
2. Establish targets that are technically and financially feasible for the market, considering current trends in the availability of sustainable services and technologies;
3. Outline varying levels of potential performance to allow flexibility in compliance and acknowledge the constraints and opportunities of different project sites;
4. Make use of measured data to verify compliance, given the municipal ownership of relevant projects;
5. Avoid the need for complex documentation that increases complexity for both compliance and enforcement; and
6. Align with existing regional and provincial requirements to enhance consistency across the industry and take advantage of opportunities for incentivize procurement.

[1] City of Mississauga. (2010). *Green Development Standards.*

1.1. Taking a Performance-Based Approach

In using the principles outlined above, the City of Mississauga's Corporate Green Building Standard has been designed to allow flexibility to design teams with respect to the level of environmental performance that can be achieved on a given project. The Standard sets three increasing levels of performance that design teams can elect to pursue according to a specific project's characteristics and constraints:

- **LEVEL 1:** This level sets the base performance targets that are required to be achieved in all new municipal buildings and facilities. New construction projects must achieve this minimum level of performance in all environmental performance areas. It should be noted that Level 1 represents a rough approximation of the Toronto Green Standard's Tier 2 performance, which is a base requirement for all City of Toronto-owned buildings and facilities.
- **LEVEL 2:** This level represents a set of performance targets that have been identified as moderately more ambitious than Level 1, and that should be considered as highly desirable by the City of Mississauga. They represent a higher level of performance than Level 1 that should be considered in design.
- **LEVEL 3:** This level outlines a set of environmental performance targets that are considered "best in class" and that should be pursued wherever project parameters allow. Applicants should note that the achievement of the International Living Future Institute's Living Building Challenge and/or any relevant petals should be considered an alternative compliance pathway for Level 3.

Targets have been set for 13 key environmental performance areas (Table 2). Applicants should strive to meet the highest level of performance while remaining within a given budget and schedule.

Table 2: Key Environmental Performance Areas

Energy and Climate Change	**Materials**	**Transportation**
• Energy and emissions • Resilience	• Low-impact materials • Carbon footprint • Ozone depleting compounds	• EV infrastructure • Bicycle infrastructure
Waste	**Water**	**Natural Heritage**
• Construction waste management	• Stormwater management • Water use intensity	• Erosion and sediment control • Light pollution • Biodiversity

In addition to achieving one of these three levels of performance, design teams should also strive to achieve the following key design principles:

1. **Ensure specific spatial programming and psychological needs of building occupants and visitors are addressed.** This means ensuring that buildings achieve higher levels of environmental performance while maintaining the core function, aesthetic, and health of the building or facility.
2. **Design building systems, materials, and technologies to be mutually supportive.** This represents the need to ensure that design and cost efficiencies are harnessed wherever possible.
3. **Meet environmental performance targets in a financially sustainable manner.** While cost premiums can be a factor in higher environmental performance buildings, design teams should seek to minimize added costs wherever possible by taking an integrated approach to design.
4. **Make use of "simple" systems that are designed for long operational life and lower maintenance costs.** This means design teams should focus on well-known technologies, locally sourced materials, and passive design strategies as much as possible to reduce the need for expensive maintenance and challenges to daily operations.

1.2. Marrying Performance with Procurement

The purpose of the new Standard is to ensure that each new City-owned building or facility constructed in the City of Mississauga will achieve the highest possible levels of environmental performance within the City's set budget. This *performance-based* approach to procurement is an area of growing interest across North America, particularly among public institutions such as municipalities, universities and colleges, and provincial or federal agencies. It allows institutions with owner-occupied buildings to achieve higher performance goals in new construction and major renovation projects without fear of exceeding maximum budgets.

In a performance-based procurement model, owners can:

- Provide input into preliminary design
- Assign a firm fixed price for project design
- Bestow contractual responsibility for meeting or exceeding performance expectations to the design team

The use of performance-based procurement models has additionally been found to:

- Encourage innovation and creativity among design teams
- Create significant reductions in design and construction costs
- Reduce or eliminate claims, controversies, and change orders
- Achieve higher overall building performance

By using this performance-based procurement approach, the Standard requires applicants to identify the level of performance (i.e. Level 1, 2 or 3) they can commit to for *each* environmental performance area.

For example, a design team with greater experience in designing and constructing highly energy efficient buildings may be confident in their ability to pursue higher levels of energy and emissions performance with minimal added effort or cost. The same team may have less experience in waste management strategies or deem higher levels of performance unattainable for this particular project. As such, the applicant may elect to pursue a Level 3 performance in energy and emissions reductions, but only a Level 1 performance in Construction Waste Management.

Using the process of performance-based procurement, the City of Mississauga will take the following steps for each new construction project:

- Identify the appropriate project delivery method (e.g. design-build, design-bid-build)
- Develops any specific performance goals for the project (i.e. Levels 1, 2 or 3)
- Include these performance goals into the RFP/Contract
- Participate in ongoing design and construction processes to ensure goals are met
- Verify that performance goals have been met post-occupancy

The City of Mississauga's *Sustainable Procurement Policy* commits the City to considering a range of sustainability aspects in procurement – including for services and technologies for new building and facility construction. It requires the City to purchase goods and services from suppliers that:

- Reduce material use, waste and packaging and promote reuse, recycled content, recyclability, reparability, upgradability, durability, biodegradability and renewable products
- Maximize energy efficiency
- Reduce greenhouse gas (GHG) emissions and air pollution, mitigate climate change and support climate change adaptation
- Conserve water and/or improve water quality
- Reduce or eliminate the use of toxins and hazardous chemicals, and
- Contribute to biodiversity preservation and habitat restoration

1.3. How to Use this Guide

This program guide has been created to provide both City staff and applicants with the information necessary to understand and conform to the Corporate Green Building Standard. It outlines the new requirements that buildings are to meet and proposes key strategies for how to achieve those targets. Applicants should use this guide together with the Standard's compliance documentation to understand all requirements.

Figure 1 below shows the key steps involved in applying for the Standard with a Design-Bid-Build approach commonly used in City of Mississauga projects. It outlines tasks for applicants, the owner's Corporate Green Building representative, and City staff. Applicants should liaise with City staff as appropriate to review requirements and ensure all documentation is submitted correctly. **APPENDIX A**: provides further details on how to integrate the Corporate Green Building Standard into the design process, including suggestions for the use of an Integrated Design Process (IDP) to enhance building performance outcomes.

Figure 1: Process of Applying to the Mississauga CGB Standard (assumes Design-Bid-Build Approach)

PROJECT PHASES	OWNER/ APPLICANT	OWNER'S CGB REPRESENTATIVE	CITY OF MISSISSAUGA
PRE-DESIGN	• Initial project visioning • Issue Request for Proposal (RFP) for Feasibility Team • Review CGB Standard and identify level of to be targeted in each performance area • Identify any relevant rebates or incentives • Feasibility Team prepares conceptual design and budget		• Review initial levels of performance targeted • Identify any relevant rebates or incentives
DESIGN	• Issue RFP for Design Team • Finalize each level of performance to be achieved • Issue drawings and specifications • Prepare and submit compliance documents to City staff		• Receive and review all documentation • Submit documentation to specialized City staff for additional review as required • Liaise with applicant on questions
CONSTRUCTION	• Issue Request for Tender and procure contractor • Host CGB Standard information session for contractor and trades • Deliver constructed building, as-builts, manuals • Collect necessary information for compliance documents	• Lead CGB Standard information session for contractor and trades	
SUBSTANTIAL PERFORMANCE/ OCCUPANCY	• Perform and submit Cx and airtightness testing documents • Prepare and submit any final compliance documents (e.g. receipts, declarations) • Set up Building Performance Evaluation		• Receive and review all documentation • Retain copies of contracts, commissioning forms, agreements, and warranties
WARRANTY PERIOD	• Address any performance/CGB Standard deficiencies	• Conduct monitoring-based Cx • Identify performance/CGB Standard deficiencies • Hold education sessions for staff and occupants	

2. Minimizing Costs

Applicants are expected to target and achieve the highest levels of environmental performance possible, while staying within a reasonable budget. Applicants should note that high-performance green buildings do not necessarily incur greater costs than those constructed using more traditional approaches. Indeed, cost premiums associated with "building green" depend on a variety of factors, including the approach to design, the experience of design team members, and others. Research on the costs of high-performance buildings has shown that cost premiums can vary considerably and can even result in cost savings. However, cost premiums have generally been found to fall between 0% and 4%, indicating that higher environmental performance can be achieved at little additional cost[2,3,4,5].

Where cost premiums do exist, these are generally derived from 1) increased time and effort from architects and engineers, modelling exercises and reporting, 2) construction time spent implementing green building features, and 3) the need for specialized equipment and less-common materials. While some of these costs are out of the direct control of the project team, there are many opportunities for teams to capitalize on savings opportunities and to limit cost overruns. These opportunities are best managed by employing an integrated design approach and making the most of available incentives. Utilizing an IDP can lower costs by bringing together stakeholders early in the process, reducing wasted time and materials, and maximizing resource efficiency through the design and construction periods. Project teams can also avoid unnecessary design draft iterations, shortening delivery times, and gain valuable insight into what materials will eventually be needed, allowing time to order specialty products and minimize waste.

In general, the earlier green building solutions are incorporated into the design process, the lower the cost premium. Projects that set goals early in the design process are often those that achieve their intended outcomes at little to no added cost. Introducing green building features as an afterthought is more likely to result in cost overruns and suboptimal systems. While some products and technologies remain cost prohibitive, the cost premium of building green is generally diminishing over time as specialized products become more widely available. In the interim, project teams should make use of available incentives wherever possible.

Overall, it is important to recall that green building projects also offer reductions in operational costs and increases to health and productivity which, though sometimes difficult to quantify, are universally valued and contribute to cost savings to the community at large. By including these factors, building green can be considered an investment in the value of a project, instead of an additional cost.

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[2] US Green Building Council. (2007). *Cost of Green Revisited: Re-examining the Feasibility and Cost Impact of Sustainable Design in the Light of Increased Market Adoption.*

[3] Houghton, A., Vittori, G., & Guenther, R. (2009). *Demystifying First-Cost Green Building Premiums in Healthcare.*

[4] Kats, G. (2010). *Greening Our Built World: Costs, Benefits, and Strategies.*

[5] Department of Energy and Environment (DOEE) & Sustainability DC. (2013). *Net Zero and Living Building Challenge Financial Study: A Cost Comparison Report for Buildings in the District of Columbia.*

3. Energy and Climate Change

3.1. Energy and Emissions Performance

Intent

To promote buildings that are designed to be energy-efficient with reduced operating costs and greenhouse gas emissions associated with building operations, while improving thermal comfort of occupants and enhancing building resilience.

Background

Buildings account for as much as half of the emissions released in Canada's major cities. As such, improving the energy efficiency of buildings and switching to low-carbon energy sources are key factors in reducing the built environment's impact on the climate. Improving energy efficiency also has the added benefits of lowering operating and maintenance costs and increasing occupant comfort. By encouraging low-carbon, energy efficient design, the City of Mississauga will move closer to its emission reduction targets.

The City of Mississauga has adopted a targets-based approach to new building performance by setting thresholds for key city building types in three overarching metrics: energy use intensity, thermal energy demand intensity, and greenhouse gas emissions intensity. Together, the achievement of these three thresholds help to improve building energy efficiency while reducing emissions.

- **Energy Use Intensity** (EUI) is sum of all energy utilities (i.e. electricity, natural gas, district heating) used on site by the project, divided by modelled floor area. EUI is reported in kWh/m^2/year. Setting an EUI target ensures that overall energy demand is reduced, as well as a building's peak demand. EUI targets can be met by designing the building to reduce overall energy needs and selecting energy efficient systems and appliances.
- **Thermal Energy Demand Intensity** (TEDI) 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. Setting a TEDI target ensures that buildings are designed to reduce overall heating demand using passive design measures, including higher quality envelopes, careful window placement, and thoughtful massing. A building with an improved TEDI improves occupant comfort, increases building resilience, and lowers replacement costs over time.
- **Greenhouse Gas Intensity** (GHGI) is the total greenhouse gas emissions associated with the use of all energy utilities on site. Setting and achieving GHGI targets ensure that building systems make use of lower carbon sources that help to meet the City's GHG reduction targets.

Requirements & Deliverables

Specific targets for key building types subject to the Standard are outlined in the table below. To demonstrate compliance, applicants need to perform and submit an energy model at key stages of the design process or wherever the design has substantially changed. The Energy Modelling Guidelines that applicants are to follow are detailed in APPENDIX B: Energy Modelling Guidelines.

In addition to the specific targets for each archetype, requirements have also been set for building commissioning, airtightness testing, sub-metering, energy reporting and benchmarking, and solar readiness/ on-site renewable energy generation.

Requirements		
Office Building		
Level 1	**Level 2**	**Level 3**
EUI: 110 kWh/m²/year **TEDI:** 55 kWh/m²/year **GHGI:** 15 kgCO2e/m²/year	**EUI:** 90 kWh/m²/year **TEDI:** 35 kWh/m²/year **GHGI:** 10 kgCO2e/m²/year	**EUI:** 60 kWh/m²/year **TEDI:** 15 kWh/m²/year **GHGI:** 5 kgCO2e/m²/year
Fire Hall		
Level 1	**Level 2**	**Level 3**
EUI: 105 kWh/m2/year **TEDI:** 75 kWh/m2/year **GHGI:** 11 kgCO2e/m2/year	**EUI:** 80 kWh/m2/year **TEDI:** 60 kWh/m2/year **GHGI:** 5 kgCO2e/m2/year	**EUI:** 60 kWh/m2/year **TEDI:** 30 kWh/m2/year **GHGI:** 5 kgCO2e/m2/year
Library		
Level 1	**Level 2**	**Level 3**
EUI: 140 kWh/m2/year **TEDI:** 50 kWh/m2/year **GHGI:** 15 kgCO2e/m2/year	**EUI:** 110 kWh/m2/year **TEDI:** 40 kWh/m2/year **GHGI:** 10 kgCO2e/m2/year	**EUI:** 60 kWh/m2/year **TEDI:** 25 kWh/m2/year **GHGI:** 5 kgCO2e/m2/year
Rec Centre		
Level 1	**Level 2**	**Level 3**
EUI: 160 kWh/m2/year **TEDI:** 45 kWh/m2/year **GHGI:** 20 kgCO2e/m2/year	**EUI:** 140 kWh/m2/year **TEDI:** 35 kWh/m2/year **GHGI:** 15 kgCO2e/m2/year	**EUI:** 70 kWh/m2/year **TEDI:** 15 kWh/m2/year **GHGI:** 5 kgCO2e/m2/year
Transit Station		
Level 1	**Level 2**	**Level 3**
EUI: 230 kWh/m2/year **TEDI:** 100 kWh/m2/year **GHGI:** 25 kgCO2e/m2/year	**EUI:** 180 kWh/m2/year **TEDI:** 50 kWh/m2/year **GHGI:** 15 kgCO2e/m2/year	**EUI:** 150 kWh/m2/year **TEDI:** 15 kWh/m2/year **GHGI:** 10 kgCO2e/m2/year
Transit Repair Station		
Level 1	**Level 2**	**Level 3**
EUI: 300 kWh/m2/year **TEDI:** 120 kWh/m2/year **GHGI:** 38 kgCO2e/m2/year	**EUI:** 280 kWh/m2/year **TEDI:** 100 kWh/m2/year **GHGI:** 35 kgCO2e/m2/year	**EUI:** 130 kWh/m2/year **TEDI:** 20 kWh/m2/year **GHGI:** 10 kgCO2e/m2/year
Ice Rink		
Level 1	**Level 2**	**Level 3**
EUI: 380 kWh/m2/year **GHGI:** 46 kgCO2e/m2/year	**EUI:** 335 kWh/m2/year **GHGI:** 38 kgCO2e/m2/year	**EUI:** 200 kWh/m2/year **GHGI:** 17 kgCO2e/m2/year
Swimming Pool[6]		
Level 1	**Level 2**	**Level 3**
EUI: 3,700 kWh/m2/year **GHGI:** 560 kgCO2e/m2/year	**EUI:** 2700 kWh/m2/year **GHGI:** 350 kgCO2e/m2/year	**EUI:** 1800 kWh/m2/year **GHGI:** 90 kgCO2e/m2/year
Deliverables		
Level 1	**Level 2**	**Level 3**

Site Plan Approval (SPA) Energy Model Documentation Requirements:

- Energy Model Report summarizing key modelling inputs, outputs and assumptions
- Working Energy Model Simulation Files
- Mechanical and Electrical Design Brief
- Related supporting drawings and calculations done external from the energy modelling software (for example, thermal bridging calculations)

As-Built Energy Model Documentation Requirements:

- Updated Energy Model Report
- Working Energy Model Simulation Files
- Mechanical and Electrical Design Brief
- Modelling Notes: General, Building Level, Plant Level, System Level, Occupancy and Minimum Outdoor Air Rates, Warnings and Errors
- Take-off Calculations (Modeller's external calculations to support the model inputs). If applicable, calculation for model

[6] All target metrics for swimming pools are normalized on the basis of pool water surface area and not gross floor area.

- work-arounds, exceptions, process energy savings, renewable energy systems, district energy systems, or other required calculations.
- Zoning Diagrams
- Outdoor Air Calculation Spreadsheets
- Architectural Drawings and Specifications (issued for construction/as-built)
- Mechanical Drawings and Specifications (issued for construction/as-built)
- Electrical Drawings and Specifications (issued for construction/as-built)

Guidance for Applicants

For the purposes of demonstrating compliance with the performance requirements outlined in **Error! Reference ource not found.,** whole-building energy models shall be developed in accordance with the energy modelling guidelines provided in APPENDIX B: Energy Modelling Guidelines of this document. Applicants are encouraged to develop energy models early in the design process to assist in making key design-related decisions, and to conduct numerous iterative simulations to determine the most cost-effective strategy that meets the project's overall performance targets.

The energy model should be treated as a 'living' document that is updated at major milestones as the project progresses through the various stages of design and construction, to ensure that the project is on track to meet its performance targets. A final 'as-built' energy model update can then be used as the basis for which actual building performance is compared against to determine whether the performance targets have been met in actual operation, and to help identify opportunities for improvement in building energy efficiency.

It should be noted that, in addition to energy modelling documentation required to demonstrate compliance with the City's Corporate Green Building Standard, applicants are expected to ensure that the project also meets the provincial energy efficiency requirements outlined in the Ontario Building Code Supplementary Standard SB-10. The applicant will also need to submit any documentation required for additional green building certification or incentive programs that the project may elect to pursue, including providing the necessary compliance documentation to the authority having jurisdiction.

Additional Resources

For helpful examples of how to design energy-efficient low-carbon buildings, visit the following links:

- *Canada Green Building Council (CaGBC). (2015). Guidance for Energy Modelling Compliance Documentation in LEED® Canada.*
    - Energy Model Reports must contain, at a minimum, the information listed in Part 1 of this document.
- Canada Mortgage and Housing Corporation. (2017). *Parametric Simulations in Support of Integrated Design Processes.*
- BC Hydro. (2018). *Building Envelope Thermal Bridging Guide.*
- BC Housing. (2018). *Guide to Low Thermal Energy Demand for Large Buildings.*
- Ontario Building Code. (2016). *Supplementary Standard SB-10 "Energy Efficiency Requirements".*

3.2. Building Commissioning

Intent

To ensure that all systems and components of a building are designed, installed, tested, operated and maintained according to its operational requirements in an optimized manner.

Background

The commissioning process is critical to ensuring that building systems operate as designed. It typically includes a review of the design intent for the building (as set out in the Owner's Project Requirements) and an evaluation of how that has been met. More extensive commissioning can also ensure that: major building systems are tested, adjusted, and balanced; maintenance and operational materials are adequate; and/or building staff have received adequate training on the operations and maintenance of building systems. Commissioning is increasingly important in higher performance buildings, as newer systems and technologies can require finer tuning to ensure their proper function.

Requirements & Deliverables

<table>
<tr><th>Level 1 – Requirements</th><th>Level 2 – Requirements</th></tr>
<tr><td rowspan="7">Monitoring-based Commissioning:
Develop monitoring-based procedures and identify points to be measured and evaluated to assess performance of the major energy-consuming systems representing more than 10% of the building's total energy use (at a minimum heating, cooling, lighting, fans, and pumps).

• Commissioning Plan that includes the following:
- Roles and responsibilities
- Preliminary commissioning schedule
- Identify seasonal/deferred testing and post construction verification phase requirements
- Final construction documents (i.e. Issued for Construction drawings and specifications)
- Energy modeling assumptions such as hours of use, occupancy, occupant behaviour, plug and process loads
- For each major energy-consuming systems:
- Measurement requirements (BAS points, sub-meters, testing devices
- Key performance metric to be used to evaluate performance and the requirement
- Frequency of analyses after substantial completion and in the warranty period (at least quarterly)
- Functional performance checklists/scripts
- Test procedures/execution/TAB requirements
• Commissioning Report that includes the following:
- Owner's Project Requirements
- Basis of Design
- Documents review log at various stages
- As-Built drawings
- Reviewed equipment shop drawings
- As-Built control drawings
- Reviewed contractor/manufacturer start-up reports and test procedures/execution
- Reviewed test, adjust, and balance (TAB) reports
- Completed functional performance checklists/scripts
- Analysed data and confirmation of performance for each major energy-consuming system
- Issues and deficiencies log
- Repairs (if needed) to maintain performance
• Incorporation of commissioning requirements into the construction tender documents must be confirmed</td><td>Level 1 +

• Systems Operation Manual that can used for the purposes of informing facilities staff, current or potential service contractors, and facility occupants for operating and maintaining a facility's systems. It shall include the following:
- A general facility description and plot plan with the location of major use areas and equipment identified
- A description of each major energy-consuming system, including location, pictures (as needed), key performance metrics/benchmarks to evaluate performance, and follow-up requirements
- Control settings for each major energy-consuming system, including setpoints, schedules, energy efficiency features, and seasonal changeover procedures
- Best practice maintenance requirements
- An on-going commissioning plan</td></tr>
<tr><th>Level 2 – Deliverables</th></tr>
<tr><td>Level 1 +
System Operation Manual</td></tr>
<tr><th>Level 3 – Requirements</th></tr>
<tr><td>Level 2 +

LEED BC+C v4 credit Envelope Commissioning (Option 2).

Fulfill the requirements in EA Prerequisite Fundamental Commissioning and Verification as they apply to the building's thermal envelope, in addition to reporting the mechanical and electrical systems and assemblies in accordance with ASHRAE Guideline 0–2005 and the National Institute of Building Sciences (NIBS) Guideline 3–2012, Exterior Enclosure Technical Requirements for the Commissioning Process, as they relate to energy, water, indoor environmental quality, and durability.</td></tr>
<tr><th>Level 3 – Deliverables</th></tr>
<tr><td>Level 2 +

• Incorporation of building envelope commissioning documentation for the deliverables identified in Levels 1 and 2
Requirements as per LEED BC+C v4 credit Envelope Commissioning (Option 2)</td></tr>
</table>

• A current facilities requirements and operations and maintenance plan that contains the information necessary to operate the building efficiently must be prepared and maintained	
Level 1 – Deliverables	
• Commissioning Plan • Commissioning Report • Current Facilities Requirements and Operations and Maintenance Plan	

Guidance for Applicants

In general, applicants should follow the requirements outlined in the LEED v4 Reference Guide for the following pre-requisites and/or credits as they relate to each of the performance tiers in the Mississauga CGB Standard:

- Level 1: Monitoring-Based Commissioning complements the fundamental commissioning requirements by providing the owner (via the commissioning authority) further oversight and verification to ensure that the building will meet its operational requirements. Given the strong desire that buildings meet their energy efficiency targets during building operation, Level 1 should also include a monitoring-based commissioning plan. This includes the implementation of an energy management and information system (EMIS) that continuously tracks building energy use and operational data to identify anomalies, with the end goal of rectifying inefficiencies as they occur to help reduce energy use, GHG emissions and utility costs over the lifecycle of the building. The requirements include in-depth reviews of the basis of design, design documents, construction submittals, operator training, post-construction verification, and development of an on-going commissioning plan.

- Level 2: This includes all the requirements under Level 1, as well as the development of a comprehensive systems manual that that can used for the purposes of informing facilities staff, current or potential service contractors, and facility occupants how to be operate and maintain the facility's systems.

- Level 3: This includes all the requirements under Levels 1 and 2, as well as those listed under LEED v4 Envelope Commissioning credit. Adding envelope commissioning ensures not only those active energy-consuming systems are considered but also that passive load-defining envelope systems are understood and verified. Such actions can help prevent problems with envelope design and construction that would be costly or impossible to address after construction. Additional benefits of BECx include improving occupants' comfort through glare control, infiltration testing, and reduced solar heat gain.

Additional Resources

For additional resources related to best practices for building commissioning, visit the following links:

- US Green Building Council (USGBC). (2018). *LEED v4 Reference Guide – Building Design and Construction.*
- CSA Group. (2016). *CSA Standard Z320-11 (R2016) – Building Commissioning.*
- ASHRAE Standards Committee. (2010). *ASHRAE Guideline 0-2005 – The Commissioning Process.*
- ASHRAE Standards Committee. (2007). *ASHRAE Guideline 1.1-2007 – HVAC&R Technical Requirements for the Commissioning Process.*
- National Institute of Building Sciences (NIBS). (2012). *NIBS Guideline 3-2012 – Exterior Enclosure Technical Requirements for the Commissioning Process.*
- Lawrence Berkeley National Laboratory. (2017). *Monitoring-Based Commissioning Plan – Sample Template.*

3.3. On-Site Renewables

Intent

To encourage on-site energy generation using renewable energy sources to reduce GHG emissions associated with building operation, as well as to reduce stresses imposed on the local electricity grid and further improve building resilience in the wake of power outages.

Background

Green buildings can incorporate a variety of renewable energy sources on-site, including solar photovoltaic (PV), solar hot water, small-scale wind turbines, and biomass combustion, among others. These systems can help a building to meet its energy needs and to lower its carbon emissions. They can also serve to protect the project from energy price volatility and reliance on the power grid, while reducing the energy that is wasted in transmission. Some factors that influence the viability of on-site renewables are building location, size, and structure, along with daily and seasonal load variations. Applicants will therefore be required to design their projects to accommodate future PV at a minimum for Level 1, increasing to a system designed to provide a minimum of 5% of the building's total annual energy needs for Level 2. Level 3 requires on-site renewable energy to be supplied for 100% of the building's annual energy demand by on-site systems, resulting in a net-zero energy building.

Requirements & Deliverables

Level 1	Level 2	Level 3
Requirements		
Designed to accommodate future installations of rooftop PV, including but not limited to structural capability to support rooftop PV, space available for future electrical equipment in electrical room, etc.	**Level 1 +** On-site renewable energy devices to offset 5% of building annual energy consumption	**Level 1 +** On-site renewable energy devices to offset 100% of building annual energy consumption
Deliverables		
• Solar-ready provisions clearly identified in all applicable design documentation, and co-ordinated between the various design disciplines (electrical, structural, etc.)	• All applicable documentation to facilitate the design, installation, operation and maintenance of the renewable energy system (drawings, specifications, maintenance manuals, etc.) • Supporting renewable energy analysis calculations to demonstrate that the 5% requirement has been met	• All applicable documentation to facilitate the design, installation, operation and maintenance of the renewable energy system (drawings, specifications, maintenance manuals, etc.) • Supporting renewable energy analysis calculations to demonstrate that net zero energy has been met

Guidance for Applicants

For the purpose of providing PV-ready provisions to meet Level 1, applicants may assume a system size that supplies at least 5% of the building's annual energy consumption. PV-ready requirements include the following:

- Designate an area of the roof for future solar PV;
- Provide adequate structural capacity for the roof structure;
- Install one or two conduits from the roof to the main electrical or mechanical room, sized based on potential solar PV system size;
- Designate a 2m x 2m wall area in the electrical and mechanical rooms for future solar PV equipment controls and connections (e.g. meters, monitors); and
- Where possible, place HVAC equipment on north side of the roof to prevent future shading.

Applicants are encouraged to consult the National Renewable Energy Laboratory's Solar Ready Buildings Planning Guide for additional considerations for PV-ready provisions.

The renewable energy calculations can be conducted either within the whole-building energy modelling software, or through recognized third-party energy modeling tools such as RETScreen Expert or PVsyst. The 5% and 100% threshold levels corresponding to Levels 2 and 3, respectively, must be determined based on the outputs of the whole-building energy model.

It should be noted that off-site solutions such as renewable energy certificates (RECs), carbon offsets, or power purchasing agreements (PPA) with renewable energy generators are not permitted to satisfy this measure, unless otherwise approved by the City.

Allowable forms of renewable energy systems to meet Level 2 and 3 requirements include the following:

- Solar photovoltaics (PV);
- Solar thermal;
- Biogas and biofuel; and
- Wind-based systems.

For greater clarity, note that geo-exchange systems (i.e. ground-source heat pumps) are considered a building energy efficiency measure, as opposed to a form of renewable energy generation. As such, these systems cannot be used for the purposes of meeting the on-site renewable energy requirement but can instead be utilized to meet the EUI and GHGI targets outlined in Section 4.1.

Applicants are encouraged to pursue a renewable strategy that considers the unique characteristics of their particular building. For example, high ventilation requirements coupled with the lack of extensive glazing on transit maintenance facilities may make solar air heating systems a particularly attractive opportunity.

Additional Resources

For additional guidance on solar-PV provisions, visit the following link:

- National Renewable Energy Laboratory's Solar Ready Buildings Planning Guide
- National Resources Canada. (2019). *RETScreen.*
- PVSyst. (2019). PVsyst Photovoltaic Software.

3.4. Air Tightness

Intent
To ensure that the air barrier systems of building envelope systems are constructed and performing as per design intent, given its significant influence on the overall energy and thermal performance of the building.

Background
Whole-building air tightness tests evaluate the leakiness of a building's envelope by measuring the pressure difference across the enclosure, with gaps leading to heat loss, condensation, and increased costs. These tests are typically conducted using a piece of equipment called a blower door and are often referred to as blower door tests. For smaller buildings, the test may only need one blower door, while a large building requires a coordinated effort with multiple blower doors running at the same time. The information gathered can highlight the location of imperfect seals and large holes, which operators can address for improved building performance. Ensuring a building's airtightness is a key step in ensuring energy efficiency targets are met; as such, applicants are required to perform and submit the results of an airtightness test for all levels of the Standard.

Requirements & Deliverables

Levels 1, 2 and 3
Requirements
Conduct a whole-building air leakage test to improve the quality and air tightness of the building envelope.
Deliverables
At 50% Construction Documents stage: • Executed contract with an airtightness testing provider • Line of air barrier system shown on drawings and indicative details • Airtightness testing plan describing the project's approach to achieving the air tightness target, proposed testing procedure, and related quality assurance and quality control activities At project completion: • Completed airtightness testing report • If results are below target, report shall include practical steps to identify areas of significant air leakage and improve air tightness for the project, as well as documentation of potential strategies can be used to improve airtightness on future projects

Guidance for Applicants
It is recommended that applicants follow ASTM WK35913 Standard Test Method for Determining the Air Leakage Rate of Large or Multi-zone Buildings or US Army Corps of Engineers (USACE) Air Leakage Test Protocol.

Projects shall conduct an operational envelope air tightness test under negative pressure producing a multi-point regression. However, projects are also permitted to pursue negative and positive pressure testing and produce a building envelope test where HVAC-related openings are excluded, as in the Passive House standard.

Projects shall target a test pressure of 75Pa. Projects unable to achieve 75Pa must follow either ASTM W35913 alternative test methods, a Repeated Single-Point Test, or a Repeated Two-Point test and demonstrate compliance using projected curves for air tightness at 75Pa.

If the whole building cannot be tested as one zone, it is acceptable to test a zone that can be partitioned temporarily, with adjacent zones 'guarded' as buffer zones using blower door equipment. Note that the air leakage rate should be normalised to the exterior surface area and not include the guarded surface areas.

All materials, assemblies and systems that form the continuous air barriers systems must be installed including any HVAC equipment, ducts and fittings included in the test boundary.

Additional Resources
For additional guidance on airtightness testing, visit the following links and resources:

- BC Housing. (2017). *Illustrated Guide to Achieving Airtight Buildings.*

- ASTM International. (2012). *ASTM WK35913 – Standard Test Method for Determining the Air Leakage Rate of Large or Multi-zone Buildings.*
- US Army Corps of Engineers (USACE). (2012). *Air Leakage Test Protocol for Building Envelopes.*
- Air Barrier Association of America (ABAA). (2012). *Air Leakage Test Protocol for Building Envelopes (Version 3) – Superseded by ASTM WK35913.*
- ASTM International. (2019). *ASTM E779-19 –* Standard Test Method for Determining Air Leakage Rate by Fan Pressurization.
- ASTM International. (2017). *ASTM E1827-11 – Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door.*
- International Organization of Standardization (ISO). (2015). *ISO 9972:2015 Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method.*
- The Air Tightness Testing and Measurement Association (ATTMA). (2015). *Technical Standard L2 – Measuring Air Permeability in the Envelopes of Buildings (Non-Dwellings).*

3.5. Metering and Benchmarking

Intent

To ensure that buildings are provided with an adequate level of metering and measurement systems to facilitate ongoing tracking of energy usage by the building systems.

Background

Comprehensive electricity and thermal metering allows building operators to track energy consumption over time, identify variations between uses, and precisely calibrate operational parameters in response. This process can show gaps between projected and actual efficiency performance, which is a vital component of energy management. By comparing the measurements from sub-meters to an established benchmark for that building type, operators can identify and remedy poorly performing buildings, reduce wasted energy, and decrease costs. Organizations can limit these findings to internal use or share them on a wider scale for competition with like buildings and participation in green building certification programs. All buildings subject to the Standard will be required to install sub-meters for all significant energy end-uses, and register the building on Energy Star Portfolio Manager.

Requirements & Deliverables

Levels 1, 2 and 3	
Requirements	
Metering	Install electricity and/or thermal sub-meters for all energy end-uses that represent more than 10% of the building's total energy consumption. All major process loads such as pools and ice rinks shall be sub-metered separately.
Benchmarking	Register the building on ENERGY STAR Portfolio Manager and co-ordinate with the City of Mississauga Energy Management Team to establish the process for ongoing reporting and benchmarking.
Deliverables	
Metering	• Provision of electricity and thermal sub-meters clearly indicated on electrical and mechanical single-line diagrams • A metering plan listing all meters along with type, energy source metered, diagrams, and/or references to design documentation
Benchmarking	• Create an account on ENERGY STAR Portfolio Manager for the building, including provision of key building input characteristics such as gross floor area, identification of multiple space uses, etc. and turn over access to the City upon project completion

Guidance for Applicants

Applicants should follow the metering requirements provided in the LEED v4 Reference Guide for the advanced energy metering, which includes the following requirements:

- Meters must be permanently installed, record at intervals of one hour or less, and transmit data to a remote location;
- Electricity meters must record both consumption and demand. Whole-building electricity meters should record the power factor, if appropriate;
- The data collection system must use a local area network, building automation system, wireless network, or comparable communication infrastructure;
- The system must be capable of storing all meter data for at least 36 months;
- The data must be remotely accessible; and
- All meters in the system must be capable of reporting hourly, daily, monthly, and annual energy use.

All energy-end uses that make up more than 10% of total building energy use, as determined through the whole-building energy model, must be sub-metered. All meters should be installed and calibrated per manufacturer recommendations.

For hydronic systems, all thermal energy meters must be ‘true’ energy meters capable of measuring flow rates as well as supply and return temperatures and computing energy consumption.

Additional Resources

For additional guidance on metering and benchmarking, visit the following links and resources:

- US Green Building Council (USGBC). (2018). *LEED v4 Reference Guide – Building Design and Construction.*
- Efficiency Valuation Organization (EVO). (2019). *International Performance Measurement and Verification Protocol (IPMVP).*
- US Environmental Protection Agency (EPA). (2018). *ENERGY STAR Portfolio Manager Technical Reference Manual.*
- Ministry of Energy, Northern Development and Mines. (2019). *Ontario Energy and Water Reporting and Benchmarking Requirements.*

3.6. Resilience Performance Requirements

Intent

To promote buildings that are designed to maintain critical operations and functions in the face of a shock or stress, and quickly return to normal operations to maintain healthy, liveable spaces for its occupants.

Background

Boosting building resilience to climate change impacts is becoming more important as projected changes in climate for the City of Mississauga include increases in the incidence of heat waves, ice storms, and other extreme weather events. Many of these events are accompanied by power outages, leaving the community without electricity. In particular, City-owned buildings can act as important centres for refuge for the community, including vulnerable populations, during these events. This is why new City buildings will be required to provide 72 hours of back-up power to key components of the building. Coupled with the energy efficiency requirements of the Standard (see Section 3.1), providing 70 hours back-up power over and above minimum building code requirements will ensure that facilities such as community centres and libraries will be able to provide a safe, comfortable place for people to take shelter, charge communication of medical equipment, and stay warm or cool, depending on the time of year.

Requirements & Deliverables

Level 1	Level 2	Level 3
Requirements		
Provide 72 hours of back-up power and thermal energy to a central refuge area and to essential building systems as per the City of Toronto's Minimum Backup Power Guidelines for MURBs. Combustion-based or battery-based systems both permitted.	**Level 1 +** Only a non-combustion-based system using battery storage or other non-combustion forms of back-up generation is permitted.	N/A
Deliverables		
• A narrative describing the project's approach to resilience, with the back-up power source/quantity of fuel to be verified post construction.	Same as Level 1	N/A

Note: *The application of Resilience Performance Requirements may be waived for select building types. Applicants should confer with City of Mississauga staff to confirm if requirements apply to their project.*

Guidance for Applicants

Providing extended back-up power is only one aspect of resilience, and applicants are encouraged to explore further solutions that are appropriate for their site. It should be noted that increasing the city's resilience to flooding and storm events can also be achieved using low-impact development and stormwater management practices, such as the use of permeable pavements, bio-retention techniques, and rainwater harvesting systems, discussed further in Section 7.1 on stormwater management.

Additional Resources

For helpful examples of how to design more resilient buildings, visit the following links:

- City of Toronto. (2016). *Minimum Backup Power Guidelines for MURBs.*
- City of Vancouver. (2019). *Resilient City.*
- City of Mississauga. (2010). *Green Development Standards.*
- Credit Valley Conservation (CVC) & Toronto and Region Conservation Authority (TRCA). (2010). *Low Impact Development Stormwater Management Planning and Design Guide.*

4. Materials

4.1. Low-impact Materials

Intent
To encourage the use of environmentally preferable building materials, including those that are reused, recycled, and locally-sourced.

Background
New, non-recyclable, and unsustainably sourced construction materials can consume large amounts of natural resources throughout their lifespan. Their production and distribution are responsible for both resource depletion and environmental impacts, while their eventual disposal after demolishment create significant quantities of waste. Low-impact materials, on the other hand, are those that require less energy for extraction, production, transport, and operation. These include materials with *recycled content* (e.g. concrete that incorporates crushed glass or wood chips), *reused content* (e.g. timber from existing structures), *locally-sourced products*, *bio-based materials* (e.g. hay for insulation), and *wood products* certified by the Forest Stewardship Council (FSC). Green building certification programs that encourage the use of low-impact materials include the International Living Future Institute's (ILFI) Living Building Challenge (through its Materials Petal) and LEED v4 (through its Materials & Resources credits), among others.

Requirements & Deliverables

Level 1	Level 2	Level 3
Requirements		
• Minimum 20% cement replacement in concrete (pre-consumer recycled content using waste fly ash or slag) and/or minimum 20% GHG reductions in concrete using low-emissions alternatives • Min. 50% post consumer recycled content in rebar • Min. 50% post consumer recycled content in structural steel, metal decks • All flooring products must meet FloorScore • Meet SCAQMD Low/No VOCs for all interior paints, coatings, adhesives, and sealants, as per ASHRAE 189.1 • Min. 25% FSC Wood • No urea-formaldehyde	**Level 1 +** • Min. 75% post consumer recycled content in rebar • Min. 80% post consumer recycled content in structural steel, metal decks • Min. of 20 Environmental Product Declarations (EPDs), as per LEED MR: Building Product Disclosure and Optimization • Min. 75% FSC Wood	Meet the Materials Petal of the Living Building Challenge.
Deliverables		
• Product documentation demonstrating that requirements have been met, including manufacturer's data, Material Safety Data Sheets (MSDS), third-party certification, or screenshots from relevant programs	**Level 1 +** • Verified EPDs that conform to ISO 14025 and EN 15804 or ISO 21930 and have at least a cradle-to-gate scope, • The EPD must also identify the declaration holder, EPD program operator, and third-party reviewers	• Documentation of compliance with the Living Building Challenge's Materials Petal

Guidance for Applicants
Meeting Level 1 will require applicants (often the project contractor) to track and document product specifications, which are provided by product suppliers. Level 2 and Level 3 will require greater coordination with the project team, increasingly careful selection of materials, involvement of the architect or interior designer, and possibly the guidance of a specialized sustainability consultant in materials selection. Meeting the Levels 2 and 3 will limit material choices overall, they are locally available and will have positive impacts for the health of building occupants in addition to their environmental benefits.

Additional Resources
For more information about selecting low-impact materials, visit the following links:

- American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). (2017). *Standard 189.1-2017 - Standard for the Design of High-Performance Green Buildings.*
- British Columbia Ministry of Environment and Climate Change Strategy. (2017). *LEED v4 and Low Carbon Building Materials - A Comprehensive Guide.*
- SCS Global Services. (2019). *FloorScore - Indoor Air Quality Certification for Flooring.*
- International Living Future Institute (ILFI). (2019). *Living Building Challenge - Materials Petal Intent.*
- South Coast Air Quality Management District (SCAQMD). (2018). *VOC Rules.*
- Mindful MATERIALS. (2019). *Mindful MATERIALS Library.*
- Vertima. (2019). *Certified Products Directory.*
- UL Environment. (2019). *SPOT*
- International Living Future Institute. (2019). Declare Product Database.

4.2. Embodied Carbon Footprint

Intent

To reduce the embodied carbon footprint of projects, while promoting environmental and social sustainability.

Background

The comprehensive embodied carbon footprint of a building material considers the total impact of the greenhouse gas emissions associated with all phases of its life, including extraction, transport, refining, processing, assembly, installation, operations, decommissioning, and disposal. Our understanding of how to reduce operational emissions has improved in recent years, but many embodied carbon emissions (and their contribution to climate change) are still going unaccounted for. While these emissions currently represent a relatively low proportion of an average building's total carbon footprint, they will grow in importance as operational emissions for buildings continue to fall.

When considering the carbon footprint of a project, it makes sense to also employ a Triple Bottom Line (TBL) approach. This means measuring success beyond simple monetary returns by considering social and environmental sustainability alongside profit. For example, ensuring fair hiring standards at a building would contribute to social sustainability, while generating onsite renewable energy would contribute to environmental sustainability. This approach encourages buildings and initiatives that create value for all potential stakeholders, not just a select few.

Requirements & Deliverables

Level 1	Level 2	Level 3
Requirements		
Conduct a Life Cycle Assessment (LCA) and report carbon footprint as the LCA impact measure 'global warming potential' (GWP) in kilograms of carbon dioxide equivalent (CO2e). The LCA report must also identify: • The LCA software that was used to make the calculation • The components of the building that are included in the calculation All suppliers used for the project must comply with the City of Mississauga Supplier Code of Conduct.	**Level 1 +** Conduct a Triple Bottom Line (TBL) Cost Benefit Analysis for the building that looks at the impacts of the building including Financial, Environmental, and Social impacts.	**Levels 1 and 2 +** Offset 100% of all embodied carbon using a one-time purchase of carbon offsets as eligible by the CaGBC ZCB standard.
Deliverables		
• A description of LCA assumptions, scope, and analysis process for baseline building and proposed building, as per LEED NC-v4 MR: Building Life-Cycle Impact Reduction • An LCA report showing outputs of proposed building with percentage change from baseline building for all impact indicators, and highlighting GWP • A narrative addressing specific strategies employed by the project team to reduce carbon footprint • A declaration that all suppliers used for the project must complied with the City of Mississauga Supplier Code of Conduct	**Level 1 +** • TBL Cost Benefit Analysis report	**Level 2 +** • Draft calculation showing target carbon offset threshold, as per LEED NC-v4 EA: Green Power and Carbon Offsets • Purchase contract or letter of commitment from a CaGBC eligible carbon offset program for targeted carbon offset threshold

Guidance for Applicants

Life Cycle Assessment (LCA) is the standardized method used to quantify the environmental impacts of a project, including material extraction, product manufacturing, decommissioning, and disposal. To meet Level 1 of the Green Building Standard, applicants will need to complete an LCA and report on the results. At the same time, all suppliers and subcontractors will need to comply with the City's *Supplier Code of Conduct*. On top of this, meeting Level 2 of the Standard involves completing a TBL Cost Benefit Analysis to quantify and attribute monetary values to the social, environmental, and economic impacts resulting from the project. Finally, to meet Level 3, applicants will need to make a one-time purchase of enough eligible carbon offsets to make the project carbon neutral. There are many software packages available to assist with these tasks, offering a range of prices and features, including openLCA, GabiSoftware, SimaPro, openTBL, and Autocase.

Additional Resources

For helpful resources and examples of how to consider embodied carbon, visit the following links:

- Canada Green Building Council (CaGBC). (2017). *Zero Carbon Building Standard.*
- BC Ministry of the Environment and Climate Change Strategy. (2017). *LEED v4 and Low Carbon Building Materials.*
- City of Mississauga. (2018). *Supplier Code of Conduct.*
- ASTM International. (2016). *ASTM E2921-16a, Standard Practice for Minimum Criteria for Comparing Whole Building Life Cycle Assessments for Use with Building Codes, Standards, and Rating Systems.*
- Green Building Certification Inc. (GBCI). (2017). *Whole building life cycle assessment through LEED v4.*

4.3. Ozone Depleting Compounds

Intent

To reduce stratospheric ozone depletion and limit human health impacts caused by refrigerant emissions.

Background

Harmful refrigerants such as CFCs, HCFCs, and halons have contributed to the degradation of the Earth's stratospheric ozone layer that absorbs most of the sun's ultraviolet radiation. The thinning of the ozone layer contributes to many human health problems, especially skin cancer, and to ecological impacts such as reduced ice and snow cover, altered precipitation, and reduced crop yields. In response, the United Nationals put forward the Montreal Protocol, which was finalized in 1987 and achieved universal ratification amongst member states. The Protocol set forth protections for the ozone layer by phasing out the production of many ozone depleting substances, with a focus on highly-damaging CFCs. Accordingly, the Province of Ontario already restricts CFC-based refrigeration, but green building designers can go a step further implementing more climate friendly alternatives.

Requirements & Deliverables

Level 1	Level 2	Level 3
Requirements		
Calculate and report HVAC&R equipment refrigerant emissions associated with project. The combination of all new and existing building HVAC&R equipment that serves the project must comply with the following formula: LCGWP + LCODP × 10^5 ≤ 13.	**Level 1 +** • Zero HCFCs • Zero halons • Report GWP and ODP as part of the Carbon Footprint requirement	**Levels 1 and 2 +** Zero refrigerants, or only naturally occurring/synthetic refrigerants that have an ozone depletion potential (ODP) of zero and a global warming potential (GWP) of less than 50 are permitted.
Deliverables		
• Draft calculations for LEED NC-v4 EA: Enhanced Refrigerant Management	**Level 1 +** • A declaration that no HCFCs were used on the project • A declaration that no halons were used on the project • An LCA report indicating GWP and ODP	**Same as Levels 1 and 2**

Guidance for Applicants

Meeting Levels 1 through 3 requires applicants to calculate and report the building's refrigerant emissions, with increasing restrictions at each level. For Level 1, applicants will need to assess the ozone depletion potential (ODP) and global warming potential (GWP) of HVAC&R systems prior to the selection of equipment to ensure they can meet the requirements for the given building design. At Level 2, the requirements will shape the selection of HVAC&R systems and equipment but will future proof ongoing building operations for the phase out of HCFCs from the HVAC industry. In this case, applicants might consider system options with lower volumes of refrigerants and/or refrigerants with lower GWP and ODP. Meeting Level 3 will require the strategies from Level 2 and may also some limit mechanical system types or reduce choice of suppliers for systems and equipment. Applicants could benefit from incorporating passive design measures (e.g. thicker building envelopes, higher performance windows) that reduce the need for cooling, with guidance available from Passive House Canada.

Additional Resources

For helpful resources and examples of how to limit ozone depleting compounds, visit the following links:

- Government of Canada. (2013). *Ozone-depleting substances.*
- Province of Ontario. (2010). *Ozone Depleting Substances and Other Halocarbons.*
- United States Environmental Protection Agency (EPA). (2018). *Ozone Layer Protection.*

- Passive House Canada. (2017). *A Developer's Guide to Passive House Buildings.*

5. Transportation Performance Requirements

5.1. Electric Vehicle Infrastructure

Intent
To reduce community-wide GHG emissions by promoting electric vehicle use.

Background
Fossil-fuel based passenger vehicles are a major source of greenhouse gas emissions in Canada and a contributor to global climate change. Electric vehicles (EVs) offer an effective means of replacing traditional vehicles and are growing in popularity with consumers, although they still represent a small portion of vehicles on the road. There are two types of EVs: 1) battery electric vehicles, which run entirely on electricity and 2) plug-in electric vehicles that combine the battery with a gasoline engine. Both types of EVs have lower fuel and maintenance costs than conventional models, produce far less greenhouse gas emissions over the lifetime of the vehicle, produce less air pollution, and are eligible to travel in designated high occupancy vehicle (HOV) lanes. Additionally, there are three types of charging stations (also known as electric vehicle supply equipment or EVSE) to consider: Level 1 is a standard outlet (120 volts) and takes between 8–20 hours to fully charge an EV; Level 2 uses a 240 volt system and can charge an EV from empty in around 4–6 hours; and Level 3 charges approximately eight times faster with a 480 volt system, bringing an EV to 80% in about 30 minutes. By promoting the installation of electric vehicle supply equipment, the City of Mississauga can help encourage residents to make the switch to EVs.

Requirements & Deliverables

Level 1	Level 2	Level 3
Requirements		
Design the building to provide 20% of parking spaces with electric vehicle supply equipment (EVSE) of Level 2 or higher. The remaining parking spaces must be designed to permit future EVSE installation (i.e. EV-ready). Include at least two regular electrical outlets for electric bicycle charging in bike storage area(s).	Design the building to provide 25% of parking spaces with electric vehicle supply equipment (EVSE) of Level 2 or higher. The remaining parking spaces must be designed to permit future EVSE installation (i.e. EV-ready). Include at least two regular electrical outlets for electric bicycle charging in bike storage area(s).	Design the building to provide 30% of parking spaces with electric vehicle supply equipment (EVSE) of Level 2 or higher. The remaining parking spaces must be designed to permit future EVSE installation (i.e. EV-ready). Include one regular electrical outlet for every four bike spaces for electric bicycle charging in bike storage area(s).
Deliverables		
• Project parking statistics including number of current and future EVSE spaces • Parking or site plan notations indicating location of current and future EVSE spaces • Photos of EVSE signage or pavement markings • Site plan notations indicating location of outlets for electric bicycles	Same as Level 1	Same as Levels 1 and 2

Guidance for Applicants

At all levels of the Green Building Standard, applicants will need to begin by determining the total vehicle parking capacity of their project. Next, they will need to calculate how many EV parking spaces are required, based on the targeted level of achievement, and incorporate these spaces into the design. At this stage, it is beneficial to distribute EVSE spaces proportionately between long-term and short-term parking sections. Applicants will then need to estimate and account for necessary sizing of electrical loads and transformer capacity, depending on the levels of EVSE they plan to incorporate, taking care to ensure that selected equipment and installation complies with the Ontario Electrical Safety Code and Electrical Safety Authority. Note that where capacity can be shared between spaces (e.g. by using a Level 2 charging station with multiple plugs), the cost and complexity of EV charging infrastructure can be greatly reduced. Finally, applicants will need to install clear and permanent signage and/or pavement markings to reserve these spaces for EVs. Considering parking design and programming early in the design process can help avoid complications and ensure that the project meets the Standard's EV infrastructure requirements.

Additional Resources

For more information on implementing EV infrastructure, visit the following links:

- Ontario Ministry of Transportation. (2018). *About electric and hydrogen vehicles.*
- Ontario Electrical Safety Authority. (2019). *Electrical Vehicle Charging Systems.*
- City of Toronto. (2019). *Electric Vehicles.*
- City of Vancouver. (2019). *Electric vehicles.*

5.2. Bicycle Infrastructure

Intent
To reduce community reliance on vehicles, lessen traffic congestion, and improve public health by promoting bicycles as a reliable mode of transportation.

Background
Bicycling offers benefits for individuals, communities, and the planet. It can be used for recreation, fitness, and daily transportation, offering health benefits and reducing traffic at the same time. In addition, every kilometre that is cycled instead of driven means fewer greenhouse gas emissions sent into the atmosphere. With its *Cycling Master Plan*, the City of Mississauga recognizes these benefits and envisions cycling as a way of life for its citizens. The Corporate Green Building Standard works to further these goals by promoting cycling infrastructure that can improve transportation network efficiency and convenience for all types of riders.

Requirements & Deliverables

Level 1	Level 2	Level 3
Requirements		
Short-term bicycle parking for 5% of all peak visitors and/or 10% of occupants, no fewer than 8 spaces per building. Provide one (1) on-site shower with changing facility for the first 100 regular occupants and 1 additional shower for every 150 regular occupants thereafter.	Short-term bicycle parking for 7% of all peak visitors and/or 15% of occupants, no fewer than 8 spaces per building. Provide one (1) on-site shower with changing facility for the first 100 regular occupants and 1 additional shower for every 150 regular occupants thereafter.	Short-term bicycle storage for 10% of all peak visitors and/or 20% occupants, no fewer than 12 storage spaces per building. Provide one (1) on-site shower with changing facility for the first 100 regular occupants and 1 additional shower for every 150 regular occupants thereafter. Provide public bicycle repair station at-grade with tools including tire levers, screwdrivers and spanners.
Deliverables		
• Project statistics including number and type of bicycle parking spaces per building • Site plan notations indicating location, number, and type of bicycle parking spaces per building • Site plan notations indicating location and number of shower and change facilities	Same as Level 1	**Levels 1 and 2 +** • Site plan notations indicating location and type of bicycle maintenance facilities

Guidance for Applicants
Meeting Levels 1 through 3 will require applicants provide increasing access to bicycle parking and facilities (e.g. changing rooms, showers, maintenance stations). Short-term bike parking stations may be constructed using canopy cover only, reducing the potential cost. However, bike parking should follow safety and accessibility standards as per the City of Mississauga Cycling Master Plan. Short-term bicycle parking should be located in a highly visible and publicly accessible location at-grade or on the first parking level of the building below grade. At Level 3, applicants are required to include a bike repair station, but may also wish to consider additional bike station programming such as a bike café.

Additional Resources
For more suggestions on creating a bike-friendly building, visit the following links:

- City of Mississauga. (2010). *Mississauga Cycling Master Plan.*
- City of Toronto. (2008). Guidelines for the Design and Management of Bicycle Parking Facilities.
- City of Vancouver. (2011). *Bicycle Parking Strategy.*
- HUB Cycling. (2016). *Not Just Bike Racks - Informing Design for End of Trip Cycling Amenities in Vancouver Real Estate.*

6. Waste Management Performance Requirements

Intent
To reduce the amount of construction and demolition waste that is sent to landfills or incinerated by promoting good waste management practices.

Background
Construction and demolition waste represent a sizable portion of the waste produced in the world, with much of it (e.g. wood, glass, plastics, and metals) being recyclable. By ensuring that these products are properly diverted instead of sent to the landfill or incinerator, green building design can prevent pollution, promote reuse and recycling, and keep valuable materials in active use longer. Planning for construction waste management early in the process allows time to identify components for reuse on site and coordinate with local handlers for different material streams. A well-designed and well-executed construction waste management plan can also decrease tipping fees and generate income by selling valuable scrap materials.

Requirements & Deliverables

Level 1	Level 2	Level 3
Requirements		
A minimum diversion rate of 75% of the total construction and demolition material must be achieved. Diverted materials must include at least three material streams, e.g. metals, concrete, drywall, wood, plastics, etc.	A minimum diversion rate of 90% of the total construction and demolition material must be achieved. Diverted materials must include at least three or four material streams, e.g. metals, concrete, drywall, wood, plastics, etc.	**Level 2 +** Minimum diversion rates must be achieved as follows: • Metals 99% • Paper and cardboard 99% • Soil and biomass 100% • Rigid foam, carpet, and insulation 95% • All others – combined weighted average 90%
Deliverables		
• Construction and demolition waste management plan • Construction and demolition waste declaration to be provided post construction	Same as Level 1	Same as Levels 1 and 2

Guidance for Applicants
Meeting Levels 1 through 3 will require increasing diversion rates of construction and demolition materials. While demolition waste from existing infrastructure does not need to meet the diversion rate requirements, a concerted effort to divert as much as possible is expected. Applicants will need to plan, manage, and track their construction materials, taking care not to over-order, and reach out to local waste receivers to coordinate their diversion needs. Once the building is constructed and operational, applicants can reinforce good waste management practices by implementing on-site waste sorting systems, organics collection and composting, and battery and electronics collection for occupants with distribution to appropriate handlers. Designers can help facilitate this by providing ample storage in the building for waste collection and storage, including space for bulky items. The continued sorting and diversion of multiple materials streams can help ensure that the building is green in practice as well as principle.

Additional Resources
For further guidance and examples on waste management practices, visit the following links:

- Region of Peel. (2019). *How to Sort Your Waste.*
- City of Toronto. (2019). *Long Term Waste Management Strategy.*
- Metro Vancouver. (2010). *Integrated Solid Waste and Resource Management.*
- Province of Manitoba. (2017). *Construction, Renovation and Demolition Waste Management Guideline.*

7. Water Performance Requirements

7.1. Stormwater Management

Intent
To reduce stormwater peak flow and runoff volume from the site by promoting the natural hydrological cycle.

Background
Urban development disrupts the natural hydrological cycle by compacting soil, removing vegetation, increasing impermeable surface area, and interrupting natural drainage. For most properties in Mississauga, this means that rain and melted snow is transported from the site as quickly as possible, through a complex network of pipes and directly into Lake Ontario. The City's population is growing, hard surface areas are increasing, and frequent and severe weather events are depositing more water than ever, so scaling up municipal infrastructure to match would be time-intensive and costly. Alternatively, designers can introduce green infrastructure and low-impact development strategies to recreate the site's natural hydrology. Such measures might include: minimizing the amount of area disturbed, limiting hardscaping, and implementing stormwater management tools like bioswales and green roofs. Introducing vegetated surface area through these steps has the added benefit of reducing the urban heat island effect.

Requirements & Deliverables

Level 1	Level 2	Level 3
Requirements		
Peak Flow Reduction: Achieve 85% reduction of the 100-year post-development flow to pre-development conditions of the site. Runoff Volume Reduction: Retain 80% runoff generated from a minimum of 15 mm depth of a single rainfall event from all site surfaces through infiltration, evapotranspiration, water harvesting and reuse.	Peak Flow Reduction: Achieve 100% reduction of the 100-year post-development flow to pre-development conditions of the site. Runoff Volume Reduction: Retain 100% runoff generated from a minimum of 15 mm depth of rainfall from all site surfaces through infiltration, evapotranspiration, water harvesting and reuse.	**Level 2 +** Incorporate green roof for the remaining roof area (excluding HVAC equipment, service pathways, and rooftop PV).
Deliverables		
• A stormwater management report including rainfall data and volume calculations • Stormwater management plans, details, or cross-sections consistent with report and including topography, landscaping, grading, etc. • A stormwater runoff declaration to be provided post construction	Same as Level 1	**Levels 1 and 2 +** • Site plan notations showing green roof details, including coverage area calculations

Guidance for Applicants
To meet the Green Building Standard, applicants will start by obtaining historic rainfall data for the project location. Ideally, this will comprise at least ten years of data collected from a consistent source such as the local airport, nearby universities, or water treatment plants. Next, the project team will need to calculate the runoff volume to be managed on site, which depends on post-development site conditions including the amount of paving, permeability of surfaces, roof area, and amount of vegetation. At this stage, the project's civil engineer or landscape architect can propose a combination of green infrastructure and low-impact development strategies to replicate the site's natural hydrological cycle and reduce the overall peak flow and runoff volume. Some examples include bioswales and rain gardens, which can be easy to implement at projects with generous green space and minimized hard surfacing. For a zero-lot lined project, where the building footprint reaches the site limits, or for heavily hardscaped areas, it may be more appropriate to incorporate rainwater collection, storage, filtration, and reuse systems. In either case, applicants

might also consider implementing infiltration planters, porous pavement, and/or a green roof, with the latter being mandatory for Level 3. It should be noted that the selected features will require regular maintenance to keep plants healthy and water flowing properly.

Additional Resources

For further guidance and examples of stormwater management techniques, visit the following links:

- City of Mississauga. (2016). *Stormwater Charge.*
- City of Toronto. (2019). *Stormwater Management Programs and Projects.*
- City of Vancouver. (2016). *Citywide Integrated Rainwater Management Plan.*
- International Living Future Institute (ILFI). (2019). *Living Building Challenge - Water Petal Intent.*

7.2. Water Use Intensity

Intent

To conserve potable water by reducing water used inside the building and for irrigation.

Background

On a global scale, clean drinking water is threatened by pollution, the impacts of climate change, and unsustainable water use patterns. Even with Canada's abundant water resources, we are witnessing continued drawdown of aquifers and lowered reservoir levels, issues that are only exacerbated by our steady population growth. The use of potable water for purposes other than drinking, such as showering and irrigation, represents a significant amount of our clean water consumption. By managing water use intensity both inside and outside buildings, the Mississauga Green Building Standard works to conserve this most precious resource.

Requirements & Deliverables

Level 1	Level 2	Level 3
Requirements		
Achieve at least a 20% reduction in potable water consumption for the building (not including irrigation) over the baseline. Achieve at least a 60% reduction in in all outdoor potable water consumption (irrigation). Where potable water is used for irrigation, provide native, drought-tolerant plants for at least 50% of the landscaped site area (including at-grade landscapes, green roofs and walls).	Achieve at least a 40% reduction in potable water consumption for the building (not including irrigation) over the baseline. Achieve a 100% reduction in in all outdoor potable water consumption (irrigation). Provide native, drought-tolerant plants for at least 60% of the landscaped site area (including at-grade landscapes, green roofs and walls).	Achieve at least a 60% reduction in potable water consumption for the building (not including irrigation) over the baseline. Achieve a 100% reduction in indoor non-potable water consumption (toilets). Achieve a 100% reduction in in all outdoor potable water consumption (irrigation). Provide native, drought-tolerant plants for 100% of the landscaped site area (including at-grade landscapes, green roofs and walls).
Deliverables		
• Water efficiency declaration to be provided post construction • Landscaping plan showing vegetated areas and potable or non-potable irrigation system • Plant list including common and scientific names, highlighting native, drought-tolerant species	Same as Level 1	**Levels 1 and 2 +** • Record that the Province has been lobbied to allow for the capture and recycling of rainwater and wastewater for use in toilets

Guidance for Applicants

Meeting each level of the Standard requires applicants to achieve increasingly ambitious targets for water use reduction. Inside buildings, applicants can lower consumption by incorporating efficient plumbing fittings, including faucets, toilets, sinks, and showerheads. Outside, applicants can reduce potable water used for landscaping by selecting plants that are native, well-adapted, and drought tolerant (i.e. xeriscaping). It may be appropriate to involve a horticulturalist or landscape architect to assist with plant selection, as future climate shifts could change what plants are best-suited to the site. At all levels, comprehensive water metering can help the project team to track water consumption and identify areas that may need improvement.

The capture and recycling of rainwater and wastewater for use in toilets and for irrigation can also help buildings to meet water use reduction targets, but this is not currently allowed in Mississauga. Those applicants wishing to pursue the ILFI's Living Building Challenge can achieve alternative credits for the Water Petal by demonstrating that they have lobbied the Province to revise these restrictions.

Additional Resources

For helpful resources and examples of how to reduce water use, visit the following links:

- City of Toronto. (2019). *Water Efficient Landscaping.*
- Halton Region. (2019). *Plant Selection & Design.*
- International Living Future Institute (ILFI). (2019). *Living Building Challenge - Water Petal Intent.*

8. Natural Heritage Performance Requirements

8.1. Erosion and Sediment Control

Intent

To reduce erosion and sediment control resulting from construction activities and changes to the site.

Background

Changes to the land resulting from urban development can decrease soil permeability and increase erosion. When trees and plants are removed and replaced with hard surfaces, natural drainage pathways are altered and stabilizing topsoil is stripped away, increasing water runoff and introducing harmful sediments, oils, chemicals, and fertilizers into downstream watercourses. These changes can lead to more severe and frequent flood events, habitat disruption and biodiversity loss. Construction activities are a major contributor of added sediment into watercourses, with much of this being avoidable.

Requirements & Deliverables

Level 1	Level 2	Level 3
Requirements		
Follow the Erosion and Sediment Control Guideline for Urban Construction during construction and demolition activities.	Follow the Erosion and Sediment Control Guideline for Urban Construction during construction and demolition activities. Remove 80% of total suspended solids (TSS) on an annual loading basis from all runoff leaving the site based on the post-development level of imperviousness.	N/A
Deliverables		
Notations on plans and drawings • Description of compliance with the Erosion and Sediment Control Guideline for Urban Construction • Erosion and sediment control plan • Site plan notations indicating erosion and sediment control measures implemented	**Level 1 +** • Stormwater runoff declaration to be provided post construction	N/A

Guidance for Applicants

The first step in meeting the Standard is to designate a party to initiate erosion and sediment control design well before construction begins. This role often falls to the civil engineer, but could also be fulfilled by the landscape architect, project hydrologist, or general contractor. This party will then review the *Erosion and Sediment Control Guideline for Urban Construction* before evaluating the site for its specific control needs. Construction projects vary greatly in type, size, and complexity, but some general points of consideration include: slope; total ground are that will be disturbed and for how long; neighbouring properties; existing stormwater management systems that need to be protected; project sequencing and phasing; construction entrances and equipment to be used; and local weather conditions. With this information, the responsible party will craft an appropriate erosion and sediment control plan to be followed throughout the project. At this stage, responsibility will likely transfer to the general contractor or builder, who will implement site-level erosion and sediment control measures (e.g. silt fences, protections for storm drains) to remove sediment for the runoff leaving the site. Throughout construction, the project team will need to monitor control measures and record their integrity through date-stamped photographs and field reports, resolving any issues in a timely manner.

Additional Resources

For more information about erosion and sediment control, visit the following links:

- Greater Golden Horseshoe Area (GGHA) Conservation Authorities. (2006). *Erosion and Sediment Control Guideline.*

- Erosion and Sediment Control Association of British Columbia (ESCA BC). (2019). *ESC Best Management Practices.*

8.2. Light Pollution

Intent
To reduce the negative impacts that a building's lighting can have while accentuating the benefits.

Background
Light pollution is misused light caused by glare, light trespass, over lighting, and sky glow. It generally results from exterior lighting designs that are inappropriate for the site context. While proper lighting is important for human safety and convenience, light pollution creates numerous environmental problems. It can interrupt wildlife species that hunt or forage at night and disrupt the movement patterns of others (e.g. migratory birds and bats). Misdirected light can also impact human health, with implications for our night vision, circadian rhythms, melatonin production, and sleep patterns. In addition, light pollution into areas that do not need illuminating is a waste of both energy and money.

Requirements & Deliverables

Level 1	Level 2	Level 3
Requirements		
All exterior fixtures must be Dark Sky compliant, as per the International Dark-Sky Association (IDA). Any rooftop and facade architectural illumination must be directed downward and turned off after facility operating hours. Install an automatic device that reduces the outward spillage of internal light by: a) Reducing the input power to non-emergency lighting fixtures by at least 50 per cent outside of facility operating hours. OR b) Shielding all non-emergency light fixtures outside of facility operating hours.	**Level 1 +** Ensure that any lighting not physically attached to the building is connected to solar PV as a primary source of power.	N/A
Deliverables		
• A lighting list highlighting Dark Sky compliant fixtures • A lighting plan showing boundaries, location of fixtures, and lighting control measures • A lighting controls declaration to be provided post construction	**Level 1 +** • Lighting plan showing solar PV connections	N/A

Guidance for Applicants
To meet the Standard, applicants will first need to establish their project goals for exterior lighting. This draft lighting plan will identify areas that need to be illuminated and to what level, along with the light boundary for the project (i.e. those portions on and off the site where illumination should be avoided). With these details in hand, the project team can populate the lighting plan with a fixture and luminaire schedule, making use of technologies designed to reduce light pollution (e.g. full cut-off luminaires, low-reflectance surfaces, low-angle spotlights) and lights that have been tested with the backlight-uplight-glare (BUG) method, both of which are becoming increasingly available. Once the lighting plan is established, the project team will want to consider each fixture for light trespass, glare, overlighting, and sky glow, making refinements as needed. To further reduce light pollution, applicants might also benefit from the use of motion sensor lighting as a means of addressing security concerns, and from lowering the colour temperature of lighting from cool (above 4000 Kelvin degrees) to warm (below 3000K) consistently across all areas. It should also be noted that, while implementing solar PV to meet the requirements of Level 2 may sound costly, the installation of solar lights can eliminate the need for extensive trenching and utility connections, moderating cost premiums when compared to traditional outdoor lights and potentially saving money over time.

Additional Resources
For helpful examples of how to reduce light pollution, visit the following links:

- City of Mississauga. (2013). *Nuisance Lighting By-law 262-12.*
- US Green Building Council. (2019). *BUG rating method.*
- City of Toronto. (2017). *Best Practices for Effective Lighting.*
- International Dark-Sky Association (IDA). (2019). *Outdoor Lighting Basics.*

8.3. Biodiversity

Intent

To conserve biodiversity by promoting planting while avoiding invasive species, in addition to protecting local bird species.

Background

Biodiversity generally refers to the variety and variability of life. It accounts for the interconnectedness of all living things and the way they interact with each other and their environment. Human beings depend on biodiversity for all aspects of our lives, from clean air and water to food and building materials. We also benefit from ecosystem services such as nutrient recycling, pollination, carbon sequestration, and reduction of the heat island effect provided by shade trees and planted areas. However, Earth's growing population is threatening biodiversity at an increasing rate, through pollution, climate change, habitat change, the introduction of invasive species, and unsustainable use of resources. To help mitigate the harmful contribution of conventional development, green buildings can consider and promote biodiversity in their designs.

Requirements & Deliverables

Level 1	Level 2	Level 3
Requirements – Planting		
Provide trees planted in both softscape and hardscape with a minimum soil volume of 15 m^3, 30 m^3, 45 m^3 for small, medium and large-sized trees, respectively. Plant 'shade trees' approximately 6-8 m (20- 27 ft) apart along all street frontages, open space frontages and public walkways, and 8-10m apart for all street frontages, open space frontages and public walkways.	Same as Level 1	Same as Levels 1 and 2
Deliverables – Planting		
• Landscaping plan indicating soil volume, species, and quantity for each planting area	Same as Level 1	Same as Levels 1 and 2
Requirements – Native species		
Provide pollinator-friendly species for at least 10% of the landscaped site area. Ensure that 25% of all proposed plantings are native species. Avoid the use of all invasive species in landscape design as per the Ontario Invasive Plant Council guidelines.	Provide pollinator-friendly species for at least 25% of the landscaped site area. Ensure that 50% of all proposed plantings are native species. Avoid the use of all invasive species in landscape design as per the Ontario Invasive Plant Council guidelines.	Provide pollinator-friendly species for at least 50% of the landscaped site area. Ensure that 100% of all proposed plantings are native species. Avoid the use of all invasive species in landscape design as per the Ontario Invasive Plant Council guidelines.
Deliverables – Native species		
• Plant list including common and scientific names, highlighting native and pollinator-friendly species • Description of compliance with the Ontario Invasive Plant Council guidelines	Same as Level 1	Same as Levels 1 and 2
Requirements – Bird friendly development		

Consult the City of Toronto's Bird Friendly Development Guidelines and provide a summary report demonstrating that the proposed project has considered bird safety.	Level 1 + Treat glass on buildings with a density pattern between 10-28 cm (4 to 11 in) apart for a minimum of the first 10 to 12 m (33-40 ft) above grade. **OR** Mute reflections for a minimum of the first 10-12 m (33-40 ft) portion of a building above grade. Where a green roof is constructed adjacent to glass surfaces, ensure that the glass is treated to a height of at least 12 m (40 ft) above the level of the green roof, to prevent potentially fatal collisions with windows. Where exhaust/ventilation grates cannot be avoided at ground level, design the grates to have a porosity of less than 2 centimetres x 2 centimetres (1inches x 1inches).	Same as Level 2
Deliverables – Bird friendly development		
• Narrative describing the project's consideration of bird safety	Level 1 + • Site plan notations showing treated area required, type of treatment, and density/colour of visual markers • Summary table of bird friendly glass treatments for each elevation • Site plan notations highlighting bird friendly grates, where applicable	Same as Level 2

Guidance for Applicants

Meeting Levels 1 through 3 of the Mississauga Green Building Standard will require applicants to incorporate increased planting into landscape designs, with a focus on increasing amounts of native and pollinator-friendly species. In addition, applicants will need to demonstrate what steps their project takes to reduce the building's harmful effect on birds, ranging from a short summary report for Level 1 to prescribed glazing and grates of a minimum size for Levels 2 and 3.

Additional Resources

For helpful guidance on using green buildings to promote biodiversity, visit the following links:

- City of Toronto. (2010). *Toronto Street Trees: Guide to Standard Planting Options.*
- City of Vancouver. (2011). *Street Tree Guidelines for the Public Realm.*
- Ontario Biodiversity Council. (2011). *Ontario's Biodiversity Strategy.*
- City of Mississauga. (2011). *Green Development Strategy.*
- Ontario Invasive Plant Council. (2019). *Invasive Plants.*
- City of Toronto. (2007). *Bird-friendly Development Guidelines.*

9. APPENDIX A: Integrating the CGB Standard into Procurement

When procuring municipal projects, the City of Mississauga traditionally employs either a Design-Bid-Build approach or a Design-Build approach, as appropriate. These processes are outlined in Figure 2 and Figure 3 below, including considerations for complying with the CGB Standard.

Figure 2: Design-Bid-Build Approach with Mississauga CGB Standard Key Steps and Roles

- Note that highlights made in green draw attention to new additions from the CGB Standard

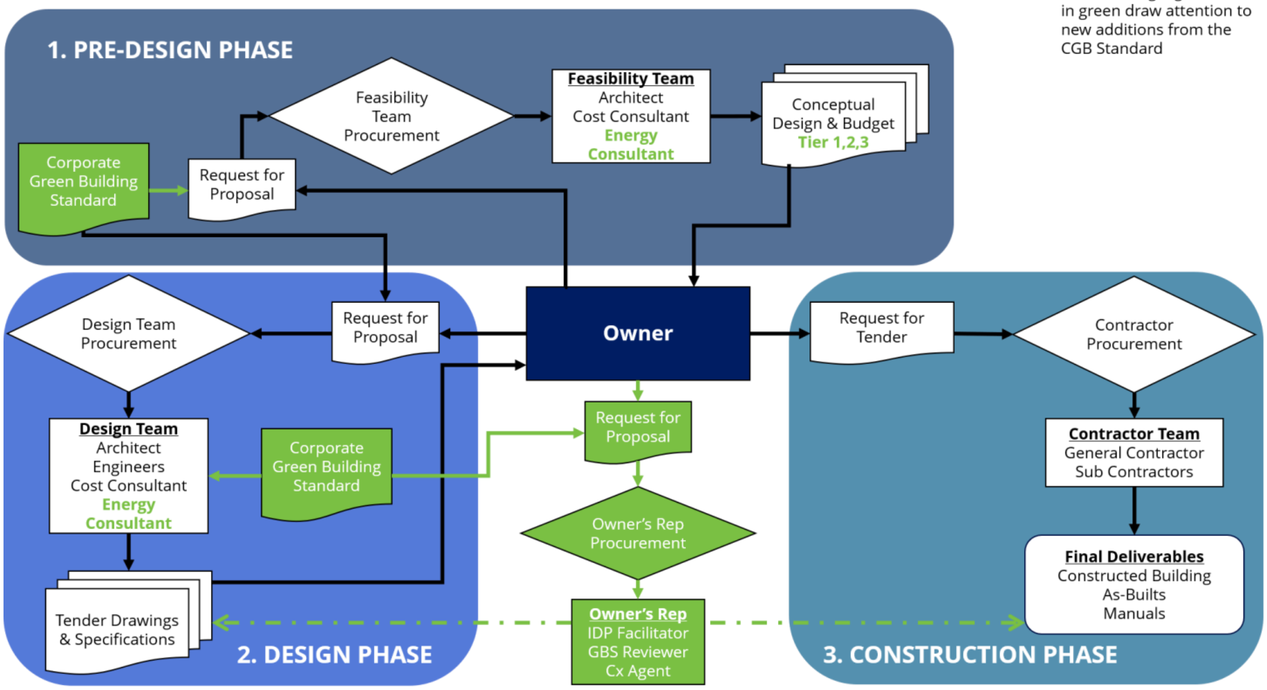
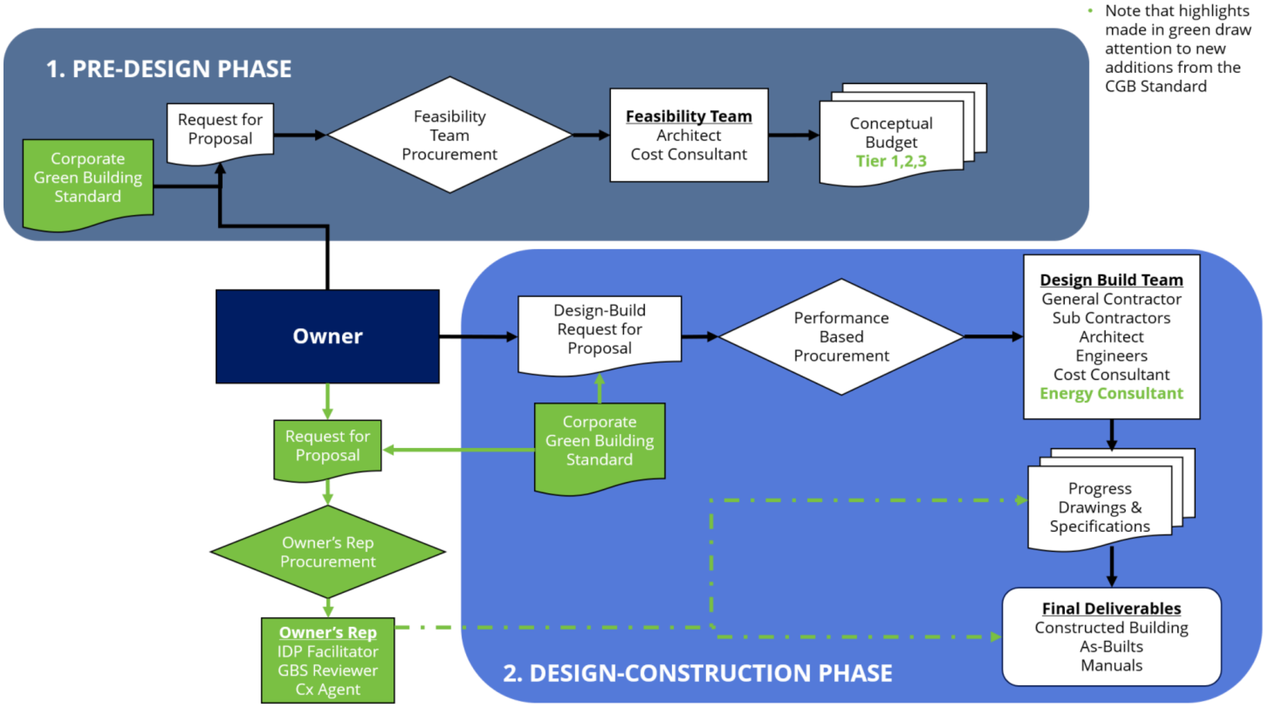


Figure 3: Design-Build Approach with Mississauga CGB Standard Key Steps and Roles

- Note that highlights made in green draw attention to new additions from the CGB Standard



9.1. Using an Integrated Design Process (IDP)

Achieving high environmental performance for minimized added cost can be greatly facilitated thought the use of an integrated design process (IDP). IDP is a highly collaborative approach to building design that brings together all stakeholders who will be involved in various aspects of a building right from the start of the project. Under IDP, a comprehensive, integrative process is used to explore interactions between building and site systems through iterative cycle of analysis, charrettes, implementation, and performance evaluation.

9.2. How is IDP different from conventional design practices?

Conventional design proceeds in a linear manner with professional often making decisions without speaking to the other parties involved. Typically, an architect will decide what the building looks like, an engineer decides what the systems will be, and then a general contractor constructs the building, with operations then handed over to a separate party once construction is complete. Any changes to the design can impose heavy costs or scheduling setbacks.

In IDP, a building is approached holistically. At the outset of the project, the building's stakeholders form an interdisciplinary team that explores, tests, and evaluates design strategies to find those with the greatest potential. Through the process, members of the team actively communicate and offer differing viewpoints, looking for synergies and trade-offs in the preliminary stages of building design. For example, minimizing the windows on the side of a building might reduce the scale of heating, ventilation, and air conditioning (HVAC) equipment required, which could free up funds for other aspects of the project. Working separately, it is unlikely that the professionals would have identified these synergies.

The costs of employing an IDP are frontloaded but can more than offset the cost of requiring it. While a project team may spend more time in the design stage of a project, the identified synergies can result in:

- Lower initial capital costs;
- Fewer change orders;
- Fewer delays in construction; and
- Reduced long term operating costs

9.3. Who should be involved?

The owner and project consultant appoint team members to represent the range of specialities, disciplines and interest involved in a building project. Team members often include:

- Owners and/or the owner's representative
- Architects
- Construction managers
- Civil engineers
- Landscape architects
- Mechanical and electrical engineers
- Specialized consultants (acoustics, lighting, ecology)
- Building commissioning professionals
- Building occupant representatives
- Building maintenance and operation representatives
- IDP facilitators

9.4. Key Steps

The following steps represent the key components in the IDP process that should be taken:

1. **Formulate project goals and expectations.** Early in the process, the owner (and/or CGB Standard Representative), and project consultant identify measurable goals and expectations for the building. They then summarize the outcomes in an Owner's Project Requirements (OPR) document that the project team can reference throughout the build. At this point, the owner can also appoint an IDP facilitator to act on their behalf.

2. **Bring together an interdisciplinary project team.** Next, the owner (or IDP facilitator) and project consultant assemble a team of stakeholders from different professions (e.g. architect, civil engineer, acoustical engineer, future occupant), aiming to achieve broad representation. The makeup of the team will depend on owner's project expectations and site-specific conditions. If possible, it is beneficial to include a representative for the builder who can speak to construction costs and timelines early on. The team then holds an integrative design charrette, aiming to align stakeholders on: the OPR, budget, schedule, scope, quality and performance expectations, and occupant expectations. This is also an appropriate time to discuss risks, risk tolerance, and risk management strategies for the project.

3. **Consult the interdisciplinary project team at key stages throughout the project.** Once the team is assembled and all parties have completed their initial research, the IDP facilitator convenes an integrative design charrette, aiming to align stakeholders on: the purpose of the project, OPR, budget, schedule, scope, quality and performance expectations, and occupant expectations. This is also an appropriate time to discuss risks, risk tolerance, and risk management strategies for the project. After the initial meeting, the IDP facilitator can hold additional charrettes with the entire team or select members at key points (e.g. pre-design, schematic design, design development, tendering/awarding, substantial completion, post occupancy).

4. **Apprize owner of progress and achievements at key stages of the project.** The IDP facilitator report to the project owner at key points of the project, highlighting significant decisions made by the team and keeping the owner appraised of implications for the OPR, budget, and timeline. The Integrative Design Process can continue well into the building's occupation and operation to ensure that the original goals are still being met.

9.5. Using this Guide with an IDP Approach

In contrast to Figure 1, Figure 4 below shows the key steps involved in applying for the CGB Standard with an Integrated Design Process approach. Notably, many responsibilities that would otherwise be assigned to the owner/applicant become IDP activities, or are made more robust, such as the initial project visioning session.

Figure 4: Complying with the Mississauga CGB Standard using an IDP Approach

PROJECT PHASES	OWNER/ APPLICANT	INTEGRATED DESIGN PROCESS ACTIVITIES	OWNER'S CGB REPRESENTATIVE	CITY OF MISSISSAUGA
PRE-DESIGN	• Review Owner's Project Requirements (OPR) • Review CGB Standard and identify level of to be targeted in each performance area • Identify any relevant rebates or incentives	• Initial project visioning session • Programming meeting with whole team (may include an IDP facilitator)	• Act as IDP facilitator	• Review initial levels of performance targeted • Identify any relevant rebates or incentives
DESIGN	• Finalize each level of performance to be achieved • Issue drawings and specifications • Prepare and submit compliance documents to City staff	• Host design charette(s) with whole team at key design intervals • Identify synergies and cost efficiencies • Hold focused meetings for specific issues as needed	• Lead design charettes	• Receive and review all documentation • Submit documentation to specialized City staff for additional review as required • Liaise with applicant on questions
CONSTRUCTION	• Collect necessary information for compliance documents	• Host CGB Standard information session for contractor and trades • Hold debriefing session to share lessons learned	• Lead CGB Standard information session for contractor and trades • Lead debriefing session to share lessons learned	
SUBSTANTIAL PERFORMANCE/ OCCUPANCY	• Perform and submit Cx and airtightness testing documents • Prepare and submit any final compliance documents (e.g. receipts, declarations)	• Set up Building Performance Evaluation		• Receive and review all documentation • Retain copies of contracts, commissioning forms, agreements, and warranties
WARRANTY PERIOD	• Address any performance/CGB Standard deficiencies		• Conduct monitoring-based Cx • Identify performance/CGB Standard deficiencies • Hold education sessions for staff and occupants	

9.6. Useful Resources

For further information about taking an integrated design approach, visit the following links:

- American National Standards Institute (ANSI). (2012). *Integrative Process (IP) ANSI Consensus Guide 2.0 for Design and Construction of Sustainable Buildings and Communities.*
- Public Services and Procurement Canada (PSPC). (2018). *Integrated Design Process.*
- BC Green Building Roundtable. (2007). *Roadmap for the Integrated Design Process.*
- Canada Mortgage and Housing Corporation (CMHC). (2004). *Integrated Design Process Guide.*

10. APPENDIX B: Energy Modelling Guidelines

This document is intended to provide clarity on energy modelling inputs for the purposes of showing compliance with the Corporate Green Building Standard ("the Standard"). This document is not intended to be an exhaustive set of technical and administrative requirements for energy modelling. Rather, it aims to dictate and/or clarify inputs to ensure that building performance, as shown in the energy models, is equitably rewarded across projects. It is also the hope that these guidelines facilitate closer agreement between energy models and actual operating performance of buildings and therefore, may be updated from time to time.

In general, this document dictates energy modelling inputs that may have a large impact on the Standard's performance targets but are not integral to building system performance (ex. Schedules) as well as clarifies inputs where current industry practice for those inputs does not support the Standard's intended outcomes (ex. Not properly accounting for total envelope heat loss).

Design related modelling inputs not specified in this document shall represent, to an appropriate degree of accuracy, the design of the facility. Software limitations shall not limit the accuracy of energy modelling to show compliance with the Standard; consultants are expected to overcome any software limitations with appropriate engineering calculations. All other modelling inputs not discussed in these guidelines shall be based on accepted industry practice.

Where elements of the design may vary from the assumptions outlined in the Energy Modelling Guidelines, these will be brought to the attention of the City of Mississauga's project manager, and a variance in targets or compliance demonstration methodology may be considered on a case by case basis.

10.1. Definitions

Modelled Floor Area – The total floor area of the building, as reported by the energy simulation software, and generally to within 5-10% of the gross floor area from the architectural drawings. The floor area specifically excludes any exterior spaces and parkades, but includes partially conditioned spaces such as apparatus bays in fire halls.

Energy Use Intensity (EUI) – The sum of **all** energy utilities (i.e. Electricity, natural gas, district heating) used on site by the project, divided by the *Modelled Floor Area*. EUI shall be reported in kWh/m^2/year.

$$EUI\ \left[\frac{kWh}{m^2 a}\right] = \frac{\sum Site\ Energy\ Use\ \left[\frac{kWh}{a}\right] - \sum Site\ Renewable\ Energy\ Generation\ \left[\frac{kWh}{a}\right]}{Modelled\ Floor\ Area\ [m^2]}$$

Site Energy Use – All energy used on site including all end-uses, such as heating, cooling, fans, pumps, elevators, parkade lighting and fans, and exterior lighting, among others. It incorporates all site efficiencies, including the use of heat pumps or re-use of waste heat. It does not include energy generated on site.

Site Renewable Energy Generation – Energy generated on site from renewable sources, such as solar photovoltaics, wind, and solar thermal. Where a site is not able to send energy off-site (e.g. connected to the electricity grid), only energy that can be consumed (or stored and then consumed) on site shall be counted as Site Renewable Energy Generation.

Greenhouse Gas Intensity (GHGI) – The **total** greenhouse gas emissions associated with the use of **all** energy utilities on site, according the following factors extracted from SB-10:

Natural Gas: 183 g/kWh
Electricity: 50 g/kWh

District Energy: As provided by utility[7],[8]
Purchased Renewable Energy: 0 g/kWh[9]

GHGI shall be reported in kg eCO_2/m^2/year.

Thermal Energy Demand Intensity (TEDI) – 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 (ex. make-up air units, air handling units, etc.), terminal equipment (ex. 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. For example, hot water or DX heating sources that are derived from a waste heat source or a renewable energy source do not contribute to a reduction in TEDI, as per the above definition.

Specific examples of heating energy that are not for space conditioning and ventilation, that would not be included in the TEDI, include domestic hot water, maintaining swimming pool water temperatures, outdoor comfort heating (ex. Patio heaters), gas fired appliances (stoves, dryers), heat tracing, etc.

TEDI shall be reported in kWh/m^2/year.

Clear Field – An opaque wall or roof assembly with uniformly distributed thermal bridges, which are not practical to account for on an individual basis for U-value calculations. Examples of thermal bridging included in the Clear Field are brick ties, girts supporting cladding, and structural studs. The heat loss associated with a Clear Field assembly is represented by a U-value (heat loss per unit area).

Interface Details - Thermal bridging related to the details at the intersection of building envelope assemblies and/or structural components. Interface details interrupt the uniformity of a clear field assembly and the additional heat loss associated with interface details can be accounted for by linear and point thermal transmittances (heat loss per unit length or heat loss per occurrence).

10.2. Acceptable Energy Modelling Software

The simulation program shall meet the requirements as set out in ASHRAE 90.1-2010, G2.2.

10.3. Weather File

Projects shall use the Pearson International Airport CWEC 2016 Weather File, available from http://climate.onebuilding.org/

10.4. Unmet Hours

Annual unmet hours for any zone in the energy simulation shall be limited to 100 hours or less, with the following exception: annual cooling unmet hours are allowed, provided that it the cooling capacity has been purposely undersized according to the design intent. Unmet heating or cooling hours does not apply to zones with no heating or cooling equipment.

[7] The emissions factor of a district energy system shall be as provided by the utility (and as agreed by the utility and the AHJ).
[8] Where a district energy utility agrees to provide a development with energy at a carbon intensity that varies from that of the overall system, documentation of that agreement (or intent to enter an agreement), and any other measures or agreements required to secure the supply of low-carbon energy, shall be provided to the authority having jurisdiction.
[9] Where renewable energy is purchased directly from utilities, and guarantees of long-term supply (in the proportions used to demonstrate compliance) are provided to the satisfaction of the authority having jurisdiction, an emissions factor of zero may be applied to the portion of the respective utility that is considered renewable.

10.5. District Energy

For buildings connecting to a district energy utility, the modeller may chose two options:

1. Model heating or cooling energy as delivered to site with 100% efficiency; or,
2. Model the building systems as including the total district energy system, and use the system efficiency as provided by the utility (and as agreed on by the utility and the AHJ) when calculating site energy use. Where district systems make use of biomass/biofuels to achieve low carbon supply, yet are limited in maximum efficiencies, consideration may be given in system efficiency agreed on with the AHJ.

10.6. Schedules, Internal, and DHW Loads

All occupancy, plug, and DHW loads shall be based on Table A-8.4.3.2.(2)-B of NECB 2015, except as specified in Tables F-1 and F-2 below for libraries and recreation centres, modified to reflect typical City of Mississauga facility operation hours. If additional modifications are required to other schedules in order to meet City of Mississauga operating parameters, the model shall be modified to account for the actual hours.

Lighting loads shall be modelled as per the design. Credit for lighting occupancy sensors may be applied as a reduction to the lighting schedule or modelled lighting power density as per the methodology in NECB 2015, Section 4.3.2.10. Daylight sensors shall be modelled directly in the software, where credit will be as per actual modelled results. Lighting schedules for spaces whose functions are not directly tied to the main building function (ex. Stairways, mechanical, and electrical rooms) may use recommended lighting hours as guidance, provided in Appendix B of BC Hydro's New Construction Program's Energy Modelling Guideline. Spaces which are normally light 24 hours a day, such a parkades and some circulation spaces, shall be modelled as such. Exterior lighting shall be scheduled on at night, using an astronomical clock.

Credit for DHW savings is permitted using industry standard methods for hot water use estimates (for example, LEED Canada NC 2009, Water Efficiency Prerequisite 1) with savings calculated to OBC requirements for maximum fixture flow rates. Reductions are also permitted for installations of passive drain water heat recovery systems to a maximum of 15%, and for heat pump systems, which shall be modelled as per the design. Savings shall be determined using good engineering practice and relative to the areas in which the system is installed (i.e. the 15% reduction is only allowed if drain water heat recovery was installed on all DHW fixtures). Models shall assume an average domestic cold water inlet temperature of 5°C.

All schedules shall be based on Table A-8.4.3.2.(2)-B of NECB 2015, except as specified in Tables F-1 and F-2 below for libraries and recreation centres, modified to reflect typical City of Mississauga facility operation hours. Space set points for temperature and humidity shall be as per design.

Table F-1 Library Schedules

Hour	Occupancy			Lighting			Receptacle			Fans			DHW		
	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun
1	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0.05	0.05	0.05
2	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0.05	0.05	0.05
3	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0.05	0.05	0.05
4	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0.05	0.05	0.05
5	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0.05	0.05	0.05
6	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0.05	0.05	0.05
7	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0.05	0.05	0.05
8	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0.05	0.05	0.05
9	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0.05	0.05	0.05
10	0.2	0.5	0.5	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.3	0.3	0.3
11	0.5	0.6	0.6	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.4	0.5	0.5
12	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.8	0.9	0.9
13	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.8	0.9	0.9
14	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.8	0.9	0.9
15	0.7	0.7	0.7	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.8	0.7	0.7
16	0.8	0.7	0.7	0.9	0.6	0.6	0.9	0.6	0.6	1	1	1	0.6	0.5	0.5
17	0.7	0	0	0.9	0.05	0.05	0.9	0.05	0.05	1	0	0	0.4	0.3	0.3
18	0.5	0	0	0.9	0.05	0.05	0.9	0.05	0.05	1	0	0	0.3	0.05	0.05
19	0.3	0	0	0.6	0.05	0.05	0.6	0.05	0.05	1	0	0	0.2	0.05	0.05
20	0.3	0	0	0.5	0.05	0.05	0.5	0.05	0.05	1	0	0	0.2	0.05	0.05
21	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0.05	0.05	0.05
22	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0.05	0.05	0.05
23	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0.05	0.05	0.05
24	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0.05	0.05	0.05

Table F-2 Recreation Centre Schedules

Hour	Occupancy			Lighting			Receptacle			Fans			DHW		
	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun
1	0	0.3	0.3	0.1	0.5	0.5	0.1	0.5	0.5	0	1	1	0.05	0.6	0.5
2	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0.05	0.05	0.05
3	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0.05	0.05	0.05
4	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0.05	0.05	0.05
5	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0.05	0.05	0.05
6	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0.05	0.05	0.05
7	0.1	0.1	0.1	0.5	0.5	0.5	0.5	0.5	0.5	1	1	1	0.7	0.7	0.7
8	0.2	0.2	0.2	0.7	0.7	0.7	0.7	0.7	0.7	1	1	1	0.7	0.7	0.7
9	0.5	0.5	0.5	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.7	0.7	0.7
10	0.5	0.5	0.5	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.7	0.7	0.7
11	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.4	0.4	0.4
12	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.5	0.5	0.5
13	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.6	0.6	0.6
14	0.5	0.5	0.5	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.6	0.6	0.6
15	0.2	0.2	0.2	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.4	0.4	0.4
16	0.2	0.2	0.2	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.3	0.3	0.3
17	0.3	0.3	0.3	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.3	0.3	0.3
18	0.6	0.6	0.6	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.4	0.4	0.4
19	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.5	0.5	0.5
20	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.8	0.8	0.8
21	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.8	0.8	0.8
22	0.6	0.6	0.6	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.9	0.9	0.5
23	0.4	0.4	0.4	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.9	0.9	0.5
24	0.3	0.3	0.3	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	0.6	0.7	0.5

10.7. Other Loads

Elevators

Elevators shall be modelled by using an electrical load of 3kW per elevator and the equipment schedule of the building type.

Other Process Loads

All process loads expected on the project site are to be included in the energy model. This includes but is not limited to: IT/data loads, exterior lighting, swimming pool heating, patio heaters, heat tracing, etc. All loads are to be estimated to reflect the actual design and using good engineering practice.

Note: Electric car charging is not included in the building process loads, as this is a growing load that is associated with transportation rather than buildings, and may include sub-metering and/or re-sale of electricity.

10.8. Infiltration

Infiltration shall be modelled as a fixed rate of 0.2 L/s/m^2 (0.0394 cfm/ft^2) at operating pressure, and is to be applied to the modelled above-ground wall area (i.e. walls and windows). Infiltration shall be scheduled on at all times.

Reduced air leakage rates may be modelled. If choosing to model a reduced infiltration rate, the project must commit to achieving the corresponding airtightness target, to be confirmed by mandatory airtightness testing.

Note: projects must provide all airtightness documentation required by the AHJ at each phase of project approval, and projects using reduced infiltration rates may have additional documentation requirements.

Envelope airtightness test results at a pressure of 75 Pa can be converted to ambient pressures for use in energy modelling software by multiplying the value by 0.112. Conversely, modelled infiltration rates may be converted to an airtightness target by dividing by 0.112. Note that airtightness results are often normalized by the total envelope surface area, which is different than the above ground wall area, due to the inclusion of floors and roofs. When converting from an airtightness test to modelled infiltration or vice-versa, the difference in surface areas must be accounted for.

$$I_{AGW} = 0.112 * q_{75Pa} * \frac{S}{A_{AGW}}$$

Where:

I_{AGW}	=	infiltration rate (L/s.m^2) to be used for energy modelling, and applied to the modelled above-ground wall area
q_{75Pa}	=	normalized envelope air leakage (L/s.m^2) as tested at 75 Pa
S	=	total surface area (m^2) of the building envelope included in the air tightness test (i.e. the pressure boundary), including ground floors and roofs, and possibly below-grade walls
A_{AGW}	=	modelled area (m^2) of the above-ground wall (including windows)

10.9. Ventilation

Ventilation rates are to be modelled as per design, including but not limited to ventilation for occupants according to building code requirements, make-up air for exhaust requirements, and pressurization make-up air, among others.

Credit may be taken for demand control ventilation systems that monitor CO_2 levels by zone and that have the ability to modulate ventilation at either the zone or system level in response to CO_2 levels. Reduction in outdoor air shall be modelled as closely as possible to reflect the actual operation of the designed ventilation system and controls. The occupancy schedule can be used as a surrogate for CO_2 control in the model. For example, if a zone has the ability to decrease ventilation in response to CO_2 levels in that zone, the occupancy-based ventilation for that zone at each time step shall be determined by multiplying the zone's design occupancy-based ventilation rate with the schedules occupancy fraction.

10.10. Other Considerations

Depending on the stage of the project that the energy model is developed, there may be the need to make a number of assumptions, of which many can have a significant impact on the performance of the building. While it is up to the design team and energy modeller to make reasonable assumptions based on past experience or engineering judgement, the items noted below are explicitly listed as they are often misrepresented in energy models.

Heat or Energy Recovery Ventilators

Heat or energy recovery ventilators shall be modelled according to design, even in instances where there exist software limitations. Appropriate workarounds or external engineering calculations are expected to be performed to accurately assess the performance of the as-designed systems. This includes the use of preheat coils and/or other frost control strategies.

When modelling a heat recovery system, the energy modeller must use Sensible Recovery Efficiency (SRE), and determine if an adjustment to efficiency is required to properly account for fan heat in the system. SRE is a measure of the heat exchanger's efficiency, i.e. removing the impact of case heat loss, air leakage, fan heat, etc., and is defined in CAN-CSA C439-2014. While the impact of such items do improve the heat exchanged to the supply air of the HRV, they do so at the expense of indoor air quality or heat from the space in which the HRV is located, with the exception of fans. The modeller must do one of the following:

a) Use SRE of the specified product and model fan location and power as per the HRV's design directly in the software

b) If the software cannot model exact fan placement and/or fan power as per the HRV's design, adjust the SRE efficiency so that it incorporates the benefit of fan heat directly in the SRE value for any fans that contribute heat to the supply air stream. Model the fans without power and account for their energy use elsewhere in the software or externally to the software.

Heat or energy recovery ventilators that use frost control strategies which limit the amount of ventilation supplied to the space (i.e. exhaust only defrost) shall be modelled to include an electric preheat coil before the heat or energy recovery ventilator that heats the air to the minimum temperature before frost control is employed, as indicated by the manufacturer. For example, if the minimum temperature prior to frost control being deployed is -5°C, then an electric preheat coil shall heat the incoming air to -5°C prior to it entering into the heat or energy recovery ventilator. The purpose of this approach is to not reward designs that reduce ventilation to the space due to their lack of efficiency.

Terminal Equipment Fans

Terminal equipment fans shall be modelled according to design. Specifically, ensure that fan power and fan control (i.e. cycling, always on, multi or variable speed) of terminal equipment represent the design and design intent as accurately as possible.

VAV and Fan-Powered Boxes

Modellers must ensure that minimum flow rates and control sequences of VAV terminals and Fan Powered Boxes are modelled according to the design, and if not available at the time of modelling, according to expected operation based on maintaining ventilation and other air change requirements as appropriate. Note that default values for minimum flows of VAV terminals are often unreasonably low in most energy modelling software.

Exhaust Fans

Exhaust fans that are not part of the ventilation system (ex. kitchen exhaust or bathroom exhaust not connected to an HRV or similar), shall have a runtime of 2 hours/day. Enclosed parking garage ventilation fans shall be modelled as running 4 hours per day. All other exhaust fans, including heat recovery units, shall be modelled to reflect the design intent as accurately as possible.

10.11. Calculating Envelope Heat Loss

One of the Standard's key performance targets is based on TEDI, which is primarily a representation of the annual heating load required to offset envelope heat loss and ventilation loads. Choosing TEDI as a target supports the Policy's direction to encourage energy efficient building envelopes. However, building envelope heat loss has historically been simplified due to past difficulties in cost-effectively providing more accuracy. This has generally led to overly optimistic assessments of building envelope performance by way of ignoring or underestimating the impact of thermal bridging.

Typical building envelope thermal bridging elements that can have a significant impact on heat loss that have historically been underestimated or unaccounted for include: balcony slabs, cladding attachments, window wall slab by-pass and slab connection details, interior insulated assemblies with significant lateral heat flow paths such as interior insulated poured-in-place concrete or interior insulation inside of window wall or curtain wall systems, and others. With the recent addition of industry resources that support more efficient and accurate calculations of building envelope heat loss, assemblies and associated thermal bridging elements must be accurately quantified for the purposes of complying with the Standard, according the requirements below.

10.12. Opaque Assemblies

The overall thermal transmittance of opaque building assemblies shall account for the heat loss of both the Clear Field performance, as well as the heat loss from Interface Details. Additional heat loss from Interface Details are to be incorporated in the modelled assembly U-values, according to the provisions below.

Overall opaque assembly U-values must be determined using the Enhanced Thermal Performance Spreadsheet (available from BC Hydro New Construction Program), performance data for Clear Fields and Interface Details from the Building Envelope Thermal Bridging Guide (BETBG), and the calculation methodology as outlines in 3.4 of the BETBG. A detailed example is provided in Section 5 of the BETBG.

If clear fields or interface details matching the proposed opaque assemblies are not available in the BETBG, overall U-values may be determines using any of the following approaches:

a. Using the performance data for Clear Field and Interface Details from other reliable resources such as ASHRAE 90.1-2010, Appendix A, ISO 14683 Thermal bridges in building construction – Linear thermal transmittance – Simplified Methods and default values, with the methodology described above in BETBG. For spandrel panels, consider using the Reference Procedure for Simulating Spandrel U-Factors, developed for Fenestration BC

b. Calculations, carried out using the data and procedures described in the ASHRAE Handbook – Fundamentals

c. Two- or three-dimensional thermal modelling, or

d. Laboratory tests performed in accordance with ASTM C 1363, "Thermal Performance of Building materials and Envelope Assemblies by Means of a Hot Box Apparatus," using an average temperature of 24±1°C and a temperature difference of 22±1°C.

Except where it can be proven to be insignificant (see below), the calculation of the overall thermal transmittance of opaque building envelope assemblies shall include the following thermal bridging effect elements:

- Closely spaced repetitive structural members, such as studs and joists, and of ancillary members, such as lintels, sills and plates,
- Major structural penetrations, such as floor slabs, beams, girders, columns, curbs or structural penetrations on roofs and ornamentation or appendages that substantially or completely penetrate the insulation layer,
- The interface junctions between building envelope assembles such as: roof to wall junctions and glazing to wall or roof junctions,
- Cladding structural attachments including shelf angles, girts, clips, fasteners and brick ties
- The edge of walls or floors that intersect the building enclosure that substantially or completely penetrate the insulation layer.

The following items need not be taken into account in the calculation of the overall thermal transmittance of opaque building envelope assemblies:

- Mechanical penetrations such as pipes, ducts, equipment with through-the-wall venting, packaged terminal air conditioners or heat pumps.
- The impact of remaining small unaccounted for thermal bridges can be considered insignificant and ignored if the expected cumulative heat transfer though these thermal bridges is so low that the effect does not change the overall thermal transmittance of the above grade opaque building envelope by more than 10%.

10.13. Fenestration and Doors

The overall thermal transmittance of fenestration and doors shall be determined in accordance with NFRC 100, "Determining Fenestration Product U-factors", with the following limitations:

a. The thermal transmittance for fenestration shall be based on the actual area of the windows and not the standard NRFC 100 size for the applicable product type. It is acceptable to area-weight the modelled fenestration U-value based on the relative proportions of fixed and operable windows and window sizes. It is also acceptable to simplify the calculations by assuming the worst case by using the highest window U-value for all fenestration specified on the project.

b. If the fenestration or door product is not covered by NFRC 100, the overall thermal transmittance shall be based on calculations carried out using the pro procedures described in the ASHRAE Handbook – Fundamentals, or Laboratory tests performed in accordance with ASTM C 1363, "Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus," using an indoor air temperature of 21±1°C and an outdoor air temperature of -18±1°C measured at the mid-height of the fenestration or door.

10.14. Mixed-Use Buildings

Buildings consisting of different occupancies with different EUI, TEDI, and GHGI targets shall create whole-building targets by area-weighting the EUI, TEDI, and GHGI requirements accordingly.

10.15. References and Resources

1. 2014 Building America House Simulation Protocols, NREL, 2014
2. ASHRAE Handbook of Fundamentals, ASHRAE, 2013
3. ASHRAE Standard 90.1-2010 – Energy Standard for Buildings Except Low-Rise Residential Buildings, ASHRAE 2010
4. Commercial Buildings Building Envelope Thermal Bridging Guide, Version 1.1, BC Hydro, 2016
5. Energy Modelling Guidelines and Procedures, CONMET, 2014
6. EnergyStar Multifamily High Rise Program, Simulation Guidelines, Version 1.0, Revision 03, January 2015
7. Infiltration Modelling Guidelines for Commercial Building Energy Analysis, PNNL, 2009
8. National Energy Code of Canada for Buildings, NRCan, 2011
9. New Construction Program's Energy Modelling Guideline, BC Hydro, March 2015
10. TM54 – Evaluating Operational Energy Performance of Buildings at the Design Stage, CIBSE, 2014
11. National Energy Code of Canada for Buildings, NRCan, 2015
12. Guide to Low Thermal Energy Demand in Large Buildings, BC Housing, March 2018
13. Reference Procedure for Simulating Spandrel U-Values, Fenestration BC, September 2017
14. Illustrated Guide to Achieving Airtight Buildings, BC Housing, September 2017

11.APPENDIX C: Glossary of Terms

Airtightness: The measure of a building envelope's resistance to air leakage in or out of the building

BOD: Basis of Design

Building envelope: The elements that make up the outer shell of a building and maintain a division between outside weather and the conditions inside the building's spaces

BUG: Backlight-Uplight-Glare (in reference to lighting)

CaGBC: Canada Green Building Council

Carbon offset: A credit for greenhouse gas reductions achieved by one party that can be purchased and used to compensate for the emissions of another party, typically measured in CO_2 equivalent

CFC: Chlorofluorocarbon

Charette: An interdisciplinary meeting in which all stakeholders on a project attempt to map solutions together

Cx: Commissioning

CxA: Commissioning Authority

Embodied carbon: The emissions associated with the production, transportation, assembly, use and eventual decommissioning of materials used in a building's construction

Energy efficiency: A measure of the effectiveness of energy use (when referring to buildings, one with high energy efficiency requires less energy to perform the same tasks as one with lower energy efficiency)

EUI: Energy Use Intensity, a representing all the energy required to power a building's operations

EV: Electric vehicle

EVSE: Electric Vehicle Supply Equipment

FSC: Forest Stewardship Council

GHG: Greenhouse Gas

GHGI: Greenhouse Gas Intensity

Glazing: Windows on a building

GWP: Global Warming Potential

HCFC: Hydrochlorofluorocarbon

HVAC&R: Heating, Ventilation, Air Conditioning, and Refrigeration (usually referring to equipment)

IDP: Integrated Design Process

ILFI: International Living Future Institute

LCA: Life Cycle Assessment

LEED: Leadership in Energy and Environmental Design

MURB: Multi-Unit Residential Building (or multi-family building)

ODP: Ozone Depletion Potential

OPR: Owner's Project Requirements

Permeability: The ability of a surface to transmit water and air

Potable water: Clean water that is safe to drink or use for food preparation

Pollinator-friendly: Plants that are beneficial to animals such as bees, butterflies, and hummingbirds

Renewable energy: A source of energy that is replenished through natural process or using sustainable management policies such that it is not depleted at current levels of consumption

Solar PV: Solar photovoltaic (referring to the technology that converts sunlight into direct current electricity)

TBL: Triple Bottom Line

TEDI: Thermal Energy Demand Intensity, a metric representing a building's demand for heat energy

Ventilation: The process of intentionally exchanging air in a building to replace stale air with fresh air from outside

VOC: Volatile Organic Compound