City of Mississauga

Agenda

MISSISSAUGA

Environmental Action Committee

Date

2019/09/09

Time

9:30 AM

Location

Civic Centre, Hearing Room - Second Floor,
300 Civic Centre Drive, Mississauga, Ontario, L5B 3C1

Members

Matt Mahoney	Councillor - Ward 8 (Chair)
Stephen Dasko	Councillor - Ward 1 (Vice-Chair)
George Carlson	Councillor - Ward 11
Brad Bass	Citizen Member
Chelsea Dalton	Citizen Member
Lea Ann Mallett	Citizen Member
Pujita Verma	Citizen Member
Shazerah Qureshi	Peel Environmental Youth Alliance
Carina Suleiman	University of Toronto Mississauga
Britt McKee	Ecosource
Melanie Kramer	Credit Valley Conservation
Joel Longland	Partners in Project Green
Non-Voting Members	
Alice Casselman	Association for Canadian Educational Resources
Teresa Ierullo	Greening Sacred Spaces
Brad Butt	Mississauga Board of Trade
Sid Gendron	Sawmill Sid Inc.

Contact

Dayna Obaseki, Legislative Coordinator, Legislative Services
905-615-3200 ext. 5425
dayna.obaseki@mississauga.ca

1. **CALL TO ORDER**

2. **APPROVAL OF AGENDA**

3. **DECLARATION OF CONFLICT OF INTEREST**

4. **MINUTES OF PREVIOUS MEETING**

4.1. Environmental Action Committee Minutes – July 9, 2019

5. **DEPUTATIONS**

5.1. Mojan Jianfar, Planner & Project Lead, City Building Initiatives to present on the Downtown Strategy

5.2. Sumeet Jhingan, Project Manager, Energy Management to present on the Corporate Green Building Standard ***(Item 7.1)***

6. **PUBLIC QUESTION PERIOD** - 15 Minute Limit (5 Minutes per Speaker)

Pursuant to Section 42 of the Council Procedure By-law 0139-2013, as amended:

Environmental Action Committee may grant permission to a member of the public to ask a question of Environmental Action Committee, with the following provisions:

1. The question must pertain to a specific item on the current agenda and the speaker will state which item the question is related to.
2. A person asking a question shall limit any background explanation to two (2) statements, followed by the question.
3. The total speaking time shall be five (5) minutes maximum, per speaker.

7. **MATTERS TO BE CONSIDERED**

7.1. Corporate Green Building Standard for New Construction and Major Renovations Building Projects ***(Item 5.2)***

7.2. Environmental Action Committee Work Plan

8. **INFORMATION ITEMS**

9. **OTHER BUSINESS**

10. **ENQUIRIES**

11. **DATE OF NEXT MEETING**

Tuesday, October 8, 2019 at 9:30am
Committee Room B, Civic Centre
300 City Centre Drive
Mississauga, ON L5B 3C1

12. **ADJOURNMENT**

City of Mississauga
Minutes

MISSISSAUGA

Environmental Action Committee

Date
2019/07/09

Time
9:30 AM

Location
Civic Centre, Committee Room A - Second Floor,
300 Civic Centre Drive, Mississauga, Ontario, L5B 3C1

Members Present

Matt Mahoney	Councillor - Ward 8 (Chair)
Stephen Dasko	Councillor - Ward 1 (Vice-Chair)
George Carlson	Councillor - Ward 11
Brad Bass	Citizen Member
Chelsea Dalton	Citizen Member
Lea Ann Mallett	Citizen Member
Pujita Verma	Citizen Member
Melanie Kramer	Credit Valley Conservation Authority
Britt McKee	Ecosource
Non-Voting Members	
Brad Butt	Mississauga Board of Trade
Alice Casselman	Association for Canadian Educational Resources

Members Absent

Vacant (PAN)	Group Representative/Stakeholder Member - Peel Aboriginal Network
Leena Baber	Peel Environmental Youth Alliance
Simran Persaud	University of Toronto Mississauga
Dianne Zimmerman	Partners in Project Green
Teresa Ierullo	Greening Sacred Spaces
Shelia Storey	Sawmill Sid Inc.

Staff Present
Andrea J. McLeod, Manager, Environment
Lisa Urbani, Environment Research Assistant, Environment
Dayna Obaseki, Legislative Coordinator, Legislative Services
Sarah Piett, Acting Supervisor, Woodlands & Natural Areas
Leya Barry, Climate Change Coordinator, Climate Change
Teresa Chan, Climate Change Specialist, Climate Change

Find it online
http://www.mississauga.ca/portal/cityhall/environmentalactioncommittee

1. **CALL TO ORDER** – 9:34 AM

2. **APPROVAL OF AGENDA**

   Approved (L. Mallet)

3. **DECLARATION OF CONFLICT OF INTEREST** – Nil.

4. **MINUTES OF PREVIOUS MEETING**

4.1 Environmental Action Committee Minutes – June 11, 2019

Approved (B. McKee)

5. **DEPUTATIONS**

5.1 Pollinator Initiatives

Sarah Piett, Acting Supervisor, Woodlands & Natural Areas provided an overview on the Pollinator Initiatives. Ms. Piett described what pollinators are and the various types. Ms. Piett noted the current initiatives the City is taking are the honeybee hive at City Hall, pollinator hotels at City owned garden parks, pollinator gardens, the One Million Tree Mississauga program and Bee City Canada. Ms. Piett noted the public can help further these initiatives by planting native plants; such as wild flowers, tree and shrubs as well as picking up a pollinator packs from the City.

Members of the Committee spoke to the matter and raised the following questions and concerns;

- Bee City Canada conditions and process;
- Inquired if local nurseries/garden centres are advertising whether the plants are native or non-native;

Ms. Piett responded to the questions from the Members of the Committee;

- To become a Bee City – the City of Mississauga fills out an annual application form outlining future plans and past achievements.
- Due to being privately owned establishments advertisements at local nurseries surrounding whether the plants are native or not are done on an individual basis.

RECOMMENDATION
That the deputation and associated presentation by Sarah Piett, Acting Supervisor, Woodlands & Natural Areas to present on Pollinator Initiatives be received.

Received (M. Kramer)
Recommendation EAC-0025-2019

5.2 The Climate Change Project/Action Plan Update

Leya Barry, Climate Change Coordinator provided an update on The Climate Change Project and encourage members to provide in-depth feedback to help further the project plan. Ms. Barry noted the timeline of the project as well as the goals and visions outlined in the plan. The vision is for a low carbon and resilient community, whereas the goals are centered on mitigation and adaption. Ms. Barry provided a total carbon-related emissions comparison in Mississauga from 1990 to projected reduction rates in 2020. Ms. Barry further discussed the five action pathways that consist of buildings, resilient and green infrastructure, accelerating discovery and innovation, low emissions mobility and engagement and partnerships.

Members of the Committee spoke to the matter and raised the following questions and concerns;

- Waste resources;
- Heat pumps/heat storage;
- Geothermal;
- Whether the Green Development Standards are mandatory or optional;
- Green initiatives on planning applications;
- Concerned with the disconnect of communication between developers and owners pertaining to the Storm Water rebate;
- Concerned with the lack green transportation initiatives;
- Electric bus fleet;
- Inquired about the target disconnect;
- Retrofits;
- Solar panels;
- Green Infrastructure definition;
- Urban Agriculture;
- Tree Campaigns;
- Citizen involvement;
- Incentives and community grants for residents to plant trees;
- Size of scale of creating awareness;
- By-law mandates;
- Erosion;
- Evaluation of cost; and
- How can the EAC members help expedite the process.

Ms. Barry, Teresa Chan, Climate Change Specialist, Andrea J. McLeod, Manager of Environment, Councillor Mahoney and Councillor Dasko responded to the questions from the Members of the Committee;

- Waste water/sewage plants with a focus on the GE Booth Lakeview Waste Water Plant are considered as primary resources.
- In the previous update – the City presented on the use of Siemen's modeling tool which outlined electric heat pumps as an option and retrofitting older buildings. The focus is to move away from the use of natural gas and conduct pilot projects on buildings with electric bass board heaters.
- Geothermal is a great idea, however involves a very complicated installation process and can be quite expensive.

- The Green Development Standards are voluntary, however the City is aiming for compliance in stages, such as initially filling out that particular section on the application to having a minimal standard reached as a requirement.
- The City would like to create a better flow of information and education surrounding the StormWater rebate and other environmental initiatives.
- The City has adopted the Transportation Master plan, which encompasses green initiatives, therefore the Climate Change Project does not act as the lead on those initiatives, but more so in complimentary capacity.
- Investing into electric bus fleet and smaller buses for less busy routes is being considered from all perspectives with staff to ensure a service level is not affected.
- The set targets are based off a different metric that focus on the reduction of energy consumptions that helps with lower greenhouse emissions.
- Retrofits are a priority during a renovation period and lifecycle replacements.
- Solar energy is being utilized at City owned facilities.
- The City is working towards a standard definition of green infrastructure and moving away from working in silos towards a more municipal holistic approach.
- Action 9 listed in the presentation and the sub-actions that fall under these high-level action items deal with food security and touch on urban agriculture.
- Community grants are already in place as well as conservations that help towards planting more trees, life sustainability, the support for diversity of habitats and different types of eco-sources.
- Creating incentives, such as community champion awards helps change societal behaviour towards citizen involvement. The focus is to promote awareness and educate the public as well as provide opportunities to participate and help improve the environment. Set targets produce sustainable action, such as mode sharing reducing to 50%.
- Raising awareness, natural theming, training 311 staff on existing and upcoming programs, working with support groups, and climate hubs are dealt with on a neighbourhood scale.
- There is no current by-law that mandates a target for green infrastructure.
- Vulnerability assessments of parks are being considered and erosion aspects will be addressed under this initiative.
- Cost assessments have been conducted on the basis if the City did not take on any future green initiatives vs. the implementation of those suggested initiatives.
- Presently members can provide feedback and participate in these set out initiatives to help achieve these set targets. In five years the plan will be reassessed and at that time new technologies may help further expedite the set goals.

<u>RECOMMENDATION</u>
That the deputation and associated presentation by Leya Barry, Climate Change Coordinator to present on The Climate Change Action Plan be received.

<u>Received</u> (A. Cassleman)
Recommendation EAC-0026-2019

6. **<u>PUBLIC QUESTION PERIOD</u>** - 15 Minute Limit (5 Minutes per Speaker)

No members of the public requested to speak.

7. **MATTERS CONSIDERED**

7.1 Environmental Action Work Plan

Alice Cassleman, Member advocated that there should be a spring and fall EAC Work Plan progress report. This suggested will be updated and reflected in the EAC Work Plan.

Pujita Verma, Member inquired about the Committee's interest in the Adopt-A-Park Program. Members of the Committee noted that the main struggle has been due to time constraints and that the turnout at past events has been disheartening. Members expressed their interest in the program continuing and suggested facilitating these events on weekends, in order for members to attend alongside with their family and friends and to compound these events with tree planting as well.

RECOMMENDATION
That the Environmental Action Committee Work Plan be approved as discussed at the July 9, 2019 meeting of the Environmental Action Committee.

Approved (P. Verma)
Recommendation EAC-0028-2019

8. **INFORMATION ITEMS**

8.1 Committees of Council Procedure

Dayna Obaseki, Legislative Coordinator provided a brief overview on the committee procedures in specific relation to the Environmental Action Committee operations.

Melanie Kramer, Member inquired how the public requests are processed. Ms. Obaseki responded by noting that the staff help members of the public frame their requests for the appropriate audience.

RECOMMENDATION
That the Committees of Council Procedure be received.

Received (M. Kramer)
Recommendation EAC-0029-2019

9. **OTHER BUSINESS –** Nil.

10. **ENQUIRIES** – Nil.

11. **DATE OF NEXT MEETING(S)** – To be determined.

12. **ADJOURNMENT** – 11:22 AM (L. Mallet)

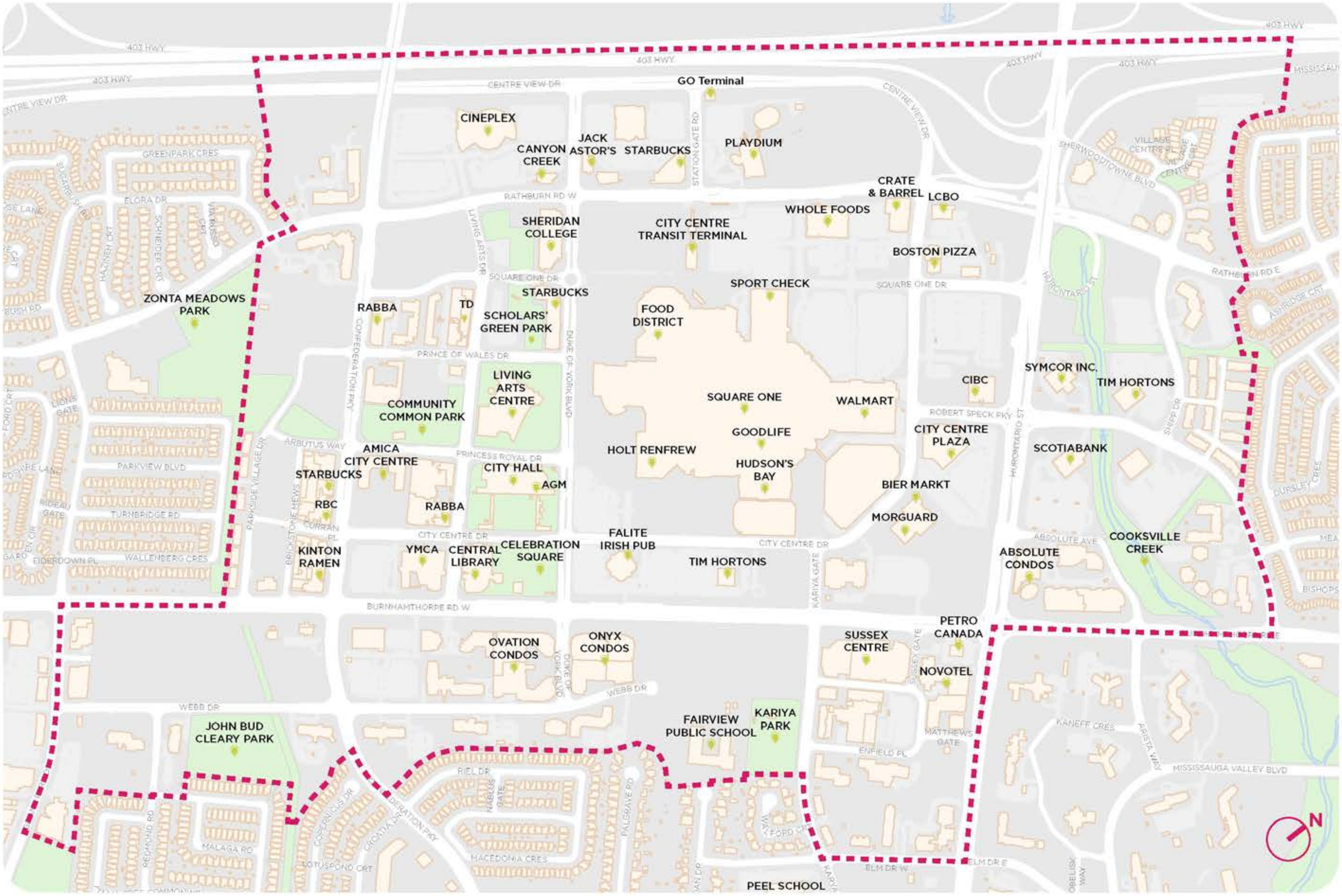
Help shape our City

Downtown Strategy

Environmental Advisory Committee
September 9, 2019
Mojan Jianfar, Planner
City Planning Strategies

The City of Mississauga is creating a downtown for today and tomorrow.

Downtown Mississauga



Downtown 21 Master Plan

- Downtown21 Master Plan (2010) outlined a vision to transform the Downtown from suburban to urban and laid the foundation for the current downtown core.

- Identified 6 guiding principles:
  – Parks and Open Spaces
  – Trails and Cycling
  – Transit
  – Urban Design
  – Districts
  – Street Character

Downtown Mississauga

- Downtown Mississauga is rapidly growing
  - Since 2009, the population has grown by 42%, from 28,500 to 40,300 people
  - Projected to grow to ~61,000 people by 2031
  - Overall population is slightly younger than the rest of the city

Downtown Strategy

- Building on the foundation of Downtown21, the Downtown Strategy will be a guiding document to ensure we are building a vibrant downtown
- The Downtown Strategy will:
  - Consider Downtown users, to enhance their experiences living, working and playing in the core
  - Guide the Downtown's future growth and transformation
  - Identify planning, policy, process, operations, programming and infrastructure improvements
  - Strategically direct efforts and resources to where they will have the most impact

Project Timeline

we're here

Phase 1: Background
Q2 – Q3 2019

Engagement Initiatives:
- Discovery Engagement
- Online Survey
- Living Arts Drive Pilot

Phase 2: Current State
Q4 2019 – Q1 2020

Engagement Initiatives
- Internal Staff workshops
- Online survey
- Focus groups and one-on-one interviews
- Film Event

Phase 3: Defining the Future
Q1 – Q2 2020

Engagement Initiatives:
- 2 public workshops
- Public review of what we heard from engagement
- Online survey

Phase 4: Draft Vision and Direction
Q2 – Q3 2020

Engagement Initiatives:
- Public Open House
- Review of Draft Downtown Strategy
- Online survey

Phase 5: Downtown Strategy
Q4 2020

Engagement Initiatives:
- Planning and Development Committee – Public Meeting

Phase 1: Background

- Reviewing City policies, strategies and priorities for the Downtown
- Gather your feedback on building a vibrant Downtown
  - Throughout Phase 1 and 2 we will be gathering feedback with an online survey, interviews in the community, and stakeholder meetings
  - We will share back on what we heard in Phase 3

Discovery Engagement

- Share your feedback on:
  - What are Downtown Mississauga’s strengths?
  - Where are the opportunities? (e.g. to make it easy to live, work, play, shop, gather and learn in the Downtown)
  - What are our needs and aspirations for the Downtown?
  - What is our vision for the future and what actions will get us there?

Next Steps

- HAVE YOUR SAY:
  - **Survey:**
    - Please fill out and share the survey: https://yoursay.mississauga.ca/downtown/survey_tools/your-experience
  - **Stay informed:**
    - Sign up on the website to stay informed on project updates and upcoming meetings: yoursay.mississauga.ca/downtown
  - **Connect with us:**
    - Email us at downtown.strategy@mississauga.ca with questions or feedback
  - **Join the conversation:**
    - Follow and use #saugadowntown to join the conversation on Twitter

Feedback and Questions

Thank you

Mojan Jianfar

Project Lead

Planner, City Planning Strategies

downtown.strategy@mississauga.ca

Corporate Green Building Standard

For New Construction and Major Renovation

Environmental Action Committee Presentation

November 9th, 2019

MISSISSAUGA

Agenda

- The Project Team
- The Current Standard – Background
- Why Change?
- Our Approach – A New Standard
- Implications for Cost
- Questions

The Project Team

INTEGRAL GROUP

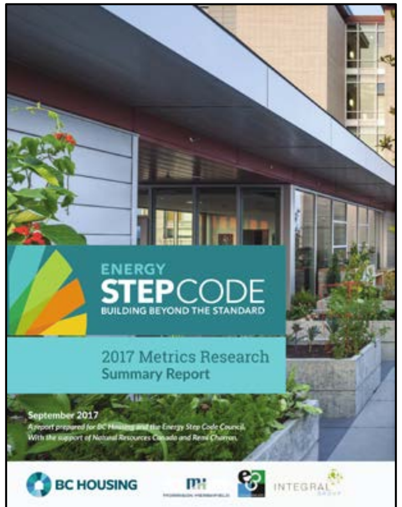
- **Lisa Westerhoff**, Associate & Project Manager
- **Bill Updike**, Principal
- **Aaron Wouters**, Sustainability Advisor

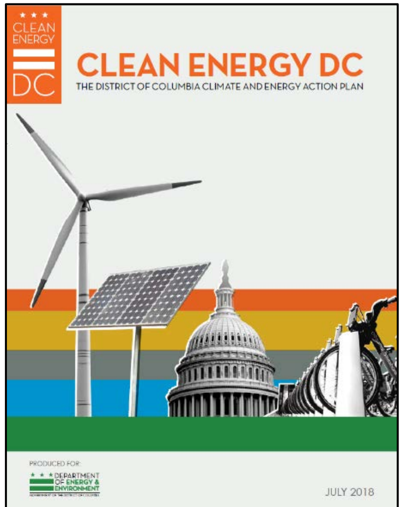
MORRISON HERSHFIELD

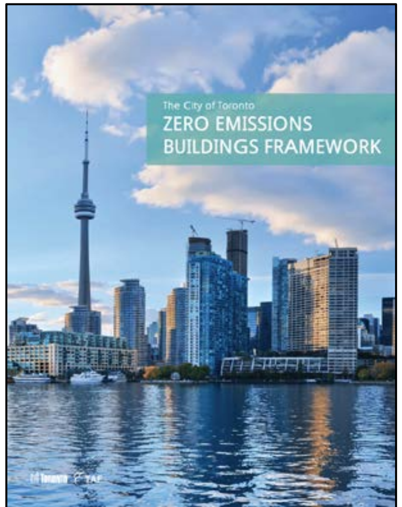
- **Neel Bavishi**, Building Energy Specialist
- **Alex Blue**, Principal
- **Ruth McClung**, Building Science Consultant

MISSISSAUGA

- **Sumeet Jhingan**, Project Manager, Energy Management
- **Daniela Paraschiv**, Manager, Energy Management
- **Raj Sheth**, Director F&PM



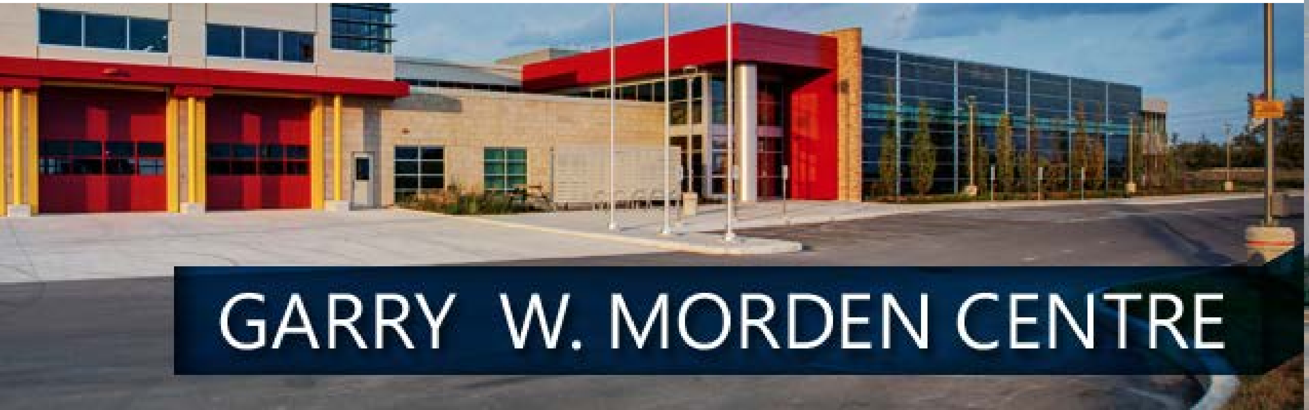




The Current Standard

As of January 2010:

All new construction and major renovation of City buildings to be constructed to the LEED Silver Standard

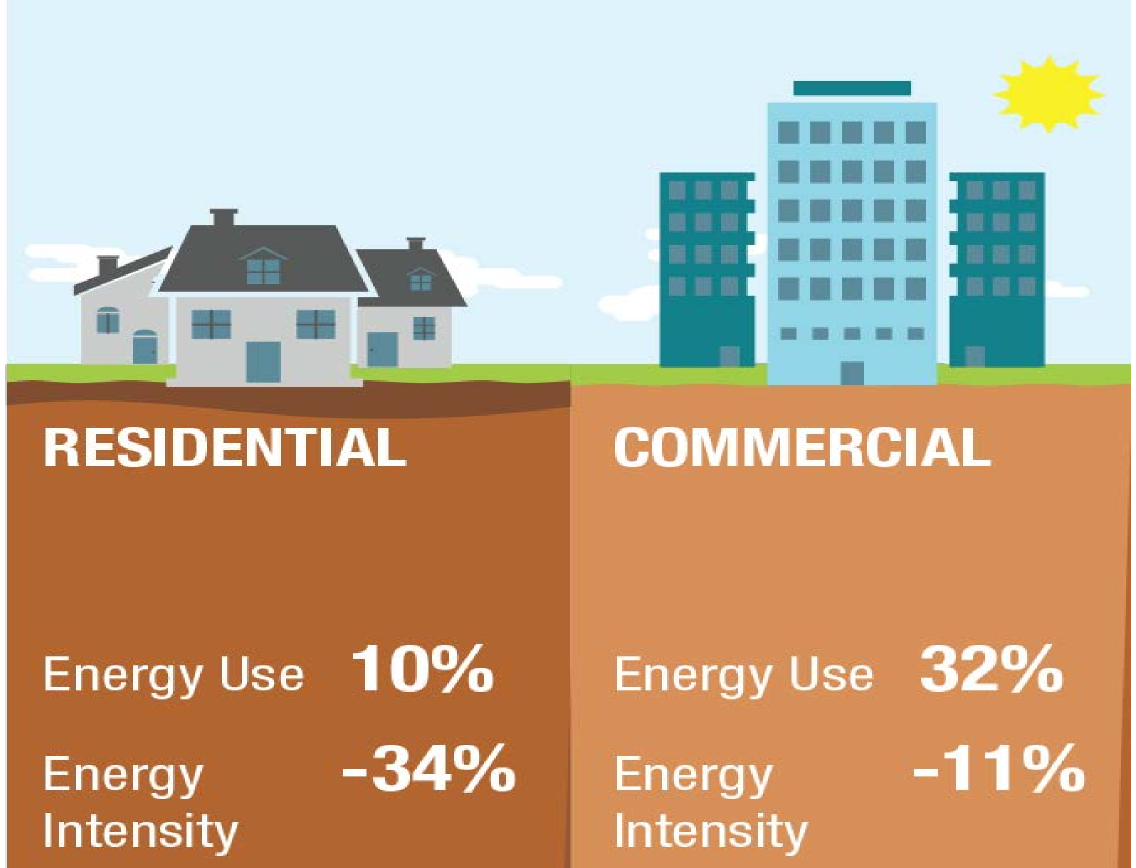


Why Change? – Community Perspective

Commercial & Institutional Buildings (1990 vs. 2014)

- Energy Intensity **reduced 11%**
- Total Energy Consumption **increased 32%**
- Without energy efficiency improvements in existing buildings
  Energy Use **increased 61%**

Trends in Energy Use & Intensity 1990 - 2014



Source: Natural Resources Canada, 2018, Energy Facts, Energy and Greenhouse Gas Emissions (GHGs)

Why Change? – Corporate Perspective

strategicplan
Our Future Mississauga

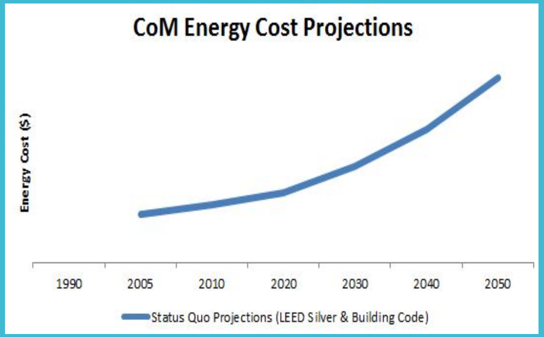
Net-zero Carbon City

- Need to support this Visionary Action
- Need to demonstrate environmental leadership

the CLIMATE CHANGE project

80% GHG reduction by 2050

- Need to meet the city's aggressive Community & Corporate targets



Utility Budget Stability

- Need to mitigate the rising utility costs (projected at 3% annually)

Sustainable Procurement

- Need to demonstrate fiscal, social, environmental leadership

NEED TO ADDRESS ENERGY & CLIMATE CHANGE IN CITY BUILDINGS

Our Approach – A New Standard

Corporate Green Building Standard:

- To improve environmental performance
- Reduce operating & maintenance costs
- Place Mississauga as a leader in green building

Catered to Mississauga	Higher emphasis on energy & resiliency	Tier-based system	Absolute vs. relative performance

Source: City of Mississauga

Our Approach – Comparing Standards

	LEED Silver	CGB Standard
Energy & Climate Change	• Energy performance • Commissioning • Ozone depleting compounds	• Energy and emissions performance • Monitoring-based commissioning/verification • Air tightness testing • On-site renewables • Metering and benchmarking • Resilience performance • Ozone depleting compounds
Sustainable Sites	• Erosion and sediment control • Bicycle infrastructure • Stormwater management	• Erosion and sediment control • Bicycle infrastructure • Stormwater management • Light pollution • Biodiversity
Water	• Water use intensity	• Water use intensity
Materials & Resources	• Construction waste management • Recycled Content	• Construction waste management • Low-impact materials (recycled content) • Embodied carbon footprint
Indoor Environmental Quality	• Low-emitting materials (adhesives, sealants, paints, coatings, flooring)	• Low-impact materials (adhesives, sealants, paints, coatings, flooring)

Our Approach – Tier-based Performance Requirements

Level 1: 'Must Have' performance targets that are required in all buildings and facilities

Level 2: 'Highly Desirable' performance targets that represent a more ambitious level of performance

Level 3: 'If Possible' performance targets that are considered 'best in class' and that should be pursued when project parameters allow

425 Concourse (NYC), Passive House

What does this mean for Mississauga's buildings?

Source: City of Mississauga

Beautiful & Comfortable Buildings

EcoLock

George Brown College

TRCA Headquarters

TRCA Headquarters

Elementary Teachers' Federation of Ontario

Vancouver Fire Hall No. 17

Applying the Standard to Meadowvale CC

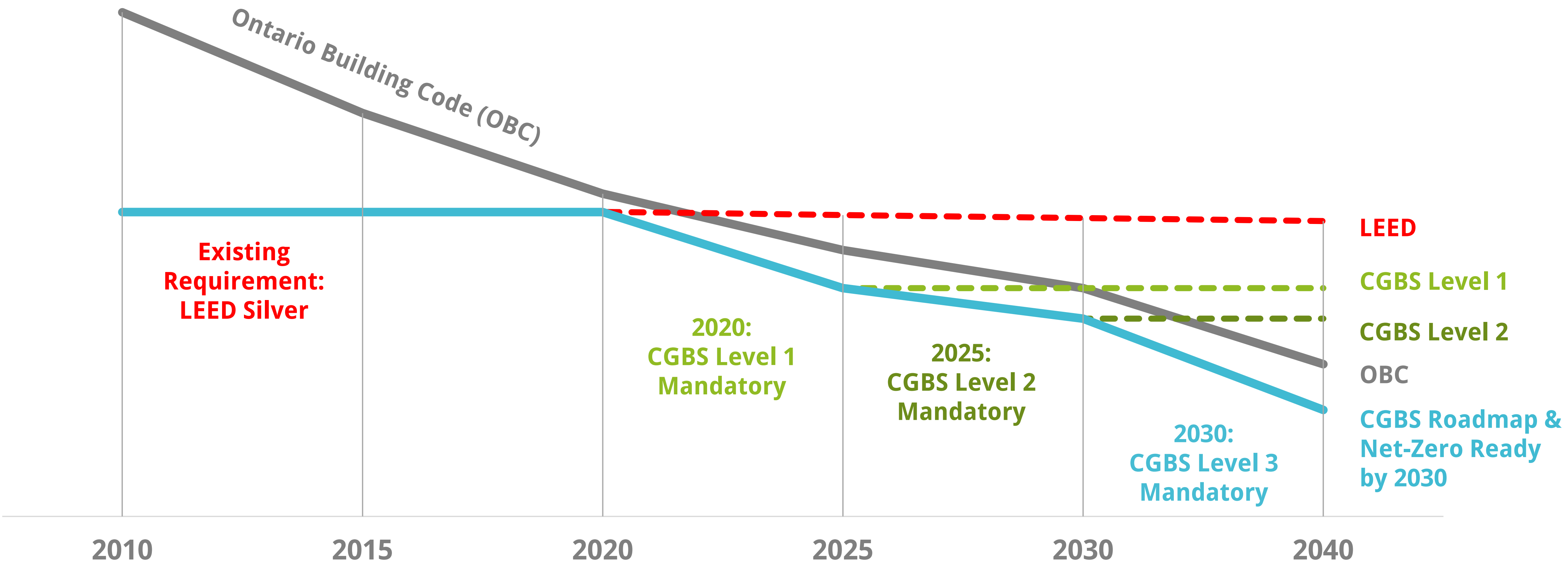
	Level 1	Level 2	Level 3
Building Measures	• 30% better than code airtightness • 70% heat recovery • Low-flow plumbing	• 50% better than code airtightness • 90% heat recovery • Low-flow plumbing • Triple glazed windows • R-15 and R-40 roof • 100% LED lighting	• 50% better than code airtightness • 90% Heat Recovery • Low-flow Plumbing • Passive House Windows • R-20 Wall & R-60 Roof • 100% LED Lighting • Heat Pump Technology • Fuel Switching • Net-Zero "Ready"
Performance over LEED Silver	• 3% better energy use • 4% lower GHGs • 1% lower utility costs	• 17% better energy use • 22% lower GHGs • 5% lower utility costs	• 55% better energy use • 82% lower GHGs • 10% lower utility costs
Cost Premium	• 2% estimated cost premium ($0.5M)	• 7.5% estimated cost premium ($2.0M)	• 13.5% estimated cost premium ($3.6M)

Benefits of High Performance Buildings

- ✓ Increased productivity and staff retention
- ✓ Improved health and reduced sick days
- ✓ Improved resilience to extreme events
- ✓ Create jobs and GDP

Telus Garden (Vancouver) | LEED Platinum

Corporate Green Building Standard Roadmap



Questions?

“The best time to plant a tree was 20 years ago. The second best time is now.”

- Chinese Proverb

Source: City of Mississauga

City of Mississauga
Corporate Report

Date: 7/31/2019 To: Chair and Members of Environmental Action Committee From: Gary Kent, CPA, CGA, ICD.D, Commissioner of Corporate Services and Chief Financial Officer	Originator's files:
	Meeting date: 09/09/2019

Subject
Corporate Green Building Standard for New Construction and Major Renovations Building Projects

Recommendation
1. That the Corporate Report entitled, "Corporate Green Building Standard for New Construction and Major Renovations[1] Building Projects", dated July 31st, 2019 from the Commissioner of Corporate Services and Chief Financial Officer, be recommended by the Environmental Action Committee to General Committee for endorsement.

2. That the Corporate Green Building Standard for New Construction and Major Renovations Building Projects be submitted to Chair and Members of General Committee prior to the end of the year for endorsement, along with the Climate Change Action Plan.

3. That the documentation package attached in Appendix 1 for the Corporate Green Building Standard for New Construction and Major Renovations Building Projects be received.

Report Highlights
- In line with the Green Pillar of the Strategic Plan, the Chair and Members of General Committee approved the existing Green Building Standard of constructing new and renovated City-owned buildings to LEED® Silver certification in January 2010.
- The need to update our existing Green Building Standard for City-owned buildings was

[1] For the purposes of the CGB Standard, "major renovations" refers to extensive alteration work to an existing building to the extent such that the primary function of the space cannot be used for its intended purpose while the work is in progress and where a new certificate of occupancy is required before the work area can be reoccupied.

driven by a number of reasons including the forthcoming Mississauga Climate Change Action Plan, the need to build resilient buildings, the need to mitigate rising utility costs, and the evolving market place for design and construction of high performance buildings.

- Various standards, including LEED®, ASHRAE® 189.1, Living Building Challenge, PassivHaus®, and Net Zero Energy Buildings, were reviewed in order to develop the new performance, reduce costs, and place Mississauga as a leader in green buildings for new corporate buildings and major renovation.
- Similar to the Toronto Green Standard and BC-Step Code, a tier-based Corporate Green Building Standard for new buildings and major renovations building projects was developed with a roadmap of Level 1 becoming mandatory in 2020, Level 2 in 2025, and Level 3 in 2030; this roadmap is aligned with the targets set out in the forthcoming Mississauga Climate Change Action Plan.
- It is estimated that a project budget premium of 2.6% - 5.0% for Level 1, 7.6% - 12.5% for Level 2, and 20.0% - 40.0% for Level 3 is required in order to implement the respective levels of compliance for all new corporate construction and major renovation[2] building projects.

Background

In January 2010, the Chair and Members of General Committee approved and adopted a LEED® Silver standard of performance for all new construction and major renovation of the City buildings above 10,000 ft^2. The City required mandatory achievement in the following categories:

Erosion and sediment control	Minimum energy performance
Alternative transportation: Bicycle storage and changing rooms	Ozone protection
Stormwater management	Water efficient landscaping
Construction waste management	Water use reduction
Fundamental building systems commissioning	Low emitting materials

Present Status

In its forthcoming Climate Change Action Plan, the City has proposed targets of reducing greenhouse gas (GHG) emissions by 40% compared to 1990 levels by 2030 and 80% by 2050. Further, the visionary action in the City's Strategic Plan to support a net-zero carbon city, and Sustainable Procurement Policy, as well as the need to mitigate rising utility costs require a

[2] For the purposes of the CGB Standard, "major renovation" refers to extensive alteration work to an existing building to the extent such that the primary function of the space cannot be used for its intended purpose while the work is in progress and where a new certificate of occupancy is required before the work area can be reoccupied.

strong approach to the energy requirements of the Corporate Green Building Standard. While the LEED® Silver standard was a comprehensive sustainability standard at the time of its adoption, it falls short compared to the federal goal of requiring provinces and territories to adopt a "net-zero energy ready" model building code by 2030[3]. Figure 1: Evolution of Energy Efficiency Requirements, below, demonstrates how the City's current Corporate Green Building Standard of LEED® Silver will soon fall behind even the Ontario Building Code.

The current standard now represents a relatively low baseline from which more ambitious and indeed necessary energy and environmental performance achievements should be set. The City isn't alone in this ambition. First introduced in 2006 and now in Version 3, the Toronto Green Standard includes four tiers of energy efficiency and emissions performance for new private and their City-owned developments (community and corporate). The City of Vancouver has similar levels of ambition, having released its Zero Emissions Building Plan that aims to eliminate emissions from new buildings by 2030. These and other jurisdictions have put themselves on the map as leaders in sustainability, and have helped pave the way for cities like Mississauga by doing a lot of work to raise standards, build industry awareness and capacity, and set new expectations.

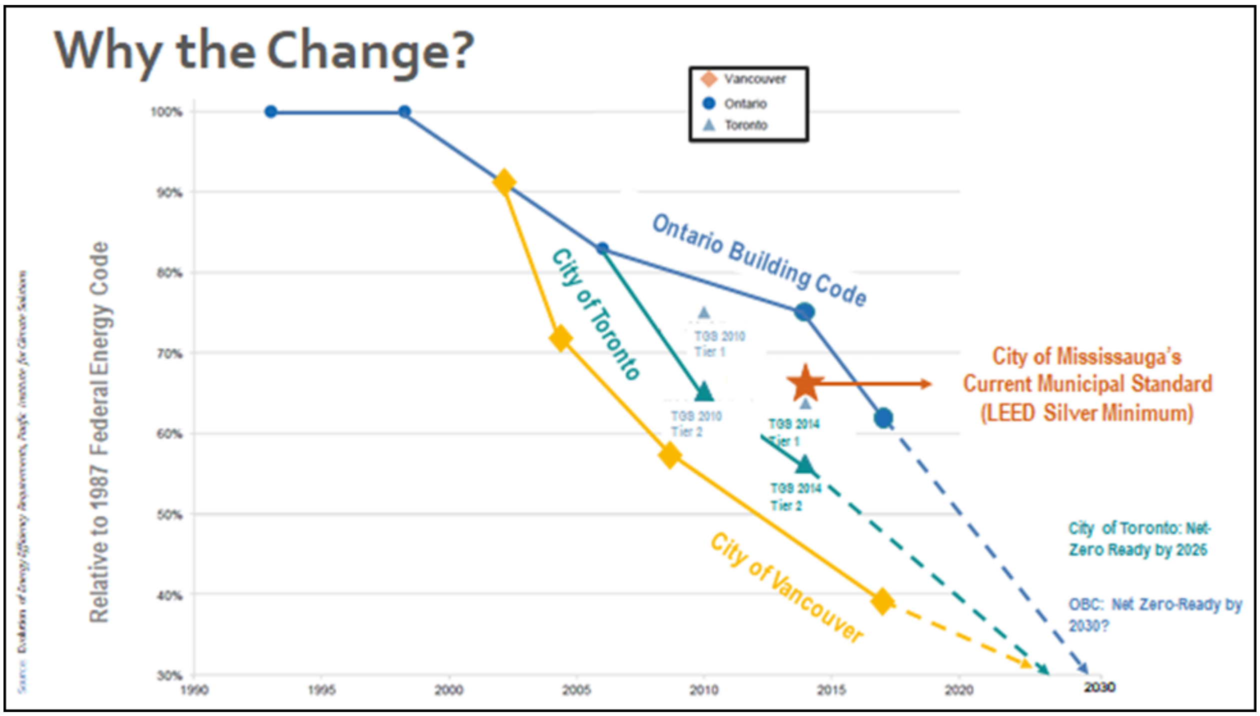


Figure 1: Evolution of Energy Efficiency Requirements

[3] Natural Resources Canada, 2017, Build Smart Canada's Buildings Strategy: A key driver of the Pan-Canadian Framework on Clean Growth and Climate Change 2017

Comments

To address these gaps, staff retained a consultant to develop a Corporate Green Building (CGB) Standard for new construction and major renovation[4] building projects containing a comprehensive set of environmental performance requirements that establish the City as a leader in sustainable buildings in Canada. The consultant reviewed various standards, including LEED®, ASHRAE® 189.1, Living Building Challenge, PassivHaus®, and Net Zero Energy Buildings, against our mandate to improve environmental performance, reduce costs, and place Mississauga as a leader in green buildings for new corporate buildings and major renovation4. Ultimately, it was found that no single certification/standard met all of the City's sustainable priorities in a financially sustainable manner. Hence, a "Made for Mississauga" CGB Standard was recommended.

The City's CGB Standard is a set of performance requirements that applies to new construction and major renovation in City-owned buildings of the following archetypes:

Office	Fire Hall	Library	Recreation Centre
Ice Rink	Swimming Pool	Transit Station	Transit Repair Station

It has been designed to allow flexibility to project teams with respect to the level of energy and environmental performance that can be achieved on a given project. It sets three (3) increasing levels of performance that 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 and major renovation City-owned buildings of the above archetypes i.e. projects must achieve this minimum level of performance.
- **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.
- **Level 3**: This level outlines a set of environmental performance targets that are considered "superior" and that should be pursued wherever parameters allow.

Targets have been set for 17 key environmental performance areas (Table 1), and project teams will be encouraged to achieve the highest level of performance while remaining within a given budget and schedule. The performance targets and deliverables for all the environmental performance areas have been provided in Appendix 1.

[4] For the purposes of the CGB Standard, "major renovation" refers to extensive alteration work to an existing building to the extent such that the primary function of the space cannot be used for its intended purpose while the work is in progress and where a new certificate of occupancy is required before the work area can be reoccupied.

<table>
<tr><th>Energy and Climate Change</th><th>Natural Heritage</th><th>Materials</th></tr>
<tr><td rowspan="5">Energy and emissions performance
Building commissioning
On-site renewables
Air tightness testing
Metering and benchmarking
Resilient structures</td><td>Erosion and sediment control
Light pollution
Biodiversity</td><td>Low-impact materials
Embodied carbon Footprint
Ozone depleting compounds</td></tr>
<tr><th>Water</th><th>Waste</th></tr>
<tr><td>Stormwater management
Water use intensity</td><td>Construction waste management</td></tr>
<tr><th colspan="2">Transportation</th></tr>
<tr><td colspan="2">Electric vehicle infrastructure
Bicycle infrastructure</td></tr>
</table>

Table 1: Key Environmental Performance Areas in the Corporate Green Building Standard

In order to reach the City’s long-term goal of a net-zero carbon city, a roadmap (Figure 2: Corporate Green Building Standard Roadmap) for the CGB Standard has been developed that increases the performance level every five (5) years. This roadmap is consistent with the proposed targets in the forthcoming Mississauga Climate Change Action Plan. Such a roadmap is also similar to the approach taken by the Toronto Green Standard and the British Columbia (BC) Step-Code.

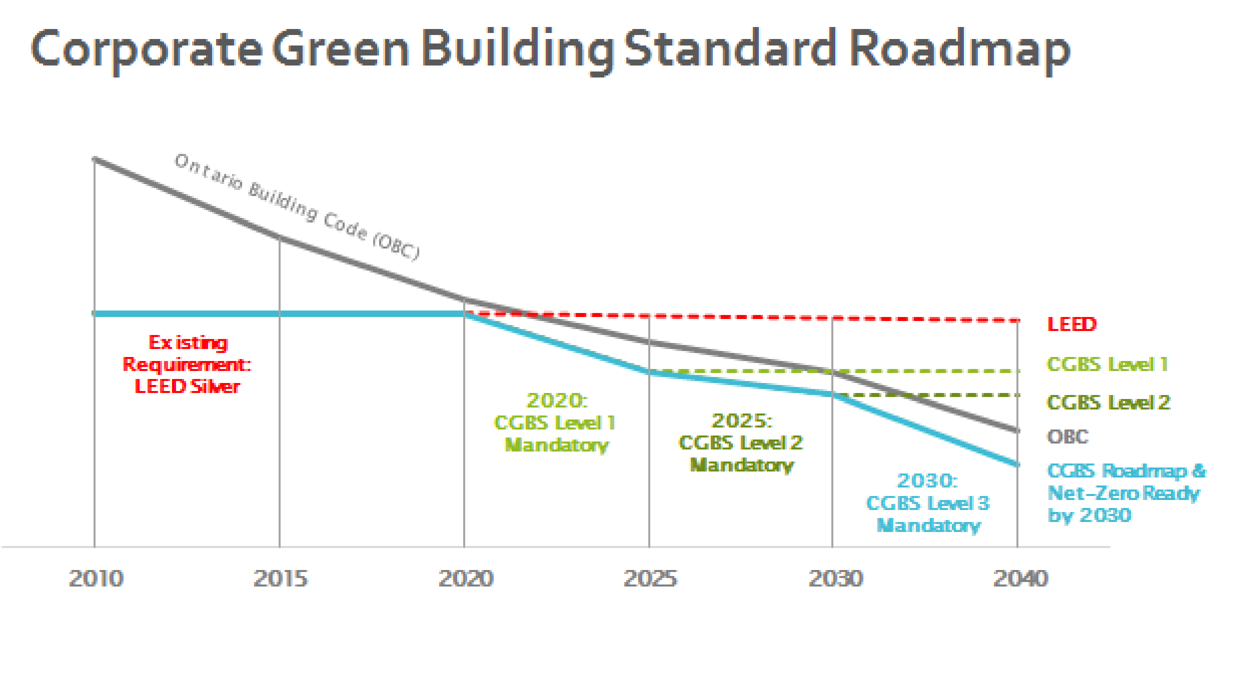


Figure 2: Corporate Green Building Standard Roadmap

Strategic Plan

The endorsement of constructing our future buildings to meet the CGB Standard would be an important step in achieving some of the City’s environmental goals as outlined in the Green

Pillar of the Strategic Plan. The standard also supports the visionary action of transforming Mississauga into a “net-zero” carbon city in the Strategic Action Plan.

Financial Impact

It should be noted 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, experience of design team members, increased time and effort from architects and engineers, construction time spent implementing green building features, and the need for specialized equipment and less-common materials.

While project teams can mitigate cost premiums by incorporating green building solutions early in the design process, it is prudent to account for the total project cost premiums in Table 2 depending on the project. Therefore, it is recommended that, starting 2021, all new construction and major renovation building projects include a cost premium of 2.6% - 5.0% to implement the CGB Standard, and that additional monies be requested through the annual budget cycle for new building projects as appropriate. Since these projects will showcase environmental leadership, staff will also investigate grant opportunities available from high performance new construction programs offered by organizations such as Federation of Canadian Municipalities (FCM), Independent Electricity System Operator, and local distribution companies. It is also recommended that the performance requirements be increased per the roadmap in Figure 2, and that staff be directed to revise the project cost premiums every five (5) years.

Note that the total project cost premiums in Table 2 have been developed by a consultant compared to the current City LEED® Silver standard construction. The range represents the cost premium over the different archetypes of buildings that the City builds and operates.

SN #	Performance Area	Project Cost Premiums		
		Level 1	Level 2	Level 3
1	Energy and emissions performance	0.5% - 2.9%	1.5% - 6.4%	6% - 14%
2	Building commissioning	0.75%	0.85%	1.1%
3	On-site renewables	0.25%	1%	2% - 4%
4	Air tightness testing	0.25%	0.25%	0.25%
5	Metering and benchmarking	0.5%	0.5%	0.5%
6	Resilient structures	0%	0.25%	0.25%
7	Erosion and sediment control	0%	0.15%	0.15%
8	Light pollution	0%	0.5%	0.5%
9	Biodiversity	0%	0.25%	0.5%
10	Stormwater management	0%	0.5%	1%
11	Water use intensity	0%	0.5%	1%
12	Electric vehicle infrastructure	0.25%	0.5%	1%
13	Bicycle infrastructure	0%	0.25%	0.5%
14	Low-impact materials	0%	0.25%	2.5%
15	Embodied carbon footprint	0.1%	0.25%	1.5%
16	Ozone protection	0%	0%	1%
17	Construction waste management	0%	0.1%	0.25%
TOTAL		**2.6% - 5%**	**7.6% - 12.5%**	**20% - 40%**

Table 2: Project Cost Premiums over current City LEED® Silver standard construction

Conclusion

While the LEED® Silver standard was a comprehensive sustainability standard and played a significant role in promoting our sustainability priorities at the time of its adoption, it will soon fall short compared to the increasing levels of energy requirements being introduced at both the provincial and federal levels. New construction and major renovation building projects presents a clean slate, allowing the City to achieve its goals in an environmentally and financially sound way. In fact, a study by the Canadian Green Building Council (CaGBC) found that if all new buildings in Canada over 25,000 square feet were built to achieve net zero carbon level of performance between now and 2030, GHG emissions for this sector would be cut to 17% lower than 2005 levels[5].

A low-to-zero carbon approach to new construction and major renovation building projects will not only be aligned with our forthcoming Mississauga Climate Change Action Plan (i.e. helping to meet our GHG reduction goals) but also supports our visionary action in the City's Strategic Plan to achieve a net-zero carbon city. The City's actions in its own buildings will position itself as a leader in the city and among municipalities.

[5] CaGBC, 2016, Building Solutions to Climate Change: How Green Buildings Can Help Meet Canada's 2030 Emissions Targets.

Originators files: File names

Attachments

Appendix 1: City of Mississauga Corporate Green Building Standard for New Construction and Major Renovations Building Projects

G. Kent.

Gary Kent, CPA, CGA, ICD.D, Commissioner of Corporate Services and Chief Financial Officer

Prepared by: Sumeet Jhingan, P.Eng., CEM, LEED® AP BD+C, Energy Management Section, Facilities & Property Management

City of Mississauga

Corporate Green Building Standard

Prepared on: May 7, 2019
Corporate Services
Facilities & Property Management
Energy Management

MISSISSAUGA

1. Introduction

1.1. Scope

The City of Mississauga's (the City) Corporate Green Building (CGB) Standard is a set of performance requirements that applies to new construction and major renovation in City-owned and operated buildings of the following archetypes:

- Office
- Fire Hall
- Library
- Recreation Centre
- Ice Rink
- Swimming Pool
- Transit Station
- Transit Repair Station

For the purposes of this standard, "major renovation" refers to extensive alteration work to an existing building to the extent such that the primary function of the space cannot be used for its intended purpose while the work is in progress and where a new certificate of occupancy is required before the work area can be reoccupied.

1.2. Intent

The intent is to promote environmentally, financially, and socially responsible practices in building design and construction. It is intended to be a standard and a guide for the City, design, and construction teams to deliver high-performance buildings with market-leading design, construction, and operations practices.

1.3. Environmental Performance Areas

The CGB Standard Is organized into the following environmental performance areas:

Energy and Climate Change	Materials	Transportation
• Energy and emissions performance • Building commissioning • On-Site renewables • Air tightness • Metering and benchmarking • Resilience performance requirements	• Low-impact materials • Embodied carbon footprint • Ozone depleting compounds	• Electric vehicle infrastructure • Bicycle infrastructure
Waste	**Water**	**Natural Heritage**
• Construction waste management	• Stormwater management • Water use intensity	• Erosion and sediment control • Light pollution • Biodiversity

1.4. Structure

The following documentation forms the CGB Standard:

- Corporate Green Building Standard Reference Guide: Provides an overview of the requirements and deliverables for each environmental performance area under the CGB Standard
- Corporate Green Building Standard Program Manual: Provides additional details regarding each environmental performance area under the CGB Standard, including the intent, background, requirements, deliverables, guidance, additional resources, and the energy modelling guidelines
- Archetype Energy Modelling Report for Corporate Green Building Standard: Energy modelling study for the eight (8) City building archetypes used to develop energy and greenhouse gas emissions targets in the CGB Standard
- Corporate Green Building Standard Checklist: Is a Microsoft Excel-based checklist to be utilized by project teams to confirm compliance

Corporate Green Building Standard Reference Guide

1. Energy and Climate Change

1.1. Energy and Emissions Performance

Requirements		
Office Building		
Level 1	**Level 2**	**Level 3**
EUI: 110 kWh/m^2/year **TEDI:** 55 kWh/m^2/year **GHGI:** 15 kgCO2e/m^2/year	**EUI:** 90 kWh/m^2/year **TEDI:** 35 kWh/m^2/year **GHGI:** 10 kgCO2e/m^2/year	**EUI:** 60 kWh/m^2/year **TEDI:** 15 kWh/m^2/year **GHGI:** 5 kgCO2e/m^2/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[1]		
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

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

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 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)		

1.2. Building Commissioning

Level 1 – Requirements	Level 2 – Requirements
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 - Design Drawings - Measurement requirements (BAS points, sub-meters, testing devices - Points to be tracked with frequency and duration - Key performance metric used to evaluate performance - Frequency of analyses after substantial completion and in the warranty period (at least quarterly) - Performance requirements (i.e. compared to design/specification requirements) • Commissioning Report that includes the following: - Owner's Project Requirements - Basis of Design - Reviewed design documents and specifications at various stages - As-Built drawings - Reviewed equipment shop drawings - As-Built control drawings	**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 **Level 2 – Deliverables** **Level 1 +** • System Operation Manual **Level 3 – Requirements**

- Contractor/manufacturer start-up reports and test procedures/execution - Reviewed test, adjust, and balance (TAB) reports - Analysed data and confirmation of performance - Issues and deficiencies log - Repairs (if needed) to maintain performance • Incorporation of commissioning requirements into the construction tender documents must be confirmed • 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 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.
Level 1 – Deliverables	**Level 3 – Deliverables**
• Commissioning Plan • Commissioning Report • Current Facilities Requirements and Operations and Maintenance Plan • Construction Checklists • Functional Test Scripts	**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)

1.3. On-Site Renewables

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

1.4. Air Tightness

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

1.5. Metering and Benchmarking

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 • An IPMVP-compliant Measurement & Verification (M&V) Plan consistent with the metering and monitoring requirements of IPMVP Volume III Option D: Calibrated Simulation
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

1.6. Resilience Performance Requirements

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.*

2. Materials

2.1. Low-impact Materials

<table>
<tr><th>Level 1</th><th>Level 2</th><th>Level 3</th></tr>
<tr><td colspan="3">Requirements</td></tr>
<tr><td>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</td><td>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</td><td>Meet the Materials Petal of the Living Building Challenge.</td></tr>
<tr><td colspan="3">Deliverables</td></tr>
<tr><td>A materials tracking table must be completed and provided in sortable Excel format (a template will be available)
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</td><td>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</td><td>Documentation of compliance with the Living Building Challenge's Materials Petal</td></tr>
</table>

2.2. Embodied Carbon Footprint

<table>
<tr><th>Level 1</th><th>Level 2</th><th>Level 3</th></tr>
<tr><td colspan="3">Requirements</td></tr>
<tr><td>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.</td><td>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.</td><td>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.</td></tr>
</table>

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

2.3. Ozone Depleting Compounds

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**

3. Transportation Performance Requirements

3.1. Electric Vehicle Infrastructure

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

3.2. Bicycle Infrastructure

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

4. Waste Management Performance Requirements

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

5. Water Performance Requirements

5.1. Stormwater Management

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

5.3. Water Use Intensity

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

6. Natural Heritage Performance Requirements

6.1. Erosion and Sediment Control

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

6.3. Light Pollution

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

6.4. Biodiversity

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

The City of Mississauga's Corporate Green Building Standard

Program Manual

MISSISSAUGA

INTEGRAL GROUP

MORRISON HERSHFIELD

Table of Contents

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.

1.1. 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

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

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 17 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 performance • Building commissioning • On-Site renewables • Air tightness • Metering and benchmarking • Resilience performance requirements	• 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.

[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/m^2/year **TEDI:** 55 kWh/m^2/year **GHGI:** 15 kgCO2e/m^2/year	**EUI:** 90 kWh/m^2/year **TEDI:** 35 kWh/m^2/year **GHGI:** 10 kgCO2e/m^2/year	**EUI:** 60 kWh/m^2/year **TEDI:** 15 kWh/m^2/year **GHGI:** 5 kgCO2e/m^2/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,

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

Warnings and Errors

- Take-off Calculations (Modeller's external calculations to support the model inputs). If applicable, calculation for model 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="5">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
- Design Drawings
- Measurement requirements (BAS points, sub-meters, testing devices
- Points to be tracked with frequency and duration
- Key performance metric used to evaluate performance
- Frequency of analyses after substantial completion and in the warranty period (at least quarterly)
- Performance requirements (i.e. compared to design/specification requirements)

• Commissioning Report that includes the following:
- Owner's Project Requirements
- Basis of Design
- Reviewed design documents and specifications at various stages
- As-Built drawings
- Reviewed equipment shop drawings
- As-Built control drawings
- Contractor/manufacturer start-up reports and test procedures/execution
- Reviewed test, adjust, and balance (TAB) reports
- Analysed data and confirmation of performance
- Issues and deficiencies log
- Repairs (if needed) to maintain performance

• Incorporation of commissioning requirements into the construction tender documents must be confirmed

• A current facilities requirements and operations and maintenance plan that contains the information necessary to operate the building efficiently must be prepared and maintained</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><td>Level 2 – Deliverables</td></tr>
<tr><td>Level 1 +

• System Operation Manual</td></tr>
<tr><td>Level 3 – Requirements</td></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><td>Level 1 – Deliverables</td><td>Level 3 – Deliverables</td></tr>
</table>

• Commissioning Plan • Commissioning Report • Current Facilities Requirements and Operations and Maintenance Plan • Construction Checklists • Functional Test Scripts	**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)

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: Enhanced and Monitoring-Based Commissioning

  Enhanced 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. This includes 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.

  In addition, 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.

- 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 that 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 • An IPMVP-compliant Measurement & Verification (M&V) Plan consistent with the metering and monitoring requirements of IPMVP Volume III Option D: Calibrated Simulation
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 credit, 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.

As part of the metering requirements, an International Performance Measurement and Verification Protocol (IPMVP) Measurement and Verification (M&V) Plan should be developed during the Design Development phase and provided to the City's representative for approval. The M&V Plan should be updated to as-built conditions prior to project completion, such that it can be used as a reliable basis for verifying building performance during the occupancy phase.

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		
• A materials tracking table must be completed and provided in sortable Excel format (a template will be available) • 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

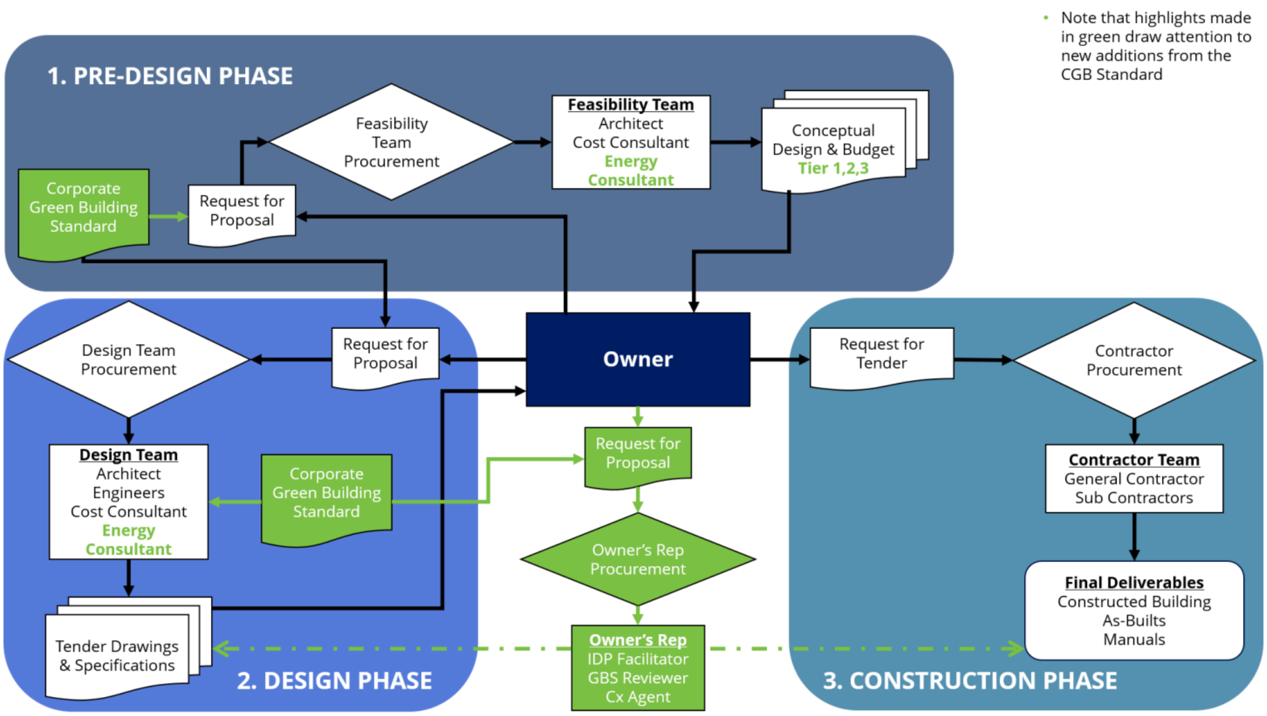
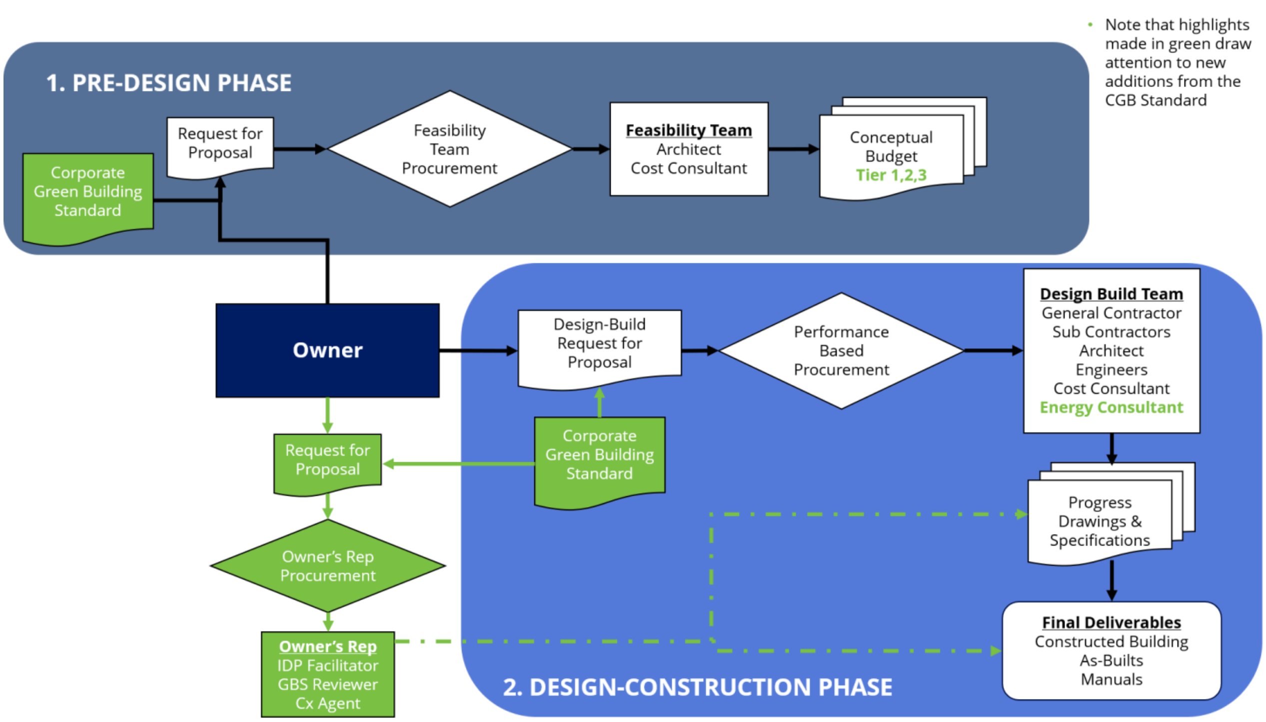


Figure 3: Design-Build Approach with Mississauga CGB Standard Key Steps and Roles



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/

[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.

10.4. 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.

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

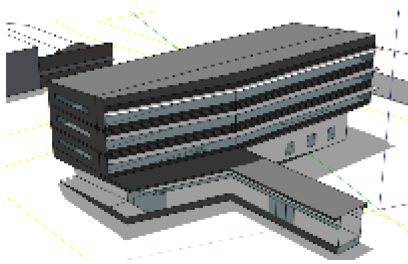
VOC: Volatile Organic Compound

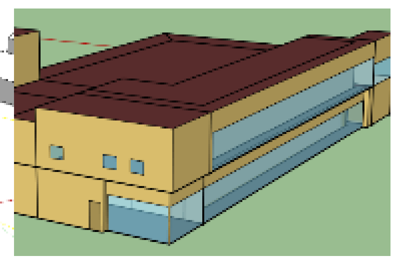
MORRISON HERSHFIELD

FINAL REPORT

Municipal Green Building Standard Redevelopment – Energy Modelling Report

City of Mississauga





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1. EXECUTIVE SUMMARY

The City of Mississauga is in the process of putting policies and actions in motion to place sustainability and climate change mitigation and adaptation as a priority, and has recognized the need to update its existing municipal green building standard (LEED® Silver) for new construction and major renovation projects. The new standard targets a low energy and carbon approach with infrastructure to easily transition to a net zero level of performance in the future.

To specifically address energy and emissions performance, there was a desire to shift from the prescriptive approach towards a performance-based approach for total energy use intensity (TEUI), thermal energy demand intensity (TEDI), and greenhouse gas emissions intensity (GHGI) for key building types, in line with the approach being recently adopted by other progressive municipal green building policies across Canada. Analysis for the inclusion of a cooling energy demand intensity (CEDI) metric was also conducted, but the metric was ultimately not recommended due to reasons outlined in Section 2.3.2 of the report.

In addition, the proposed policy also adopts an absolute targets-based approach, as opposed to a reference building-based approach currently used by the National Energy Code of Canada for Buildings (NECB) and the LEED certification program. A target-based approach focuses on absolute values, rather than a comparative value, and tends to lead to more appropriate design solutions for reducing energy and/or carbon rather than solutions selected for the purpose of outperforming a fictitious reference building. Furthermore, a target-based approach has been used successfully in high performance standards, such as Passive House, and has shown success in reducing actual energy use of operating buildings.

In order to better understand the energy, emissions and cost implications associated with various measures to attain a high performance building design, as well as to set appropriate absolute performance targets for the identified metrics at three discrete levels of performance, an energy modelling study was completed for the six of the most common City of Mississauga building types: administration building, fire hall, library, recreation centre (including pool and/or ice rink), transit station, and transit repair/maintenance facility. The objective of the analysis was to identify how much the City's current energy efficiency requirements could be improved upon while maintaining cost effectiveness, and to develop targets that could lead to reliable energy and greenhouse gas emissions reductions across the City's built environment.

The analysis indicates that there are a wide range of design options that can meet the proposed new performance targets for most archetypes, with varying levels of incremental capital cost and life cycle cost benefit depending on the performance level being targeted. Table 1 summarizes the typical expected energy, greenhouse gas (GHG) emissions, and cost impact over typical practice, based on achieving LEED Silver under the current municipal buildings green standard, on the analyzed building types if they were to comply with the various performance levels for the three new metrics identified.

In general, Level 1 targets represent an improvement in envelope compared with current typical practice, incorporating either triple glazing or higher effective wall performance. Level 2 targets incorporate improved windows and walls, reduced window to wall ratios, and reduced air leakage targets. Level 3 targets add a fuel switch to a lower-carbon fuel, additional lighting savings, additional domestic hot water savings, further improvements to envelope, and any additional available mechanical system savings. These measures are customized to each building type, and targets do not require prescriptive measures so can be customized to individual projects, but the above principles generally were used to set targets for each building type.

Depending on the archetype, it is generally expected that the Level 1 targets will result in energy and GHG emissions savings that are between 2-10% better than current typical practice, Level 2 will result in 15-35% savings, and Level 3 would represent a net-zero ready level of performance with energy and GHG emissions savings ranging between 40-65%.

The incremental capital costs presented in Table 1 are associated the energy efficiency and emissions reduction measures required to attain the TEUI, TEDI and GHGI target for each performance level. In general, incremental capital costs are less than 1% at performance level 1, and range between 4.6% and 18.9% at the highest performance level (i.e. level 3) due to the requirement of more capital-intensive measures for improved building performance to meet the Level 3 targets.

The net present value (NPV) represents the net present value of cost savings over a 25-year lifecycle period, i.e., a positive value indicates that the present value of utility cost savings exceeds that of the incremental capital costs.

For certain archetypes such as the repair/maintenance facility and pool, the NPV increases at the higher performance levels as the lifecycle cost savings from reduced energy consumption outweigh the additional incremental capital costs, and suggests that achieving the higher tiers of performance is more attractive from a lifecycle perspective. For other archetypes such as the administration building, fire hall, recreation centre, and transit station, the economics are less favourable from a 25-year lifecycle period due to the incremental capital costs being greater than the utility cost savings, but pursuing the higher level of performance may still be desirable due to the ancillary benefits associated with GHG emissions reduction, thermal comfort, resiliency, and improved durability of a high-performing building envelope, which would typically provide for savings beyond a 25-year lifecycle period.

Table 1. Archetype Performance Outcomes

Archetype	Energy Savings (%)	GHG Emissions Savings (%)	Incremental Capital Cost (%)	NPV 25-Year Cost Savings ($/m²)
Admin	Level 1: 9.8 Level 2: 26.0 Level 3: 56.6	Level 1: 14.3 Level 2: 32.9 Level 3: 77.1	Level 1: 0.8 Level 2: 1.3 Level 3: 6.9	Level 1: -25.4 Level 2: -27.8 Level 3: -168.3
Fire Hall	Level 1: 2.8 Level 2: 25.4 Level 3: 46.2	Level 1: 1.6 Level 2: 61.2 Level 3: 71.5	Level 1: 0.5 Level 2: 4.8 Level 3: 7.0	Level 1: -18.1 Level 2: -240.1 Level 3: -290.7
Rec Centre	Level 1: 4.9 Level 2: 14.6 Level 3: 63.2	Level 1: 7.6 Level 2: 21.5 Level 3: 84.5	Level 1: 0.7 Level 2: 0.6 Level 3: 6.2	Level 1: -28.3 Level 2: -18.8 Level 3: -170.1
Pools	Level 1: 6.1 Level 2: 32.5	Level 1: 7.3 Level 2: 49.6	Level 1: 0 Level 2: 0	Level 1: 143.2 Level 2: -218.9

Archetype	Energy Savings (%)	GHG Emissions Savings (%)	Incremental Capital Cost (%)	NPV 25-Year Cost Savings ($/m²)
	Level 3: 56.2	Level 3: 85.8	Level 3: 12.2	Level 3: 1138.5
Ice Rinks	Level 1: 1.3 Level 2: 13 Level 3: 48.1	Level 1: 2.1 Level 2: 19.1 Level 3: 63.8	Level 1: 0.5 Level 2: 1.9 Level 3: 5.0	Level 1: -15.5 Level 2: -48.7 Level 3: -30.0
Library	Level 1: 6.9 Level 2: 26.8 Level 3: 67.8	Level 1: 13.1 Level 2: 30.0 Level 3: 78.7	Level 1: 0.8 Level 2: 0.9 Level 3: 4.7	Level 1: -39.9 Level 2: 33.7 Level 3: -54.5
Vehicle Maintenance	Level 1: 11.6 Level 2: 17.1 Level 3: 63.0	Level 1: 12.3 Level 2: 20.0 Level 3: 85.7	Level 1: 0.2 Level 2: 0.6 Level 3: 4.6	Level 1: 43.3 Level 2: 43.3 Level 3: 416.5
Transit Station	Level 1: 14.8 Level 2: 34.0 Level 3: 43.5	Level 1: 25.9 Level 2: 53.9 Level 3: 72.5	Level 1: 0.6 Level 2: 6.1 Level 3: 18.9	Level 1: 52.9 Level 2: -38.4 Level 3: -264.1

2. PROJECT OVERVIEW

2.1 Introduction

Morrison Hershfield has partnered with Integral Group to aid the City of Mississauga in updating its Municipal Green Building Standard as it relates to energy and emissions performance targets. A cost-benefit analysis has been completed for six common archetypes of city-owned buildings in order to make recommendations on the most suitable performance targets, based on energy and emissions savings, as well as technical and economic viability. The six archetype buildings that have been analyzed are an office/administration building, fire hall, library, recreation center, transit station, and transit repair and maintenance facility.

The building energy analysis in this report was completed using EnergyPlus, and costing information is based past projects and information available at the time of the analysis. The impact of a variety of parameters including envelope performance, HVAC system performance, building window-to-wall ratio, and lighting was assessed. The range of conditions analyzed generated a large data set, which was then analyzed using Morrison Hershfield's interactive Building Energy Performance Map to determine trends in the data and derive conclusions in terms of target recommendations. A detailed description of the methodology and analysis is provided in Section 3. Financial rates and assumptions are provided in section 4.1 and Appendices B and C. Detailed model inputs and assumptions for each archetype are summarized in Appendix A. List of Acronyms is provided in Appendix D.

2.2 Scope of Analysis

The objective of the energy modelling study was to better understand the impact of key design parameters on energy and emissions performance of City of Mississauga municipal facilities, and to develop absolute performance-based targets for identified archetype facilities across three discrete levels of performance. A parametric modelling study was completed for the six of the most common City of Mississauga building types: administration building, fire hall, library, recreation centre (including pool and/or ice rink), transit station, and transit repair/maintenance facility.

For each archetype, three levels of absolute performance-based targets were established to generally correspond to the following performance levels:

- Level 1: "Mission Critical" – Required for all new buildings and facilities as a mandatory minimum level of performance, and generally on par or better than the Toronto Green Standard Tier 2 level of performance.

- Level 2: "Highly Desirable" – Performance targets that represent a more ambitious level of performance overall, and serve as an intermediate bridging step between Tiers 1 and 3.

- Level 3: "If Possible" – Performance targets that are considered best in class and should be pursued when project constraints allow. The targets are generally with net zero-ready and net zero energy outcomes, as well as performance levels typically aimed towards Passive House or the Living Building Challenge.

2.3 Energy Performance Approaches and Metrics

2.3.1 Reference Building Approach

Targeting a performance level relative to an energy code, such as the National Energy Code of Canada for Buildings (NECB), is known as a reference building approach. The key features of a reference building approach are:

- The “reference building” is a fictitious building that the design is compared to for assessing performance.
- The reference building predominantly has the same physical characteristics as the proposed design, such as program type, geometry, and orientation.
- The reference building approach normalizes certain assumptions about the building, thereby eliminating any performance biases related to building characteristics that are not typically under the control of the design team. This typically includes characteristics such as occupancy, hours of operation, receptacle and process loads, among others.
- The reference building approach typically uses a strict ruleset that dictates how performance is to be assessed using energy modeling, and how credit is rewarded for energy efficiency measures.
- The reference building approach typically results in a moving target, in that the performance of the reference building changes based on certain characteristics of the design (see below for examples in the NECB). This can sometimes result in situations where better relative performance does not equal better absolute performance.
- The reference building approach does not typically reward innovative strategies that minimize absolute energy use, such as night setback of temperatures, reductions in receptacle and process loads, and other types of measures that would be considered standardized assumptions.

The reference building approach is common throughout North America, with most states in the US, British Columbia, and Ontario referencing some version of ASHRAE 90.1 – Energy Standard for Buildings except Low-Rise Residential Buildings. The NECB is currently referenced in British Columbia, Alberta, Manitoba, Ontario and Nova Scotia. However, the reference building approach is less common in other parts of the world, such as Europe, where a target-based approach is used.

Reference building-based metrics that were considered in this analysis:

Energy and Emissions Savings over Ontario SB-10

This metric looks at the relative energy savings of a particular design over an NECB 2015 reference building (as modified by SB-10) that is minimally compliant with the energy efficiency requirements of Ontario SB-10, and as such provides a baseline that corresponds to the minimum energy performance required for new construction projects in the province. This metric does not rely on utility cost rates or GHG factors to weigh different fuel types and focuses strictly on percentage energy savings.

This metric has the same opportunities and challenges as discussed above for a reference building approach.

Number of LEED v4 Energy Points

This metric is based on the relative energy cost savings of a particular design over an NECB 2011 reference building. This metric relates to the current policy which references LEED (LEED energy points is calculated based on energy cost savings over a baseline).

The current Municipal Green Building Standard requires that large projects (gross floor area greater than 10,000 ft^2) achieve LEED Silver certification whereas small projects (gross floor area less than 10,000 ft^2) be designed to achieve LEED Silver certification, and that a minimum of four (4) energy points be targeted for LEED credit EAc1: Optimize Energy Performance, which translates to a 12% improvement in energy costs over the reference building.

Given that the metric is based on energy costs, it provides an inherent incentive for prioritizing electricity load reductions over reductions in natural gas use due to the higher utility rates for electricity, and may not necessarily be aligned with a low GHG emissions outcome due to the clean nature of Ontario's electricity grid.

This metric also has the same opportunities and challenges as discussed above for a reference building approach. In addition, this metric depends on the cost rates of different fuel type and may need to be updated periodically to account for fuel cost changes.

2.3.2 Target Based Approach

A target-based approach sets absolute targets for energy efficiency. A range of metrics have been used in this approach, such as Energy Use Intensity, Heating Demand Intensity, and Greenhouse Gas Emissions Intensity. These are defined in more detail below. The key features of a target-based approach are:

- It focuses on absolute values, rather than a comparative value. This tends to lead to more appropriate design solutions for reducing energy and/or carbon rather than solutions selected for the purpose of outperforming a fictitious reference building.

- A target-based approach has been used successfully in high performance standards, such as Passive House, and has shown success in reducing actual energy use of operating buildings.

- Targets and metrics can be chosen to achieve the specific outcomes desired by a particular policy (ex. energy, carbon, etc.)

- Targets often have to be set for different building types that inherently have different energy use characteristics; this can make it challenging to implement in a policy intended to capture all buildings.

Recently, some North American jurisdictions have moved from a reference building approach to a target-based approach. One example is the City of Vancouver, where City Council recently adopted a “Zero Emissions Building Plan” that set absolute targets for buildings city-wide. The advantage of such a policy is that it identifies a long-term goal, which in the City of Vancouver’s case is carbon neutral new buildings by 2025, and then sets incremental improvements towards that goal that are transparent and can be planned for by industry.

Given the shift towards a target-based approach in some of the more progressive energy policies across Canada, the City of Mississauga has expressed desire to develop a set of absolute performance-based targets for key metrics that help drive to towards low energy and carbon outcomes. The following metrics have been proposed to be adopted in the redeveloped Municipal Green Building Standard:

Energy Use Intensity (EUI)

This metric looks at the absolute energy use of the building, and is typically varied depending on building type or climate. The metric focuses on lowering overall energy use without consideration of fuel source to improve building energy efficiency, reduce energy costs and stresses on the electrical grid.

Absolute EUI targets have been incorporated into several energy policies across Canada, such as the B.C. Energy Step Code, City of Vancouver’s Zero Emissions Building Plan, and the Toronto Green Standard.

GHG Emissions Intensity

This metric is similar to EUI, but instead of focusing on absolute energy use, it focuses on absolute GHG emissions, with the intent of maximizing GHG reductions by prioritizing savings for high GHG fuels, encouraging low carbon fuel choices, and reducing building emissions.

The incorporation of the GHGI metric into the Municipal Green Building Standard will help for better alignment with City-wide environmental policies such as the Living Green Master Plan and the Green Pillar of the City’s Strategic Plan, which aims to transform Mississauga into a net-zero carbon city as an end-goal.

Annual Heating Load Intensity or Thermal Energy Demand Intensity (TEDI)

This metric represents the amount of heating a building needs to offset building envelope losses and temper ventilation air, prior to any mechanical interventions (with the exception of ventilation heat recovery equipment). The intent of this metric is to maximize passive or near passive systems before looking at heating delivery methods and technology. This metric has been made popular by Passive House, an international high-performance building standard, which promotes highly insulated buildings with exceptional ventilation heat recovery and otherwise simple mechanical systems.

This metric is agnostic to fuel source, with the primary intention of imposing efficient building envelope solutions. According to the Pembina Institute's report on "Accelerating Market Transformation for High-Performance Building Enclosures", in addition to providing energy savings, prioritizing building envelope solutions are also important for the following reasons:

- Building envelope solutions "are long lasting and costly to refurbish, unlike other systems that can be more easily replaced as better technologies become available"
- Building envelope solutions are simpler, "their performance does not depend on complex energy management systems and they are more tolerant to delayed maintenance"
- Reducing heating and cooling demand early in the design process allows for reduction of the size of space conditioning systems, reducing construction cost and ongoing energy demand.
- Better building envelopes "also offer significant non-energy benefits, such as thermal comfort, acoustic isolation, durability, and increased resiliency to power outages and extreme temperature events."

TEDI has attracted interest from policy makers in an effort to promote better building envelopes without being overly prescriptive on requirements. Under current energy codes like ASHRAE 90.1 (ASHRAE, 2007) or NECB (NRC, 2011), there is substantial room to trade-off mechanical and electrical efficiencies with lower performing envelopes. A metric like TEDI elevates the importance of the building envelope, which is viewed as one of the more robust energy saving measures in a building. Unlike mechanical and electrical systems, the building envelope is typically not prone to user or operator error, thereby more likely to realize its projected energy savings.

Moreover, many components of the building envelope typically last the service life of the building, making its initial make-up and performance critical for the building's long-term performance. Finally, efficient building envelopes can provide additional benefits to energy and greenhouse gas emissions reductions, as shown in the "Zero Emissions Building Framework" (City of Toronto, 2017). The analysis done to support this policy showed how improved building envelopes can perform substantially better in power outages and maintain livable space temperatures, even under extended cold periods.

In view of the benefits outlined above, as well as the potential for improvements in energy efficiency of the building envelope relative to current typical practice in the City's municipal buildings, it is recommended that the TEDI be adopted as a target metric in the City's redeveloped Municipal Green Building Standard.

Cooling Energy Demand Intensity (CEDI)

Similar to the TEDI metric, the cooling energy demand intensity metric represents the amount of cooling a building needs to offset heating gains through the building envelope (primarily windows) and to cool ventilation air, prior to any mechanical interventions (with the exception of ventilation heat exchange equipment).

It should be noted that some strategies that seek to reduce TEDI may have an adverse impact on CEDI, and vice versa. For example, passive solar heating through the placement of larger windows on the southern orientation would help reduce space heating demand, thereby reducing TEDI, but would result in increased cooling demand during the summer months, which would lead to an increase in CEDI.

However, given that space cooling does not represent a significant end-use in the Mississauga climate for most archetypes, that the GHG emissions associated with cooling are already low (since it is fuelled by electricity), and the potential for conflict with TEDI, imposing targets for CEDI would not have any significant impact towards driving for low energy and carbon outcomes, and as such is not recommended for inclusion in the redeveloped policy.

3. ARCHETYPE BUILDING DESCRIPTIONS AND CURRENT TYPICAL PRACTICE

Morrison Hershfield modelled building floor plans provided by City of Mississauga, as well as existing energy models from MH's internal database based on real building floor plans from buildings that best reflected the six building types that were to be analyzed.

The energy models were modified to form typical City of Mississauga archetypes, where the key performance criteria, such as building envelope performance, mechanical systems and efficiency, and lighting efficiency, reflected typical strategies that were used in recently built City of Mississauga facilities. The six archetype models were then analyzed in EnergyPlus whole building energy simulation software with properties outlined below. Energy end use break downs are provided for each baseline archetype. Detailed input tables are found in Appendix A.

3.1 Administration Building

The Administration archetype building is 3,800 m^2 office facility. Based on current practices, a City of Mississauga office building typically has effective R-10 walls, R-40 roof, 45% WWR, double-glazed windows with low-e coating (USI of approximately 2.2), window SHGC of 0.3, 70% efficiency heat recovery, typical air infiltration levels, and 50% lighting savings from the reference building (typically all LED lighting). The baseline HVAC system typically consists of a dedicated outdoor air system with heat recovery providing ventilation air, and fan coils which cycle to serve heating and cooling loads supplied by a high efficiency central boiler and chiller plant.

The baseline energy end-use breakdown is shown in Figure 1, and indicates natural gas use for space heating accounts for the majority of the energy consumption (i.e. more than 50%), followed by lighting and plug loads.

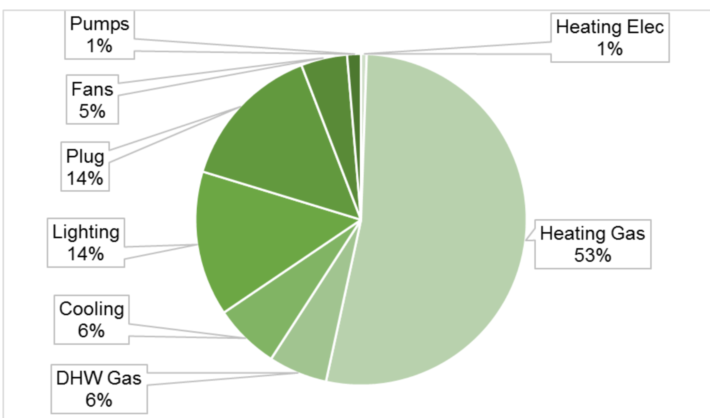

Figure 1: Administration Building - Baseline Energy End-Use Breakdown

Parameters varied include effective wall (R-5 to R-40), roof (R-20 to R-60), window thermal (USI 2.2 to 0.8) and air tightness performance, glazing ratio (15% to 45%), heat recovery efficiency (70% to 90%), lighting savings (50% to 70%), and two central plant types.

Table 2 shows the key performance metrics associated with the baseline condition. The baseline design performs well against the SB-10 building code-minimum (35% energy savings) as well as the LEED v4 baseline (39% cost savings), due to the presence of ventilation air heat recovery, high efficiency plant systems, electric load reductions from LED lighting, and DOAS system reducing airflows and eliminating reheat energy. However, more than 50% of the end-use breakdown is accounted for by space heating which is fueled by emissions-intensive natural gas, and as such represents the most significant opportunity from both an energy and carbon perspective.

Table 2: Office Archetype - Baseline Performance Characteristics

TEUI (kWh/m^2.yr)	119
TEDI (kWh/m^2.yr)	62
CEDI (kWh/m^2.yr)	22
GHGI (kgCO$_{2,eq}$/m^2.yr)	15
Electricity EUI (kWh/m^2.yr)	49
Gas EUI (kWh/m^2.yr)	70
Energy Cost (\$/m^2.yr)	10
SB-10 Energy Savings (%)	35
SB-10 GHG Savings (%)	27
LEED Cost Savings (%)	39
LEED v4 Points	15

3.2 Fire Hall

The Fire Hall archetype building is 1,500 m^2 facility including a 570 m^2 partially conditioned apparatus bay. The facility also included dorms, offices, and a kitchen. The baseline HVAC system consists of a dedicated outdoor air system with 60% effective heat recovery providing ventilation air to the main building, and terminal units which cycle to serve heating and cooling loads supplied by a variable refrigerant flow (VRF) system. The apparatus bay is heated by gas-fired infrared unit heaters. Kitchen and apparatus bay exhaust requirements are provided by dedicated make-up air units. Both make-up air units are assumed to operate 4 hours per day.

Parameters varied include effective wall, roof, and window thermal and air tightness performance, glazing ratio, domestic hot water load savings, heat recovery efficiency, lighting savings, option of hydronic radiant slab heating for the apparatus bay, and option of heat recovery for the apparatus bay and kitchen make-up air units. The typical City of Mississauga building has effective R-10 walls (including wall separating apparatus bay and conditioned space), R-40 roof, 15% Window to Wall Ratio (WWR), double-glazed windows with low-e coating and Solar Heat Gain Coefficient (SHGC) of 0.3, 60% efficiency heat recovery on the main building, dedicated outdoor air system (DOAS), typical air infiltration levels, 50% lighting savings from the reference building, 20% domestic hot water savings from low-flow fixtures, and a VRF system.

The baseline energy end-use breakdown is shown in Figure 2, and indicates natural gas use for domestic hot water heating accounts for 30% of total energy consumption, whereas space heating energy from a combination of electric-based heating from the VRF system and gas-fired infrared heaters accounts for 37% of energy consumption in total.

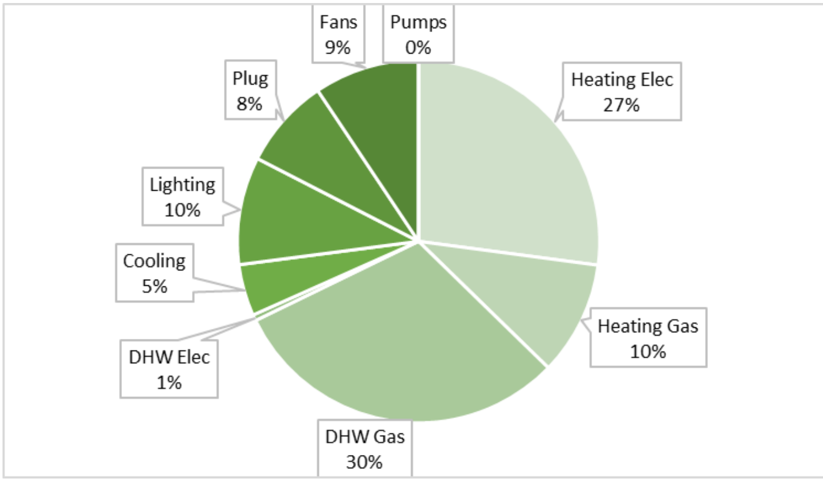

Figure 2: Fire Hall - Baseline Energy End-Use Breakdown

Table 3 shows the key performance metrics associated with the baseline condition. The baseline design performs well against the SB-10 building code-minimum (34% energy savings) as well as the LEED v4 baseline (47% cost savings), due to the presence of ventilation air heat recovery, high efficiency VRF with DOAS system for the HVAC, and electric load reductions from LED lighting.

Table 3: Fire Hall Archetype - Baseline Performance Characteristics

TEUI (kWh/m^2.yr)	109
TEDI (kWh/m^2.yr)	84
CEDI (kWh/m^2.yr)	14
GHGI (kgCO$_{2,eq}$/m^2.yr)	11
Electricity EUI (kWh/m^2.yr)	65
Gas EUI (kWh/m^2.yr)	44
Energy Cost ($/m^2.yr)	9
SB-10 Energy Savings (%)	34
SB-10 GHG Savings (%)	31
LEED Cost Savings (%)	47
LEED v4 Points	17

3.3 Recreation Centre

The Recreation Centre archetype building is 8,420 m^2 facility excluding the pool and ice rinks. The facility includes a fitness facility, gym, change rooms, multipurpose space, and offices. The base HVAC system consists of single-zone constant volume unitary systems for the fitness centre, multipurpose room and gym, with variable air volume (VAV) air handlers with baseboard heaters at the zone level for the remainder of the building, supplied by a high efficiency central boiler and magnetic bearing chiller plant.

The results are presented below for the recreation centre excluding the pool and ice rinks. Pool energy use is both very large, and highly dependent on pool water set point temperature, room air temperature and relative humidity set points, and hygiene related water turn-over rates, which are dictated by the specific type of pool and intended end user. Similar to pool, ice rink energy use is both large and highly dependent on rink size and set points. The large loads of the pool and/or ice rinks also make it difficult to assess the impact of each parameter on the rest of the building.

Parameters varied include effective wall, roof, and window thermal performance, glazing ratio, heat recovery efficiency, lighting savings, domestic hot water (DHW) savings and option of VRF with dedicated outdoor air system for the HVAC.

The typical City of Mississauga archetype building has R-10 effective walls, R-40 roof, 30% WWR, double-glazed windows with low-e coating and SHGC 0.3, 60% efficiency heat recovery on the main building ventilation unit, 50% lighting savings from the reference building, and a high efficiency condensing central boiler and magnetic bearing chiller plant to serve the VAV systems.

The baseline energy end-use breakdown is shown in Figure 3, and indicates natural gas use for space heating accounts for 38% of total energy consumption, followed by lighting (20%), and domestic hot water (16%). These results exclude pool and ice rink use, which are presented separately below.

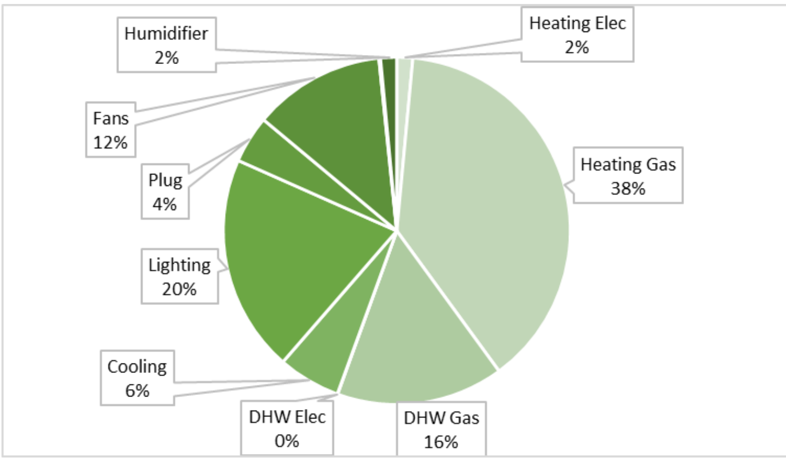

Figure 3: Recreation Centre - Baseline Energy End-Use Breakdown

Table 4 shows the key performance metrics associated with the baseline condition. The baseline design performs well against the SB-10 building code-minimum (27% energy savings) as well as the LEED v4 baseline (54% cost savings), due to the presence of ventilation air heat recovery, high efficiency condensing boilers and magnetic bearing chillers, and significant electric load reductions from LED lighting.

Table 4: Recreation Centre Archetype – Baseline Performance Characteristics

TEUI ($kWh/m^2.yr$)	167
TEDI ($kWh/m^2.yr$)	48
CEDI ($kWh/m^2.yr$)	37
GHGI ($kgCO_{2,eq}/m^2.yr$)	20
Electricity EUI ($kWh/m^2.yr$)	81
Gas EUI ($kWh/m^2.yr$)	86
Energy Cost ($\$/m^2.yr$)	12
SB-10 Energy Savings (%)	27
SB-10 GHG Savings (%)	26
LEED Cost Savings (%)	54
LEED v4 Points	18

3.3.1 Recreation Centre Pools

The pool complex in the Rec centre was modelled separately in order to assess the impacts of the pool's energy conservative measures separately. Several different design parameters were explored to determine the energy and cost savings of the Rec centre pool complex.

The main factors that affect energy use are pool water set point temperature, HVAC system, use of outdoor air economizing and heat recovery efficiency. Building envelope and lighting have little effect on overall pool energy use, and climate has a minor effect. The pool cover (assumed to be liquid cover) has a fixed effect, which becomes more significant once other methods are employed to reduce loads.

Heat recovery is effective in reducing total energy use of the building, and it has a significant effect on TEDI, as heat recovery combined with an outdoor air economizer allows more warm, dry outdoor air to be supplied, reducing the need to cool and reheat recirculated air.

The following options were considered for the parametric modelling analysis:

- Room Air Temperature: Option of 27C or 29C
- Pool Type: Leisure Pool at 34C, Main Pool at Main Pool at 30C, and Whirlpool at 40C
- Window Performance: High-performance double-glazed (USI 2.2) or Passive-House level triple-glazed (USI 0.8)

- Window Solar Heat Gain Co-efficient of 0.3 or 0.5
- Heat Recovery Effectiveness: None, 70% or 90%
- HVAC: Option of air-source heat pump, condensing boiler with mechanical DX cooling, heat recovery dehumidification unit with heat recovery to air, or heat recovery dehumidification unit with heat recovery to plant (i.e. able to offset both pool water heating and ventilation air heating loads).
- Infiltration ranging between code and Passive House levels of airtightness
- Lighting savings between 0% and 50% relative to code
- Window-to-wall ratio ranging between 15% and 80%
- Option of liquid pool cover
- Option of outdoor air economizer
- Pool changeover rate ranging between 2 and 4 hours
- Domestic hot water load savings ranging between 20% (low-flow fixtures) and 40% (drain water heat recovery)

The typical City of Mississauga pool is assumed to have a pool water temperature of 30C, room air temperature of 29C, heat recovery dehumidification unit with 70% effective heat recovery to offset both ventilation and pool water heating loads, double-glazed windows, 50% lighting savings from LED lighting, 80% window-to-wall ratio, no liquid pool cover, outdoor air economizer, pool changeover rate of 4 hours, and 20% DHW load savings from low-flow fixtures.

The baseline energy end-use breakdown is shown in Figure 4, and indicates natural gas use for pool water and ventilation air heating accounts for 73% of the total energy consumption, followed by fans (12%), and pumps 7%).

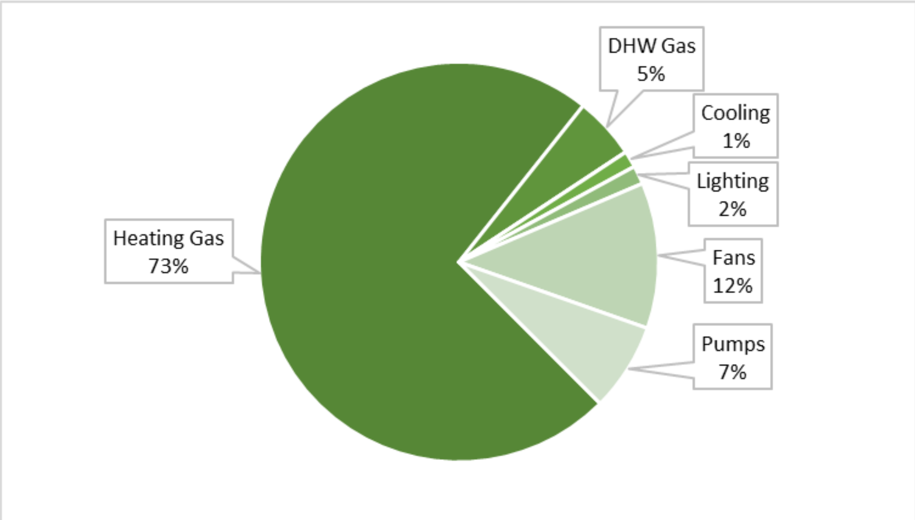

Figure 4: Pool - Baseline Energy End-Use Breakdown

Table 5 shows the key performance metrics associated with the baseline condition. It should be noted that the metrics are normalized by pool surface area, and not room area. The baseline design performs relatively well against the SB-10 building code-minimum (29% energy savings) as well as the LEED v4 baseline (17% cost savings), due to the presence of pool water heat recovery and LED lighting, but savings are limited compared to the other archetypes due to the intensive nature of the pool water process load.

Table 5: Pool Archetype – Baseline Performance Characteristics

TEUI (kWh/m^2.yr)	3,902
TEDI (kWh/m^2.yr)	904
GHGI (kgCO$_{2,eq}$/m^2.yr)	602
CEDI (kWh/m^2.yr)	186
Electricity EUI (kWh/m^2.yr)	849
Gas EUI (kWh/m^2.yr)	3,053
Energy Cost ($/m^2.yr)	182
SB-10 Energy Savings (%)	29
SB-10 GHG Savings (%)	33
LEED Cost Savings (%)	17
LEED v4 Points	6

*__Note:__ All metrics are reported on the basis of pool surface area.

3.3.2 Recreation Centre Ice Rinks

Similar to the pool, the ice rink was also modelled separately from the recreation centre archetype due to the atypical nature of the ice rink refrigeration loads, and in order to better assess the energy efficiency measures specific to ice rinks.

The typical City of Mississauga ice rink is assumed to have the following characteristics:

- Low-emissivity ceiling
- Reciprocating refrigeration compressors equipped with variable frequency drives (VFDs) and refrigeration heat recovery serving subfloor and DHW pre-heat.
- Ventilation air heat recovery with 60% effectiveness
- Brine loop with modulating flow and VFDs on all pumps
- Ice surface temperature of 22F, air temperature of 45F and relative humidity of approximately 50%
- Hot water resurfacing temperature of 120F
- Opaque wall performance of effective R-10, roof R-30, double-glazed thermally broken windows, and window-to-wall ratio of approximately 10%
- LED lighting with controls, typically 50% better than code

The baseline energy end-use breakdown is shown in Figure 5, and indicates that the ice rink refrigeration loads account for the most significant portion of the facility (38%), followed by heating energy associated with space heating and ice resurfacing (34%).

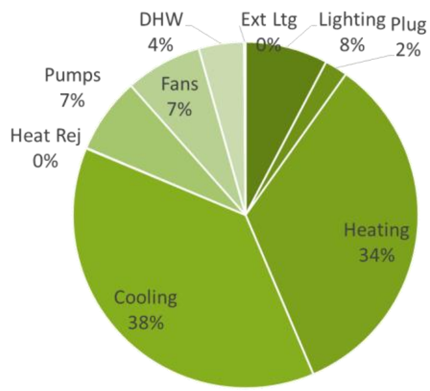

Figure 5: Ice Rink – Baseline Energy End-Use Breakdown

Table 6 shows the key performance metrics associated with the baseline condition.

Table 6: Ice Rink Archetype – Baseline Performance Characteristics

TEUI (kWh/m^2.yr)	385
TEDI (kWh/m^2.yr)	150
CEDI (kWh/m^2.yr)	185
GHGI (kgCO$_{2,eq}$/m^2.yr)	47
Electricity EUI (kWh/m^2.yr)	239
Gas EUI (kWh/m^2.yr)	146

3.4 Library

The Library archetype building is 1,280 m^2 facility including shelf areas, study areas, office and meeting spaces. The baseline HVAC system consists of packaged single zone rooftop units with DX cooling coils, condensing gas coil, ventilation air heat recovery and electric steam humidification providing ventilation air.

Parameters varied include effective wall, roof, and window thermal and air tightness performance, glazing ratio, heat recovery efficiency, lighting savings, and the option of a VRF with DOAS HVAC system.

The typical City of Mississauga library has effective R-10 walls, R-40 roof, 30% WWR, higher performance double-glazed windows with low-e coating and SHGC 0.3, 60% efficiency heat recovery on the main building ventilation unit, typical air infiltration levels, and LED lighting with 50% savings relative to code.

The baseline energy end-use breakdown is shown in Figure 6, and indicates that natural gas usage for space heating accounts for the largest energy-end use (45%), followed by fans (28%) due to the usage of constant volume rooftop units.

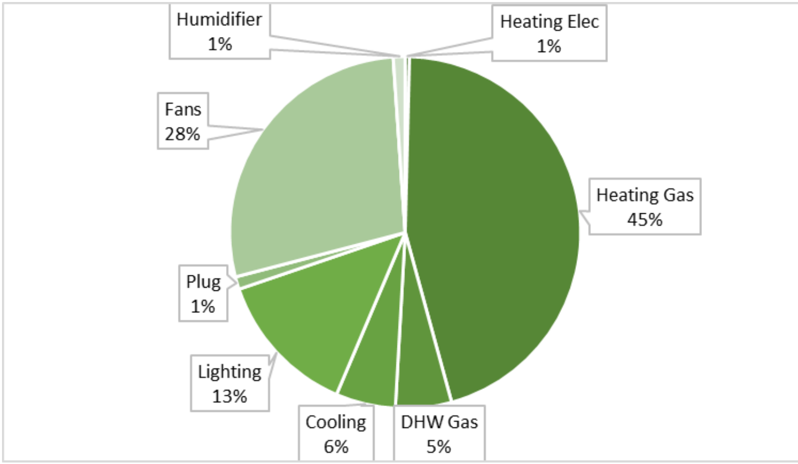

Figure 6: Library – Baseline Energy End-Use Breakdown

Figure 6 shows the key performance metrics associated with the baseline condition. Despite the presence of ventilation air heat recovery and efficient lighting, the baseline design performs only marginally better relative than the SB-10 baseline (8% improvement in energy efficiency) due to the usage of constant volume rooftop units and inferior thermal performance of the building envelope. However, the LEED cost savings are much higher (40%) due to the electrical cost savings from LED lighting.

Table 7: Library Archetype – Baseline Performance Characteristics

TEUI ($kWh/m^2.yr$)	147
TEDI ($kWh/m^2.yr$)	55
GHGI ($kgCO_{2,eq}/m^2.yr$)	16
CEDI ($kWh/m^2.yr$)	31
Electricity EUI ($kWh/m^2.yr$)	60
Gas EUI ($kWh/m^2.yr$)	67
Energy Cost ($\$/m^2.yr$)	15
SB-10 Energy Savings (%)	8
SB-10 GHG Savings (%)	-1
LEED Cost Savings (%)	40
LEED v4 Points	15

3.5 Transit Repair and Maintenance Facility

The Transit Repair and Maintenance Facility is a one-storey 21,400 m^2 facility that includes bus storage, fueling bays, repair garage, wash bay, parts storage and workshop, as well as admin areas, and is modelled based on the Edwards J Dowling facility. The base HVAC for the admin space includes VAV rooftop units with heat recovery, DX cooling, gas heating and perimeter hydronic radiators, whereas the repair and storage spaces are served by gas-fired makeup air units with heat recovery, and supplemented with gas-fired infrared unit heaters.

Parameters varied include effective wall, roof, window and overhead door thermal and air tightness performance, heat recovery efficiency and pre-heat setpoint temperature, lighting savings, option of air-source heat pumps with DOAS, and option of demand-controlled ventilation with up to 50% reduction in outdoor air.

The typical City of Mississauga facility has R-10 walls, R-40 roof, negligible glazing area, R-4 overhead door, 70% efficiency heat recovery on DOAS, high efficiency condensing boiler, gas-fired infrared unit heaters for the storage and repair areas, typical air infiltration levels, and LED lighting resulting in 50% savings relative to code lighting power densities.

The baseline energy end-use breakdown is shown in Figure 7, and indicates that natural gas usage for space heating accounts for the largest energy-end use (56%), followed by fans (26%), due to the large quantities of outdoor makeup air that are required to be brought into the facility.

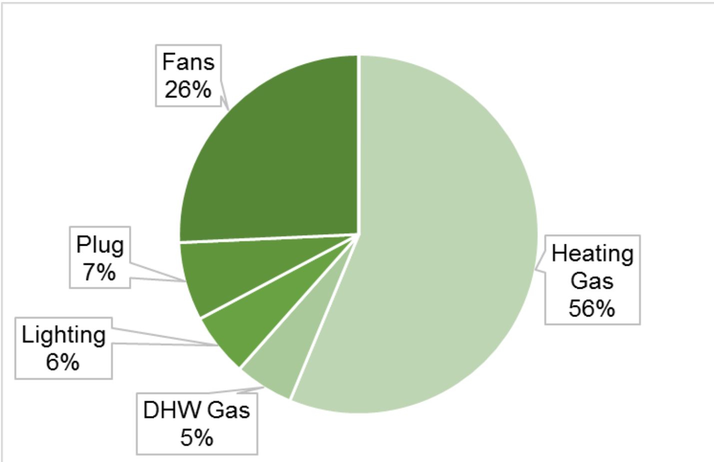

Figure 7: Transit Repair and Maintenance Facility – Baseline Energy End-Use Breakdown

Table 8 shows the key performance metrics associated with the baseline condition. The baseline design performs well against the SB-10 minimum performance (24% energy savings) as well as LEED (30% cost savings) due to the incorporation of ventilation air heat recovery in all makeup air units as well as electrical load reduction from LED lighting. The magnitude of the absolute performance metrics (TEUI, TEDI and GHGI) are higher than the other archetype facilities due to the continuous 24x7 operation of the facility.

Table 8: Transit Repair and Maintenance Archetype – Baseline Performance Characteristics

TEUI (kWh/m^2.yr)	332
TEDI (kWh/m^2.yr)	135
CEDI (kWh/m^2.yr)	0.2
GHGI (kgCO$_{2,eq}$/m^2.yr)	43
Electricity EUI (kWh/m^2.yr)	134
Gas EUI (kWh/m^2.yr)	199
Energy Cost ($/m^2.yr)	19
SB-10 Energy Savings (%)	24
SB-10 GHG Savings (%)	30
LEED Cost Savings (%)	30
LEED v4 Points	12

3.6 Transit Station

The transit station is a two storey 265 m^2 facility that includes a passenger waiting area, elevator shaft with associated machine room, janitor's closet and mechanical and electrical service rooms. The baseline HVAC system consists of radiant heaters in the waiting area served by a high efficiency condensing boiler, unit heaters in the mechanical room, DX split A/C unit in electrical and elevator machine rooms. Outdoor ventilation air for the passenger area is provided through an energy recovery ventilator (ERV).

Parameters varied include effective wall, roof, and window thermal and air tightness performance, window solar heat gain co-efficient, glazing ratio, heat recovery efficiency, lighting savings, and option of VRF with DOAS HVAC system.

The typical City of Mississauga building currently has R-10 walls, R-40 roof, 70% WWR, double-glazed windows with low-e coating and SHGC 0.3, 70% efficiency heat recovery, typical air infiltration levels, and LED lighting resulting in 50% lighting savings from code lighting power densities.

The baseline energy end-use breakdown is shown in Figure 8, and indicates that natural gas usage for space heating accounts for the largest energy-end use (54%), followed by plug loads (17%) which includes the electrical energy associated with operation of the elevators.

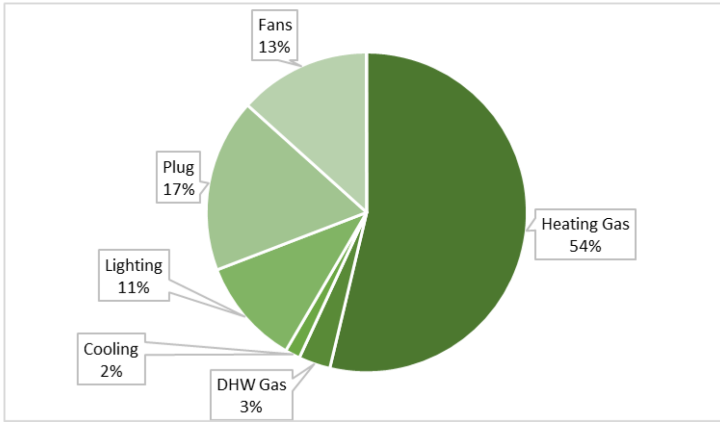

Figure 8: Transit Station – Baseline Energy End-Use Breakdown

Table 8 shows the key performance metrics associated with the baseline condition. Despite the high proportion of glazing area, the baseline design performs well against the SB-10 minimum performance (32% energy savings) as well as LEED (39% cost savings) due to the incorporation of ventilation air heat recovery for the outdoor air system serving the waiting area, condensing boilers and electrical load reduction from LED lighting. The magnitude of the absolute performance metrics (TEUI, TEDI and GHGI) are higher than the other archetype facilities due to the longer operating hours of the facility.

Table 9: Transit Repair and Maintenance Archetype – Baseline Performance Characteristics

TEUI (kWh/m^2.yr)	267
TEDI (kWh/m^2.yr)	152
CEDI (kWh/m^2.yr)	15
GHGI (kgCO$_{2,eq}$/m^2.yr)	34
Electricity EUI (kWh/m^2.yr)	112
Gas EUI (kWh/m^2.yr)	155
Energy Cost (\$/m^2.yr)	21
SB-10 Energy Savings (%)	32
SB-10 GHG Savings (%)	21
LEED Cost Savings (%)	39
LEED v4 Points	15

4. PARAMETRIC ANALYSIS OF ENERGY, COST, AND CARBON OUTCOMES

The energy models described above and in Appendix A were run through an optimization process to identify the intersections of critical metrics so that a robust energy performance policy could be developed. The optimization process involves running a large-scale parametric analysis of each archetype, where various combinations of energy efficiency measures are run, with the number of options in the thousands or tens of thousands per building. For each option, energy, carbon and financial metrics are extracted. The variations in inputs vary by building, but typically involve the following:

- Wall and Roof Effective R-Values
- Window U-values and SHGC
- Window Area / Window to Wall Ratio (WWR)
- Infiltration (Code: 2.03 L/s/m^2 @ 75 Pa, Improved: 0.8 L/s/m^2 @ 75 Pa)
- Ventilation Heat recovery efficiency and pre-heat set-point temperature
- Heating fuel source (condensing boiler, air-source heat pump or VRF)
- Lighting Savings

The measures required to attain the effective wall and window performance modelled is detailed in the capital cost data in Appendix B.

The metrics that were extracted for each run included:

- Electricity and Gas Use of building (per m^2 of floor area)
- Total energy use, GHG emissions and thermal energy demand intensities (EUI, GHGI and TEDI) (per m^2 of floor area)
- Energy, and GHG savings over Building Code (Ontario SB-10)
- Incremental Capital Cost, expressed as a percentage of total construction cost
- Annual Utilities cost of building (per m^2 of floor area)
- NPV Savings over typical design– This is the present value of the financial benefit over the 20-year study period.
- Peak demand for electricity, heating and cooling
- Breakdown of energy consumption by end-use and fuel type

4.1 Economic Information

Table 10 summarizes the economic parameters used in the energy cost benefit analysis, including utility and carbon rates, escalation rates, and GHG emission factors.

Table 10. Utility Rates, GHG Emissions Factors, and Financial Parameters

Parameter	Value
Electricity Utility Cost	**Time of Use Rate Structure Provided by the City (Refer to Appendix C)**
Electricity Utility Cost Escalation Rate (conventional and renewable)	**3.0%**
Natural Gas Utility Cost	**Rate Structure Provided by the City (includes carbon tax) (Refer to Appendix C)**
Natural Gas Utility Cost Escalation Rate	**2.4%**
Discount Rate	**3%**
Current Grid Electricity GHG Emissions Factor (Based on Regional Factor for Ontario)	**0.040 kgCO2/kWh**
Natural Gas GHG Emissions Factor	**0.183 kgCO2/kWh**
Capital Costs for Modeled Energy Efficiency Measures	**See Appendix B**
Solar PV capital cost	**$3.0/Watt**
Solar PV annual production factor	**1,128 kWh/kW**

Capital costs for each of the energy efficiency measures are approximated and based on past MH projects and relevant experience, as well as input provided by an external cost consultant. The incremental capital cost assumptions are detailed in Appendix B. Operations and maintenance costs were not included in the analysis.

4.2 Optimization Analysis

The results of the options analysis were viewed through an interactive data visualization tool developed at Morrison Hershfield. The tool allows one to analyze the relationships between energy efficiency measures and the various energy, carbon and financial outputs, as well as identify any trends or patterns in the data that would point to obvious recommendations for the policy.

The data visualization tool is dynamic and is best viewed live. The tool was used by MH to select and present likely targets and identify natural break points in the data. The screenshots that follow summarize the findings in addition to follow-up analysis conducted by Morrison Hershfield. When viewing the screenshots, note that each vertical line or axis is either an energy model input (right side of screen) or an energy model output (left side of screen). Each wavy line is one, discrete energy simulation. Where the wavy line crosses a particular axis indicates that inputs and outputs that were used or have resulted from that particular simulation. A screenshot with only one wavy line is shown in Figure to illustrate this concept. All screenshots in the body of the report are recreated in full, landscape pages, provided in Appendix C.

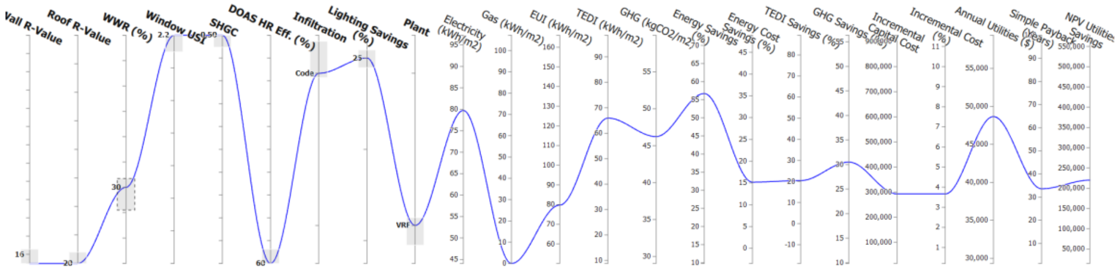

Figure 9. Data Visualization Example

4.3 Administration Building Targets

Table 11 shows the absolute performance targets for TEUI, TEDI and GHGI that have been proposed for the administration building archetype.

Table 11: Administration Building Targets

	Level 1	Level 2	Level 3
EUI	110	90	60
TEDI	55	35	15
GHGI	15	10	5

The Level 1 target for EUI is approximately 8% better than the modelled performance of the typical City of Mississauga administration building built according to current practices, whereas Level 3, which targets the performance level of a net-zero ready building working towards the Living Building Challenge, provides for 50% savings relative to the baseline level.

Typical strategies to achieve the three levels of performance are detailed below:

<u>Level 1</u>

Achieving this level requires the inclusion of many of the energy efficiency measures that are already typical of City's current design practices, which include:

- High efficiency HVAC system which decouples ventilation from heating and cooling function (e.g. DOAS with fan coils)
- Central plant consisting of condensing boilers and magnetic bearing chillers
- LED lighting throughout, typically resulting in 50% savings over code
- 70% effective ventilation air heat recovery on DOAS systems

However, envelope performance is required to be a step up compared to current typical practice, and requires improved opaque wall thermal performance and/or triple glazed IGUs to meet the TEDI target. Furthermore, effective R-values used for the purposes of energy modelling will be required to be inclusive of all thermal bridging, which should result in improved actual performance by addressing the performance gap typically associated with building envelope components.

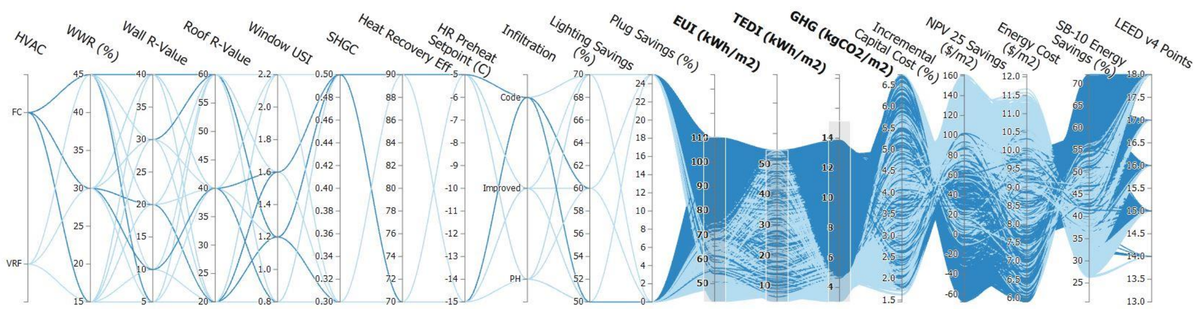

Figure 10: Administration Building Archetype - Level 1 Target Solutions

Level 2

The Level 2 targets see a significant drop in TEDI, which necessitate improved envelope performance through better opaque wall thermal performance, triple-glazed IGUs, reduced window-to-wall ratio, and improved airtightness relative to the code baseline.

A switch-over to electric-based heating is not required at this level in order to meet the TEUI and GHGI targets.

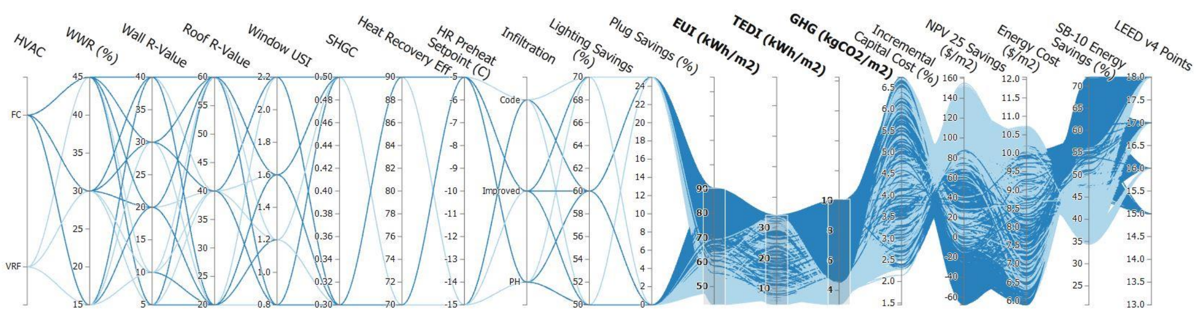

Figure 11: Administration Building Archetype - Level 2 Target Solutions

Level 3

The Level 3 targets ratchet up the building envelope requirements, resulting in the use of high performance (i.e. Passive House level) windows, reduced window-to-wall ratio, typically R-20 effective walls, increased lighting savings through improved design strategies (i.e. general and localized lighting), higher performance heat recovery with minimal preheat for frost control, demand control ventilation strategies, and a fuel switch from natural gas to electricity through the use of a heat recovery VRF system.

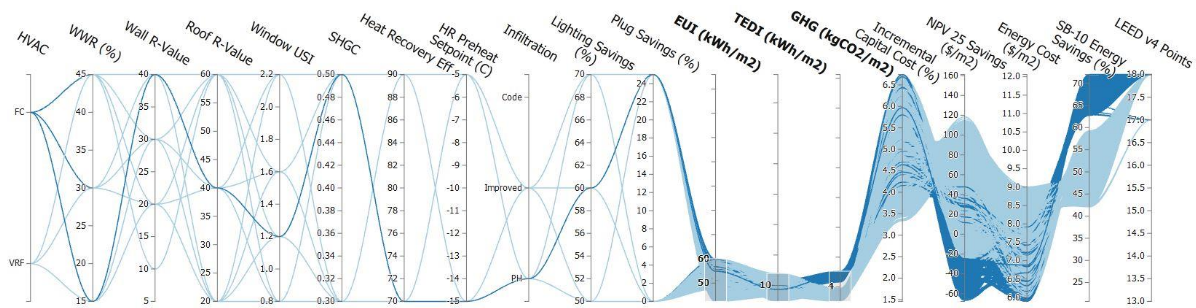

Figure 12: Administration Building Archetype - Level 3 Target Solutions

Table 12 provides the key characteristics of target solutions for the three proposed levels of performance. It should be noted that these are not cost-optimized solutions, but rather based on typical performance packages that are expected to be required to meet the three performance levels, as described above.

Table 12: Administration Building - Target Solution Characteristics

	Level 1	Level 2	Level 3
EUI (kWh/m2)	107	88	52
TEDI (kWh/m2)	50	37	11
GHGI ($kgCO_{2,eq}$/m2)	13	10	3
Incremental Capital Cost (%)	0.8	1.3	6.9
NPV 25 Savings ($/m2)	-25	-28	-168
SB-10 Energy Savings (%)	41	51	53
LEED Cost Savings (%)	41	47	60
LEED v4 Points	15	17	18

4.4 Fire Hall Targets

Table 13 shows the absolute performance targets for TEUI, TEDI and GHGI that have been proposed for the fire hall archetype.

Table 13: Fire Hall Targets

	Level 1	Level 2	Level 3
EUI	105	80	60
TEDI	75	60	30
GHGI	11	5	5

While the Level 1 target for EUI is within the same range of modelled EUI as the typical City of Mississauga fire hall built according to current best practices, the Level 1 TEDI target represents a 9% improvement relative to the baseline level of performance.

Level 3, which targets the performance level of a net-zero ready building working towards the Living Building Challenge, provides for 46% savings relative to the baseline level.

Typical strategies to achieve the three levels of performance are detailed below:

<u>Level 1</u>

Achieving this level requires the Inclusion of many of the energy efficiency measures that are already typical of City's current design practices, which include:

- Gas-fired infrared heaters in the apparatus bay, and VRF-based systems elsewhere
- LED lighting throughout, typically resulting in 50% savings over code
- 70% effective ventilation air heat recovery on DOAS systems
- Low-flow plumbing fixtures

However, envelope performance is required to be a step-up from compared to current typical practice, and requires improved opaque wall thermal performance and/or triple glazed IGUs to meet the TEDI target. Furthermore, effective R-values used for the purposes of energy modelling will be required to be inclusive of all thermal bridging, which should result in improved actual performance by addressing the performance gap typically associated with building envelope components.

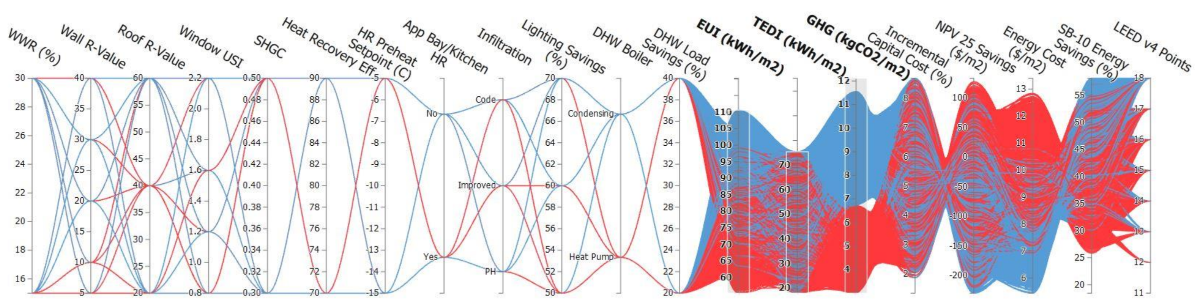

Figure 13: Fire Hall Archetype - Level 1 Target Solutions

<u>Level 2</u>

The Level 2 targets see a significant drop in TEDI, which necessitate improved envelope performance through better opaque wall thermal performance, triple-glazed IGUs, reduced window-to-wall ratio, and improved airtightness relative to the code baseline.

While not absolutely necessary, switchover of DHW heating from condensing boilers to heat-pump based heating may be also contemplated at this point, as well as addition of heat recovery to the apparatus bay and kitchen, in order to achieve the TEUI and GHGI targets.

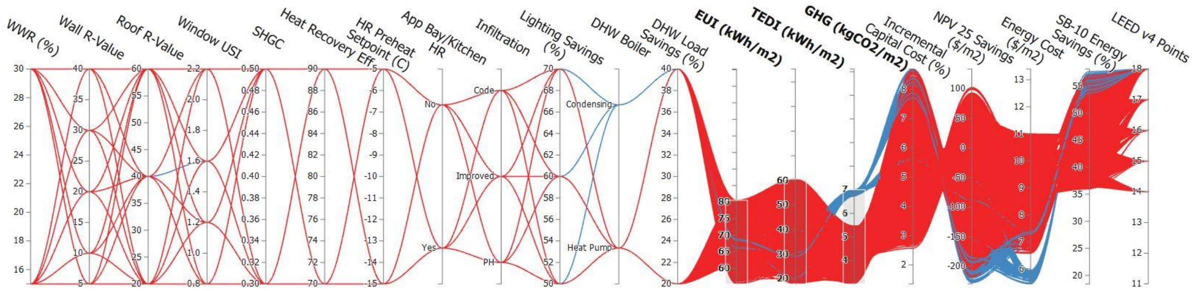

Figure 14: Fire Hall Archetype - Level 2 Target Solutions

Level 3

The Level 3 targets are based on a superior building envelope, resulting in the use of high performance (i.e. Passive House level) windows, reduced window-to-wall ratio, R-20 effective walls, increased lighting savings through improved design strategies (i.e. general and localized lighting), higher performance heat recovery with minimal preheat for frost control, demand control ventilation strategies, increased DHW load savings through more efficient water-use equipment (e.g. drain water heat recovery) and operating best practices. At this level, heat recovery for the apparatus bay and kitchen makeup air units, as well as heat pumps for domestic hot water heating will be required to meet the targets, as shown in the Figure below.

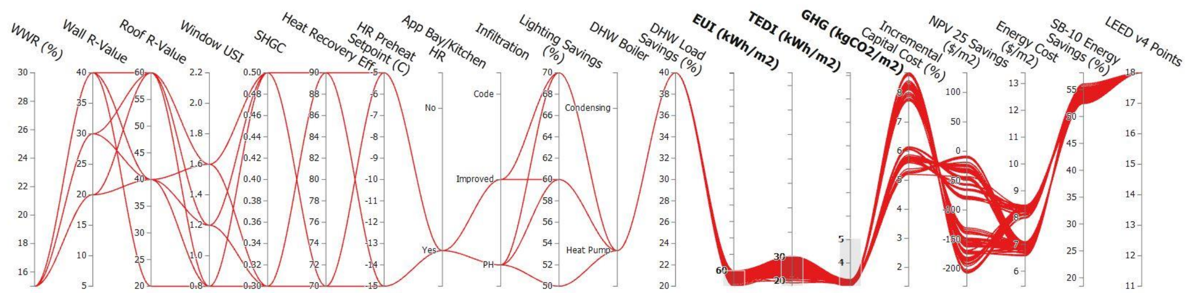

Figure 15: Fire Hall Archetype - Level 3 Target Solutions

Table 12 provides the key characteristics of target solutions for the three proposed levels of performance. It should be noted that these are not cost-optimized solutions, but rather based on typical the performance packages that are expected to be required to meet the three performance levels, as described above.

Table 14: Fire Hall - Target Solution Characteristics

	Level 1	Level 2	Level 3
EUI (kWh/m2)	106	81	59
TEDI (kWh/m2)	74	59	31
GHGI ($kgCO_{2,eq}$/m2)	11	4	3
Incremental Capital Cost (%)	0.5	4.8	7.0
NPV 25 Savings ($/m2)	-18	-240	-291

SB-10 Energy Savings (%)	36	42	53
LEED Cost Savings (%)	49	42	60
LEED v4 Points	17	15	18

4.5 Recreation Centre Targets

Table 15 shows the absolute performance targets for TEUI, TEDI and GHGI that have been proposed for the recreation centre archetype.

Table 15: Recreation Centre Targets

	Level 1	Level 2	Level 3
EUI	160	140	70
TEDI	45	35	15
GHGI	20	15	5

The Level 1 target for EUI is approximately 7% better than the modelled performance of the typical City of Mississauga administration building built according to current practices, whereas Level 3, which targets the performance level of a net-zero ready building working towards the Living Building Challenge, provides for 59% savings relative to the baseline level.

Typical strategies to achieve the three levels of performance are detailed below:

Level 1

Achieving this level requires the Inclusion of many of the energy efficiency measures that are already typical of City's current design practices, which include:

- LED lighting throughout, typically resulting in 50% savings over code
- 70% effective ventilation air heat recovery on DOAS systems
- Low-flow plumbing fixtures

However, envelope performance is required to be a step up compared to current typical practice, and requires improved opaque wall thermal performance and/or triple glazed IGUs to meet the TEDI target. Furthermore, effective R-values used for the purposes of energy modelling will be required to be inclusive of all thermal bridging, which should result in improved actual performance by addressing the performance gap typically associated with building envelope components.

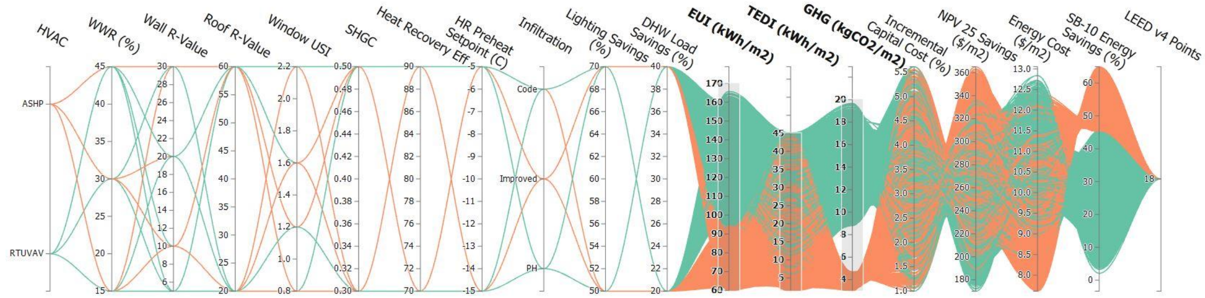

Figure 16: Recreation Centre Archetype - Level 1 Target Solutions

<u>Level 2</u>

The Level 2 targets see a significant drop in TEDI, which necessitate improved envelope performance through better opaque wall thermal performance, triple-glazed IGUs, reduced window-to-wall ratio (i.e. reducing from 45% to 30%), improved airtightness relative to the code baseline, and further reductions in domestic hot water usage through measures such as drain water heat recovery.

A switch-over to electric-based heating is not required at this level in order to meet the TEUI and GHGI targets.

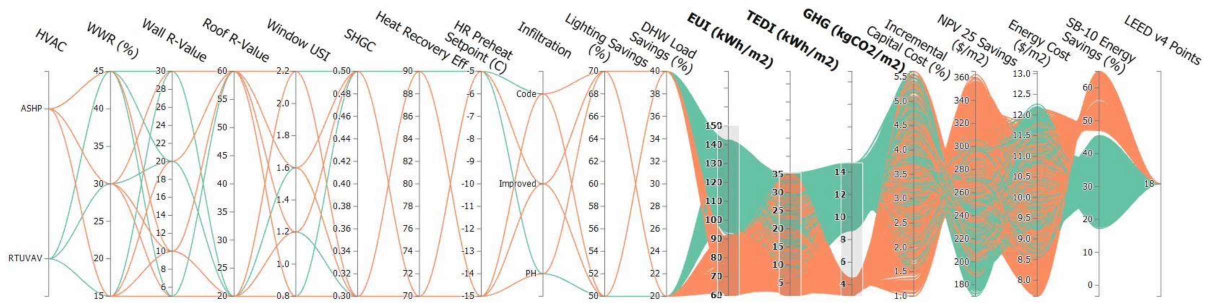

Figure 17: Recreation Centre Archetype - Level 2 Target Solutions

<u>Level 3</u>

The Level 3 targets are based on a superior building envelope, resulting in the use of high performance (i.e. Passive House level) windows, reduced window-to-wall ratio, R-20 effective walls, R-60 roof, increased lighting savings (70% relative to code) through improved design strategies (i.e. general and localized lighting), and higher performance heat recovery (90% effective) with minimal preheat for frost control. At this level, switchover of the HVAC system from gas-fired VAV rooftop units to air-source heat pumps will be required to meet the TEUI and GHGI targets, as shown in the Figure below.

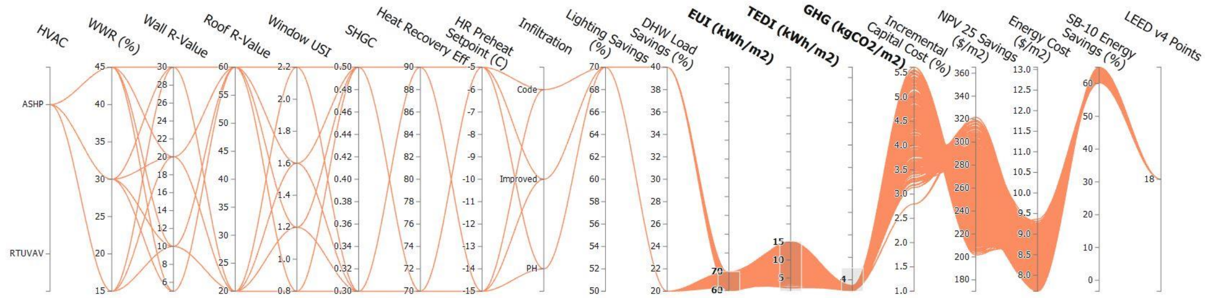

Figure 18: Recreation Centre Archetype - Level 3 Target Solutions

Figure 18 provides the key characteristics of target solutions for the three proposed levels of performance. It should be noted that these are not cost-optimized solutions, but rather based on typical the performance packages that are expected to be required to meet the three performance levels, as described above.

Table 16: Recreation Centre - Target Solution Characteristics

	Level 1	Level 2	Level 3
TEUI (kWh/m2)	159	143	62
TEDI (kWh/m2)	42	36	5
GHGI ($kgCO_{2,eq}$/m2)	18	16	3
Incremental Capital Cost (%)	0.7	0.6	6.2
NPV 25 Savings ($/m2)	-28	-19	-170
SB-10 Energy Savings (%)	10	18	64
LEED Cost Savings (%)	55	56	71
LEED v4 Points	18	18	18

4.5.1 Recreation Centre Pool Targets

Table 17 shows the absolute performance targets for TEUI and GHGI that have been proposed for the pool archetype.

Table 17: Recreation Centre Pool Targets

	Level 1	Level 2	Level 3
EUI	3,700	2,700	1,800
GHGI	560	350	90
TEDI	N/A	N/A	N/A

***Note**: All targets metrics are normalized on the basis of pool water surface area

Given the process-load heavy nature of the swimming pool due to the loads associated with pool water heating, a TEDI metric is not recommended as it would not serve to drive significant energy or carbon reductions for the archetype.

Typical strategies to achieve the three levels of performance are detailed below:

<u>Level 1</u>

Achieving this level requires the inclusion of several energy efficiency measures, which may typically include:

- Pool dehumidification unit with integrated heat recovery (70% effective) for pool water and ventilation air
- LED lighting throughout, typically resulting in 50% savings over code
- Low-flow plumbing fixtures
- Liquid pool covers to reduce evaporative losses

Due to the significant simultaneous heating and cooling (dehumidification) loads in the pool area, a heat recovery dehumidification unit is provided to recover heat from the dehumidification process. This solution is only one of several to minimize energy use for pools and is not intended to signal a requirement to achieving similar levels of performance.

Overall, the targets at Level 1 represent an 8% reduction in EUI and 7% reduction in GHGI relative to the baseline scenario.

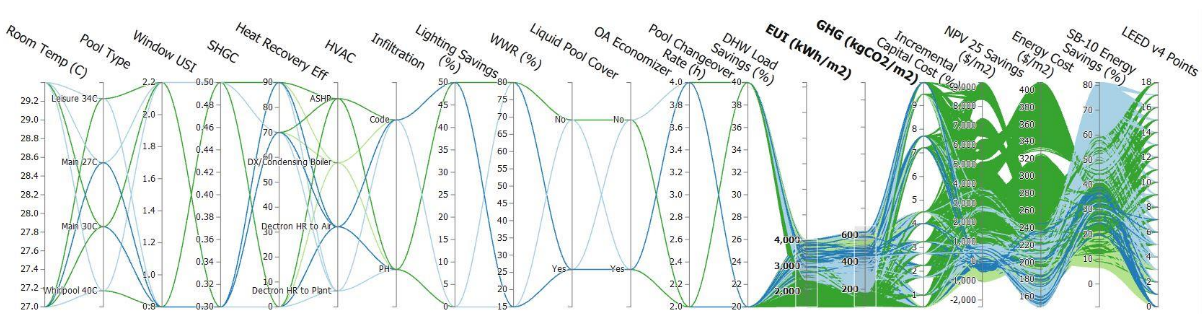

Figure 19: Pool Archetype - Level 1 Target Solutions

<u>Level 2</u>

The Level 2 targets represent a 33% decrease in TEUI and 46% drop in GHGI. One of the approaches to achieving the Level 2 target is to eliminate the usage of the outdoor air economizer.

Outdoor air economizing is usually beneficial, but in some cases depending on pool set point and climate, the air-side economizer is a detriment because the heat recovered from dehumidification is significant in reducing overall energy use, outweighing the electricity used to mechanically cool and dehumidify. The parametric map can be used to assess the benefits of the using outdoor air to dehumidify, compared to using a heat recovery dehumidification unit to mechanically cool the air to dehumidify and recover the waste heat and water during dehumidification.

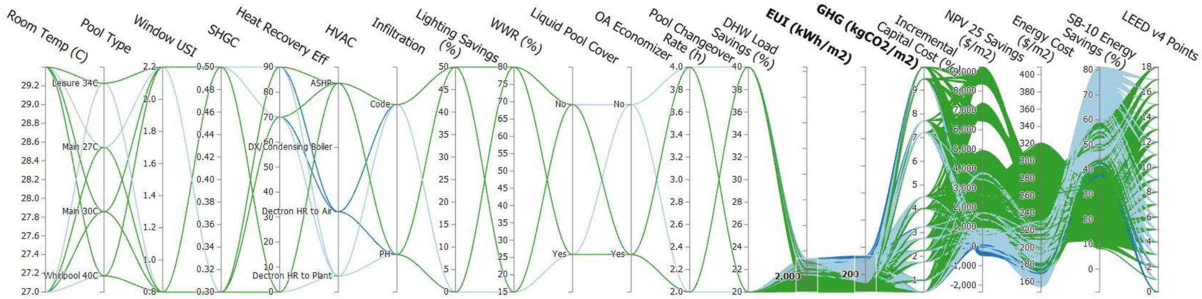

Figure 20: Pool Archetype - Level 2 Target Solutions

<u>Level 3</u>

The Level 3 targets are based on a superior building envelope, resulting in the use of high performance (i.e. Passive House) windows, increased lighting savings through improved design strategies and controls, increased DHW load savings through more efficient water-use equipment (e.g. drain water heat recovery), and usage of liquid pool covers to minimize evaporative losses.

At this level, pool water and ventilation air heating will be required to be provided an electric-based heating system such as air-source heat pumps, as indicated in the Figure below.

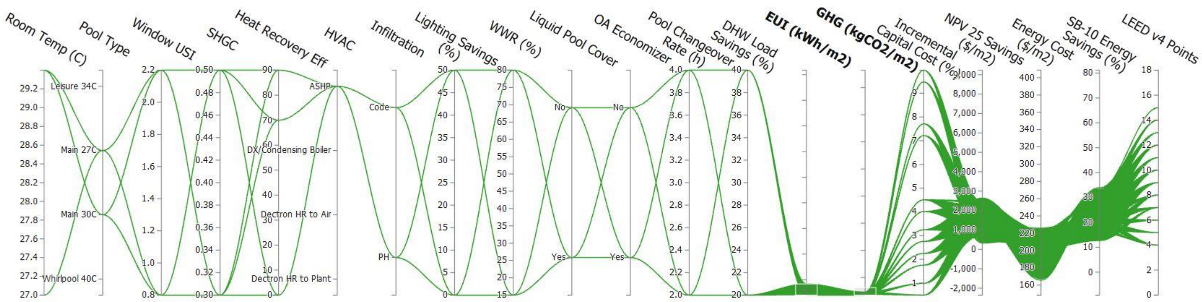

Figure 21: Pool Archetype - Level 3 Target Solutions

Table 18 provides the key characteristics of target solutions for the three proposed levels of performance. It should be noted that these are not cost-optimized solutions, but rather based on typical the performance packages that are expected to be required to meet the three performance levels, as described above.

Table 18: Pool - Target Solution Characteristics

	Level 1	Level 2	Level 3
EUI (kWh/m2)	3,661	2,636	1,710
GHGI (kgCO$_{2,eq}$/m2)	558	303	86
Incremental Capital Cost (%)	0	0	12.2
NPV 25 Savings ($/m2)	143	-219	1,139
SB-10 Energy Savings (%)	33	52	34

LEED Cost Savings (%)	20	14	35
LEED v4 Points	7	5	13

4.5.2 Recreation Centre Ice Rink Targets

Table 19 shows the absolute performance targets for TEUI and GHGI that have been proposed for the pool archetype.

Table 19: Ice Rink Targets

	Level 1	Level 2	Level 3
EUI	380	335	200
GHGI	46	38	17
TEDI	N/A	N/A	N/A

Given the process-load heavy nature of the ice rink due to the loads associated with rink refrigeration, as well as considering that the majority of the rink energy consumption is associated with cooling, as opposed to space heating, the TEDI metric is not recommended as it would not serve to drive significant energy or carbon reductions for this archetype.

It should be noted that since the ice rink archetype was modelled in eQuest, as opposed to EnergyPlus, a full parametric analysis was not conducted due to software limitations. However, appropriate targets for each level have been set based on performance packages that align with the approach applied for the other archetypes, i.e., focusing on load reductions first through improved envelope and heat recovery, followed by improvements in mechanical system efficiency and fuel switching to drive towards net zero-ready and low carbon outcomes at Level 3.

Typical strategies to achieve the three levels of performance are detailed below:

<u>Level 1</u>

Achieving this level requires the inclusion of several energy efficiency measures that are considered best practice for the City's ice rink facilities, which may typically include:

- Low-emissivity ceiling
- Refrigeration compressors and brine loop pumps equipped with VFDs
- Refrigeration heat recovery serving subfloor and DHW preheat
- 60% effective ventilation air heat recovery
- LED lighting throughout, typically resulting in 50% savings over code
- 20% reduction in DHW loads through low-flow fixtures

However, envelope performance is required to be a step-up from compared to current typical practice, and requires improved opaque wall thermal performance and/or triple glazed insulated glazing units (IGUs) to meet the TEDI target. Furthermore, effective

R-values used for the purposes of energy modelling will be required to be inclusive of all thermal bridging, which should result in improved actual performance by addressing the performance gap typically associated with building envelope components.

Level 2

The Level 2 targets represent a 13% decrease in TEUI and 20% drop in GHGI, and will typically require improved opaque wall performance (effective R-20 wall, R-40 roof), triple-glazed IGUs, improved heat recovery effectiveness (up to 80%), and improved levels of whole building airtightness.

Level 3

The Level 3 targets are based on extensive refrigeration ice plant heat recovery to serve building heating loads in addition to subfloor heating and DHW pre-heat, coupled with electric-based heating such as ground-source heat pumps to offset residual loads. Additionally, up to 70% lighting savings would typically be required through improved lighting design and advanced controls, 40% DHW savings through drain water heat recovery, and improved ice plant efficiency (seasonal COP of 4.0) through measures such as floating head and suction pressure controls.

Table 20 provides the key characteristics of target solutions for the three proposed levels of performance. It should be noted that these are not cost-optimized solutions, but rather based on typical the performance packages that are expected to be required to meet the three performance levels, as described above. The results associated with the TEDI and CEDI metric are provided for information purposes only.

Table 20: Ice Rink - Target Solution Characteristics

	Level 1	Level 2	Level 3
EUI (kWh/m2)	380	335	200
GHGI (kg$CO_{2,eq}$/m2)	46	38	17
Incremental Capital Cost (%)	0.5	1.9	5.0
NPV 25 Savings ($/m2)	-16	-49	-30
TEDI (kWh/m2)	150	140	140
CEDI (kWh/m2)	183	183	180

4.6 Library Targets

Table 21 shows the absolute performance targets for TEUI, TEDI and GHGI that have been proposed for the library building archetype.

Table 21: Library Building Targets

	Level 1	Level 2	Level 3
EUI	140	110	60
TEDI	50	40	25
GHGI	15	10	5

The Level 1 target for EUI is approximately 7% better than the modelled performance of the typical City of Mississauga library built according to current best practices, whereas Level 3, which targets the performance level of a net-zero ready building working towards the Living Building Challenge, provides for 60% savings relative to the baseline level.

Typical strategies to achieve the three levels of performance are detailed below:

<u>Level 1</u>

Achieving this level requires the Inclusion of many of the energy efficiency measures that are already typical of City's current design practices, which include:

- Central plant consisting of condensing boilers and magnetic bearing chillers
- LED lighting throughout, typically resulting in 50% savings over code
- 70% effective ventilation air heat recovery on rooftop units

However, envelope performance is required to be a step up compared to current typical practice, and requires improved opaque wall thermal performance and/or triple glazed IGUs to meet the TEDI target. Furthermore, effective R-values used for the purposes of energy modelling will be required to be inclusive of all thermal bridging, which should result in improved actual performance by addressing the performance gap typically associated with building envelope components.

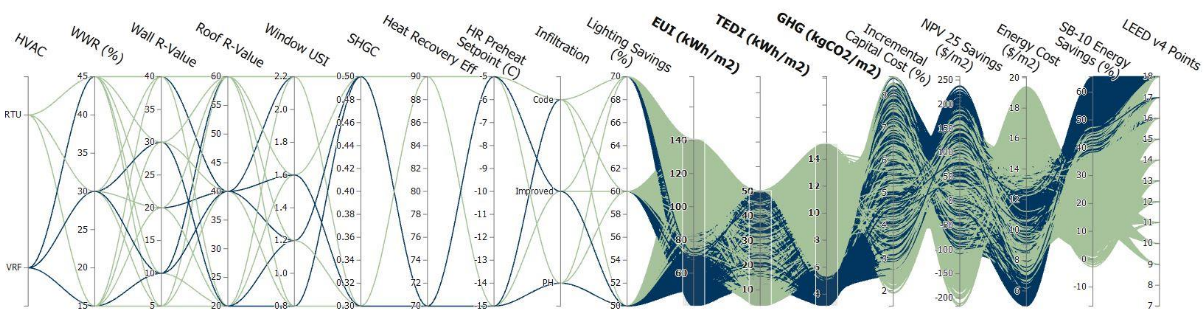

Figure 22: Library Archetype - Level 1 Target Solutions

<u>Level 2</u>

The Level 2 targets see a significant drop in TEDI, which necessitate improved envelope performance through better opaque wall thermal performance, triple-glazed IGUs, reduced window-to-wall ratio, and improved airtightness relative to the code baseline.

A switch-over to electric-based heating is not required at this Level in order to meet the TEUI and GHGI targets.

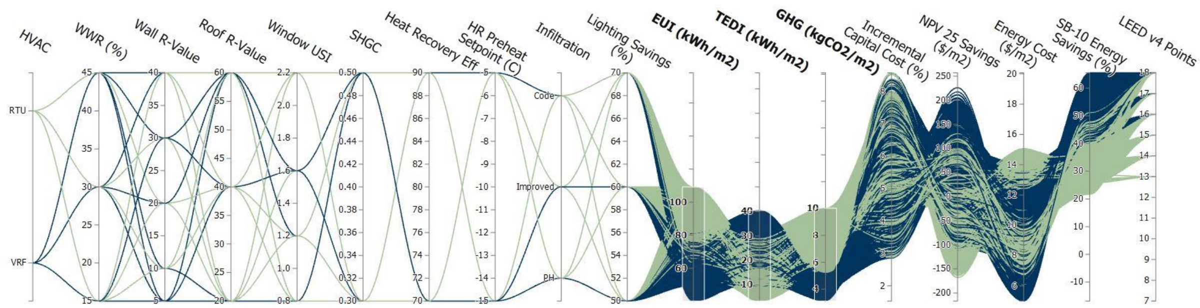

Figure 23: Library Building Archetype - Level 2 Target Solutions

<u>Level 3</u>

The Level 3 targets ratchet up the building envelope requirements, resulting in the use of high performance (i.e. Passive House level) windows, reduced window-to-wall ratio, typically R-20 effective walls, increased lighting savings through improved design strategies (i.e. general and localized lighting), higher performance heat recovery with minimal preheat for frost control, demand control ventilation strategies, and a fuel switch from natural gas to electricity through the use of a heat recovery VRF system.

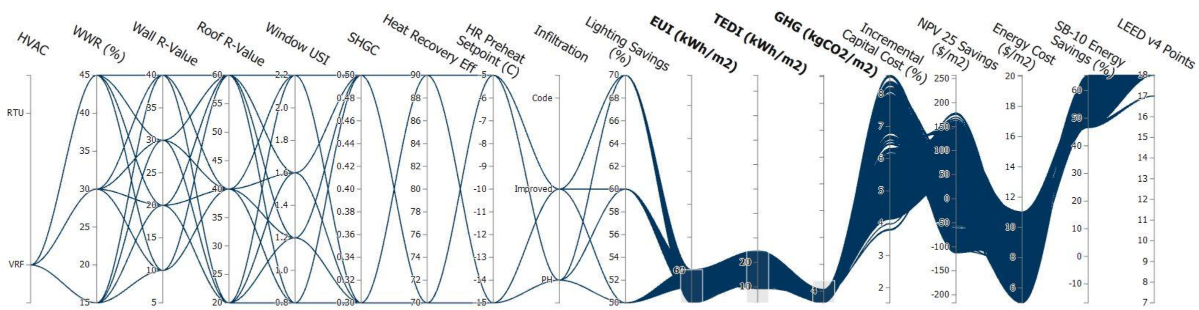

Figure 24: Library Building Archetype - Level 3 Target Solutions

Table 22 provides the key characteristics of target solutions for the three proposed levels of performance. It should be noted that these are not cost-optimized solutions, but rather based on typical the performance packages that are expected to be required to meet the three performance levels, as described above.

Table 22: Library Building - Target Solution Characteristics

	Level 1	Level 2	Level 3
EUI (kWh/m2)	137	107	47
TEDI (kWh/m2)	43	35	20
GHGI (kg$CO_{2,eq}$/m2)	14	11	3
Incremental Capital Cost (%)	0.8	0.9	4.7
NPV 25 Savings ($/m2)	-40	34	-55

SB-10 Energy Savings (%)	14	27	64
LEED Cost Savings (%)	40	57	74
LEED v4 Points	15	18	18

4.7 Transit Repair and Maintenance Facility Targets

Table 23 shows the absolute performance targets for TEUI, TEDI and GHGI that have been proposed for the transit repair and maintenance facility archetype.

Table 23: Transit Repair and Maintenance Facility Targets

	Level 1	Level 2	Level 3
EUI	300	280	130
TEDI	120	100	20
GHGI	38	35	10

The Level 1 target for EUI is approximately 12% better than the modelled performance of the typical City of Mississauga transit repair and maintenance facility built according to current practices, whereas Level 3, which targets the performance level of a net-zero ready building working towards the Living Building Challenge, provides for 60% savings relative to the baseline level.

Typical strategies to achieve the three levels of performance are detailed below:

Level 1

Achieving this level requires the Inclusion of many of the energy efficiency measures that are already typical of City's current design practices, which include:

- High efficiency direct-fired gas-heated makeup air units interlocked with exhaust fans, and gas-IR heaters at the zone level
- LED lighting throughout, typically resulting in 50% savings over code
- 70% effective ventilation air heat recovery on DOAS systems
- Demand-controlled ventilation resulting on average, a 25% reduction in outdoor airflow compared to the baseline level

Envelope performance is required to be a step-up from compared to current typical practice, and requires improved opaque wall thermal performance to meet the TEDI target. Furthermore, effective R-values used for the purposes of energy modelling will be required to be inclusive of all thermal bridging, which should result in improved actual performance by addressing the performance gap typically associated with building envelope components.

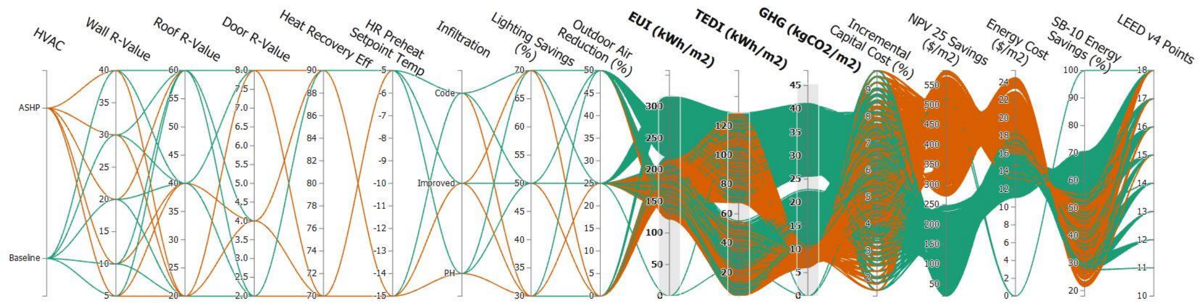

Figure 25: Transit Repair Archetype - Level 1 Target Solutions

Level 2

The Level 2 targets see a significant drop in TEDI, which necessitate improved envelope performance through better opaque wall thermal performance, improved frost control strategies for heat recovery devices which require minimal preheat energy, and improved airtightness relative to the code baseline.

A switch-over to electric-based heating is not required at this Level in order to meet the TEUI and GHGI targets.

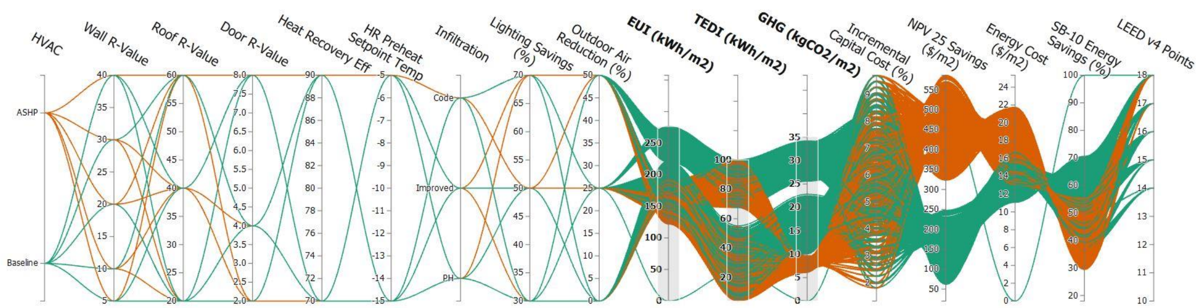

Figure 26: Transit Repair Archetype - Level 2 Target Solutions

Level 3

The Level 3 targets ratchet up the building envelope requirements, typically resulting in the use of R-20 effective walls, increased lighting savings through improved design strategies (i.e. general and localized lighting), well-insulated overhead doors with improved details to minimize thermal bridging at the door-to-wall transition, aggressive demand control ventilation strategies resulting in 50% reduction in outdoor airflow compared to the baseline scenario, and a fuel switch from natural gas to electricity through the use of air-source heat pumps.

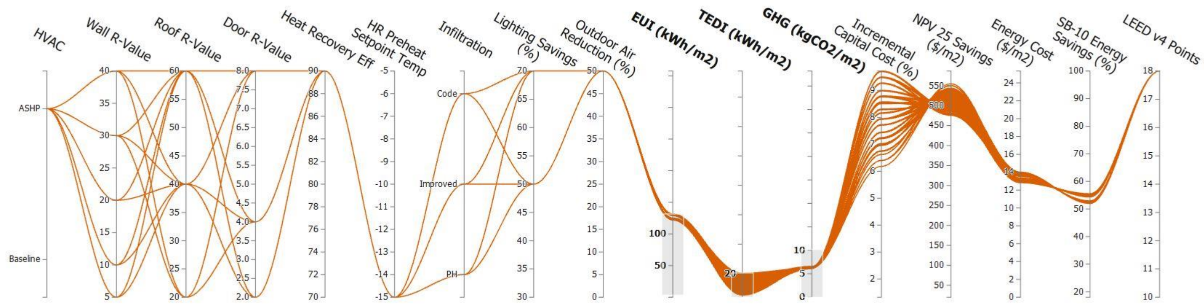

Figure 27: Transit Repair Archetype - Level 3 Target Solutions

Table 24 provides the key characteristics of target solutions for the three proposed levels of performance. It should be noted that these are not cost-optimized solutions, but rather based on typical the performance packages that are expected to be required to meet the three performance levels, as described above.

Table 24: Transit Repair Building - Target Solution Characteristics

	Level 1	Level 2	Level 3
EUI (kWh/m2)	294	275	123
TEDI (kWh/m2)	116	101	12
GHGI (kg$CO_{2,eq}$/m2)	38	34	6
Incremental Capital Cost (%)	0.2	0.6	4.6
NPV 25 Savings ($/m2)	43	43	417
SB-10 Energy Savings (%)	33	37	55
LEED Cost Savings (%)	37	39	68
LEED v4 Points	14	15	18

4.8 Transit Station Targets

Table 25 shows the absolute performance targets for TEUI, TEDI and GHGI that have been proposed for the transit station archetype.

Table 25: Transit Station Targets

	Level 1	Level 2	Level 3
EUI	230	180	150
TEDI	100	50	15
GHGI	25	15	10

The Level 1 target for EUI is approximately 15% better than the modelled performance of the typical City of Mississauga transit station built according to current practices, whereas Level 3, which targets the performance level of a net-zero ready building working towards the Living Building Challenge, provides for 44% savings relative to the baseline level.

Typical strategies to achieve the three levels of performance are detailed below:

<u>Level 1</u>

Achieving this level requires the Inclusion of many of the energy efficiency measures that are already typical of City's current design practices, which include:

- High efficiency condensing boilers serving a radiant heating system in the waiting area
- LED lighting throughout, typically resulting in 50% savings over code
- Separate energy recovery ventilator with 70% effective heat recovery serving the waiting area

Envelope performance is also required to be a step up compared to current typical practice, and requires improved opaque wall thermal performance and/or triple glazed IGUs to meet the TEDI target. Furthermore, effective R-values used for the purposes of energy modelling will be required to be inclusive of all thermal bridging, which should result in improved actual performance by addressing the performance gap typically associated with building envelope components.

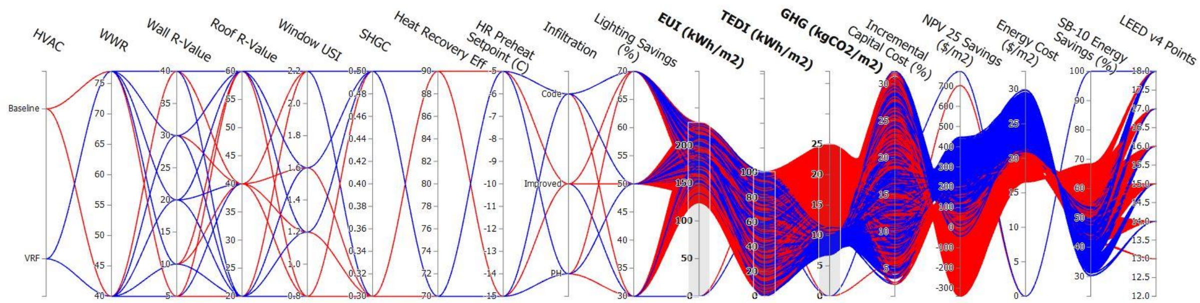

Figure 28: Transit Station Archetype - Level 1 Target Solutions

<u>Level 2</u>

The Level 2 targets see a significant drop in TEDI, which necessitate improved envelope performance through better opaque wall thermal performance, reduced window-to-wall ratio, triple-glazed IGUs, and improved airtightness relative to the code baseline.

A switch-over to electric-based heating is not required at this level in order to meet the TEUI and GHGI targets.

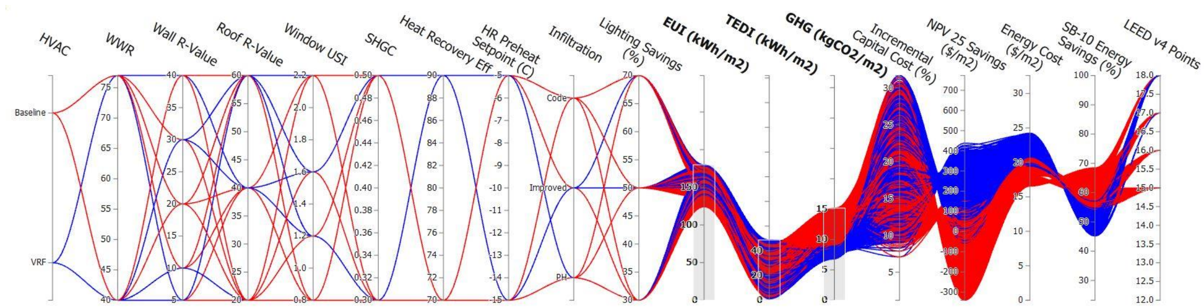

Figure 29: Transit Station Archetype - Level 2 Target Solutions

Level 3

The Level 3 targets ratchet up the building envelope requirements, resulting in the use of high performance (i.e. Passive House) windows, reduced window-to-wall ratio, typically R-20 effective walls, increased lighting savings through improved design strategies (i.e. general and localized lighting), higher performance heat recovery with minimal preheat for frost control, and demand control ventilation strategies.

In terms of HVAC system choice, the energy modelling analysis suggests at this level of performance (i.e. when heating loads are significantly reduced), both a hydronic radiant heating system and a VRF-based system offer equivalent performance in terms of energy and carbon outcomes.

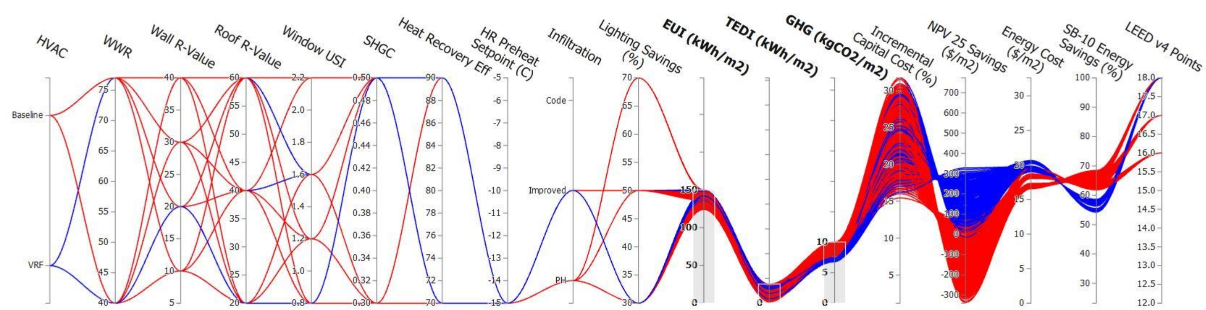

Figure 30: Transit Station Archetype - Level 3 Target Solutions

Table 26 provides the key characteristics of target solutions for the three proposed levels of performance. It should be noted that these are not cost-optimized solutions, but rather based on typical the performance packages that are expected to be required to meet the three performance levels, as described above.

Table 26: Transit Station - Target Solution Characteristics

	Level 1	Level 2	Level 3
EUI (kWh/m2)	228	176	151
TEDI (kWh/m2)	97	42	4
GHGI (kg$CO_{2,eq}$/m2)	25	16	9
Incremental Capital Cost (%)	0.6	6.1	18.9

NPV 25 Savings ($/m2)	53	-38	-264
SB-10 Energy Savings (%)	42	55	62
LEED Cost Savings (%)	39	43	42
LEED v4 Points	15	16	16

5. ACHIEVING NET ZERO

In order to achieve Level 3, a building should drive towards a net zero energy level of performance such as the Living Building Challenge, which requires the achievement of net zero site energy using on-site renewable energy.

Table 27 indicates the incremental capital cost premium associated with on-site photovoltaics (PV) for archetype facilities that meet the Level 3 targets for TEUI, TEDI and GHGI, under a typical scenario, to also achieve a net-zero energy level of performance.

While being dependent on the specifics of building geometry and available roof area, it can be seen that achieving net zero without significantly expanding the building footprint to accommodate additional on-site PV can be more challenging for certain archetypes. For example, pools and ice rinks in particular are energy-use intensive relative to their floorplate due to the pool water heating and refrigeration loads, respectively, whereas the transit archetypes have higher energy use intensities due to the longer hours of operation.

However, for other archetypes such as the fire hall, library and recreation centre (without pool or ice rink), achievement of a net zero energy outcome, which is in line with the desired level of performance at Level 3, appears to be feasible from the perspective of both project economics and rooftop space constraints.

Table 27: Typical Economic Impact and Roof Area Required to Achieve Net Zero Energy

Archetype	Expected Typical Economic Impact	
	Incremental Capital Cost (%) for PV	% Roof Coverage Required for PV
Administration	1.4	191
Fire Hall	3.3	93
Library	3.1	82
Recreation Centre	4.1	92
Pool	7.6	937
Ice Rink	5.1	274
Transit Station	8.3	214
Transit Repair and Service	10.7	135

6. IMPLEMENTATION CONSIDERATIONS

In order to ensure that the proposed performance metrics translate to real GHG emissions reductions and energy and energy cost savings, consideration should be given to implementation strategies and tools to support the policy. Some items of implementation to consider when rolling out the revised policy include:

- Commissioning: In order to reduce the performance gap between modelled performance based on design intent and actual performance during operations, it is essential that requirements for best practices in building commissioning are integrated into the Standard. The following commissioning requirements are suggested for the three levels:
    - Level 1: Conduct best practice commissioning, per the requirements referenced in LEED BD+C v4 Fundamental Commissioning and Verification pre-requisite.
    - Level 2: In addition to Level 1, meet the requirements of LEED BC+C v4 credit Envelope Commissioning (Option 2).
    - Level 3: In addition to Level 2, meet the requirements of LEED BC+C v4 credit Enhanced and monitoring-based Commissioning
- Sub-metering: In order to facilitate ongoing energy management, as well as to support post-occupancy calibration of the energy model in cases of significant discrepancy, it is suggested that electricity and/or thermal sub-meters be required to be installed for all energy end-uses that represent more than 10% of the building's total energy consumption. In addition, all major process loads such as pools and ice rinks should be sub-metered separately.
- On-Site Renewables: The following on-site renewable energy requirements are suggested at each level, to provide added benefits from on-site renewable energy generation in terms of reducing stress on the electrical grid, resiliency, and GHG emissions reduction.
    - Level 1: Designed to accommodate future connections to PV that can offset 5% of the building annual energy consumption
    - Level 2: On-site renewable energy devices to offset 5% of building annual energy consumption
    - Level 3: On-site renewable energy devices to offset 100% of building annual energy consumption
- Standard scope of work document for energy modeling professionals or energy consultants bidding on City of Mississauga work that will need to comply with these recommendations. A draft scope of work has been provided in Appendix E.
- Energy modeling guidelines to clarify standard schedules, assumptions and methodologies around energy models so that projects are meeting the proposed

performance criteria as intended. Draft modelling guidelines have been provided in Appendix F.

- Air tightness testing – The results of the energy analysis have indicated that improved air tightness over "typical" values can have significant energy savings. This can only be verified using whole building air leakage testing. This is an added expense to a project if mandated, but would likely result in actual air leakage reductions and related energy savings.

- Verification of as-designed and built energy savings – In order to close the gap between design and operational performance of buildings, it is recommended that the City include post-occupancy verification of as designed and as-built energy savings. Older versions of LEED (i.e. LEED 2009) included a credit for verifying energy savings post-occupancy (EAc5 – Measurement and Verification). This credit no longer exists under LEED v4, although portions of the credit are dealt with through other commissioning and metering credits. A process similar to that required for EAc5 under LEED 2009 is recommended for future projects; with a focus on identifying major discrepancies between the as-designed model and the operating energy, and developing corrective action plans. The process would differ from EAc5 in that intent would be to focus on corrective action for operations, rather than on verifying savings of specific ECMs. The level of effort for such a process may be somewhat variable, however the intent would be an outcomes-based investigation to ensure building operational energy savings are as designed. In order to focus effort where it is most needed, we suggest requiring this only on projects operating outside a certain range, say 15% overall EUI difference from the modeled energy use. A specific protocol has been provided for consideration as part of the suggested energy consultant scope of work in Appendix E.

- While the proposed policy and energy modeling guidelines generally do not contradict industry practice for code compliance or other ratings systems, there are some deviations that are expected to improve the accuracy of models and the quality of designs, in particular the full evaluation of effective R-values. The added effort to incorporate these into models, which may lead to two versions of energy models on projects, is minimal and should not be a reason to endorse practices that do not support the City's overall objectives.

Table 28. Summary of Target Recommendations for Each Archetype

Archetype	Total Energy Use Intensity (kWh/m^2.yr)	Thermal Energy Demand Intensity (kWh/m^2.yr)	Greenhouse Gas Emissions Intensity (kg$CO_{2,eq}$/m^2.yr)
Admin	Level 1: 110 Level 2: 90 Level 3: 60	Level 1: 55 Level 2: 35 Level 3: 15	Level 1: 15 Level 2: 10 Level 3: 5
Fire Hall	Level 1: 105 Level 2: 80 Level 3: 60	Level 1: 75 Level 2: 60 Level 3: 30	Level 1: 11 Level 2: 5 Level 3: 5
Rec Centre without Pools	Level 1: 160 Level 2: 140 Level 3: 70	Level 1: 45 Level 2: 35 Level 3: 15	Level 1: 20 Level 2: 15 Level 3: 5

Archetype	Total Energy Use Intensity (kWh/m^2.yr)	Thermal Energy Demand Intensity (kWh/m^2.yr)	Greenhouse Gas Emissions Intensity (kg$CO_{2,eq}$/m^2.yr)
Pools	Level 1: 3,700 Level 2: 2,700 Level 3: 1,800	N/A	Level 1: 560 Level 2: 350 Level 3: 90
Ice Rinks	Level 1: 380 Level 2: 335 Level 3: 200	N/A	Level 1: 46 Level 2: 38 Level 3: 17
Library	Level 1: 140 Level 2: 110 Level 3: 60	Level 1: 50 Level 2: 40 Level 3: 25	Level 1: 15 Level 2: 10 Level 3: 5
Vehicle Maintenance	Level 1: 300 Level 2: 280 Level 3: 130	Level 1: 120 Level 2: 100 Level 3: 20	Level 1: 38 Level 2: 35 Level 3: 10
Transit Station	Level 1: 230 Level 2: 180 Level 3: 150	Level 1: 100 Level 2: 50 Level 3: 15	Level 1: 25 Level 2: 15 Level 3: 10

APPENDIX A: ENERGY SIMULATION DETAILS

Table A-1. Library Simulation Input Summary

Characteristic	Library
Weather	Pearson Int'l CWEC 2016
Software	EnergyPlus v8.9
Climate Zone	5
Building Area	1,283 m^2
Operating Hours	Modified NECB Schedule C occupancy, lighting and plug loads to match typical hours of operation: Weekdays: 10 AM to 9 PM Weekends: 10 AM to 5 PM
Occupancy	200 m^2/person Stairs, Mechanical 100 m^2/person Corridor, Storage 30 m^2/person Washroom 20 m^2/person Office, Shelf Area, Cataloguing 10 m^2/person Lounge 5 m^2/person Conference
Plug & Process Loads	7.5 W/m^2 Office 1 W/m^2 Lounge, Conference, Mechanical, Washroom, Storage 2.5 W/m^2 Cataloguing
Outdoor Air	Minimum ventilation/exhaust flow-rates as per ASHRAE 62.1-2010 DOAS: 1,570 cfm
Infiltration	0.25 L/s/m^2 Exterior Wall Area, Code Options: 0.1 L/s/m^2 Exterior Area, Improved 0.01 L/s/m^2 Exterior Area, Passive house
Wall R-Value	Options: R-10 to R-30
Roof R-Value	Options: R-20 to R-60
Window U-Value	Options: 2.2 USI to 0.8 USI
Window SHGC	Options: 0.3 or 0.5
Window Area %	Options: 15% to 60%
Interior Lighting	18 W/m^2 Shelf Area 13.4 W/m^2 Mechanical 13.2 W/m^2 Conference 11.9 W/m^2 Office 11 W/m^2 Cataloguing 10.5 W/m^2 Washrooms 9.4 W/m^2 Lounge 7.4 W/m^2 Stairs 7.1 W/m^2 Corridor 6.8 W/m^2 Storage Options: 50% to 70% Savings
HVAC Systems	Options: Packed Single Zone Roof-Top Units

Characteristic	Library
	or VRF and Dedicated Outdoor Air System (DOAS)
Supply and Ventilation Air	Constant ventilation air supplied directly to zones through DOAS. Fan coil fans cycle to meet heating and cooling loads.
Heat Recovery	Options: 60% to 90% effective HR
Fans	1 W/cfm DOAS 0.3 W/cfm Fan Coils
Cooling	RTU Option: DX Coil, 3.8 nominal COP VRF Option: 3.3 nominal COP
Heating	RTU Option: Condensing Gas Coil, 90% eff. VRF Option: 3.4 nominal COP
Pumps	60 ft head, variable speed
Humidification	Electric Steam Humidification to 20% RH
DHW	4,650 W Peak Load Condensing Gas boiler, 96% eff.

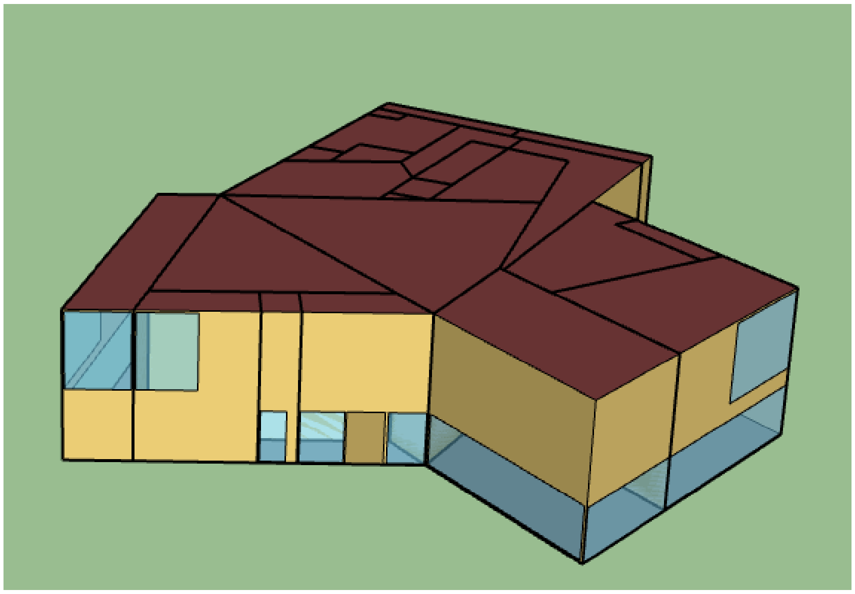

Table A-2. Rec Centre Building Simulation Input Summary

Characteristic	Rec Centre
Weather	Pearson Int'l CWEC 2016
Software	EnergyPlus v8.9
Climate Zone	5
Building Area	9,794 m^2
Operating Hours	Modified NECB Schedule B occupancy, lighting and plug loads to match typical operating hours: Friday and Saturday: 5:30 AM to 1:00 AM All Other Days: 6:00 AM to 12:00 AM
Occupancy	20 m^2/person Office 10 m^2/person Lobby, Change Rooms 5 m^2/person Gym, Meeting, Multipurpose, Pool 4 m^2/person Gym
Plug & Process Loads	7.5 W/m^2 Office 1 W/m^2 Gym, Fitness, Meeting, Multipurpose, Lobby 2.5 W/m^2 Change Rooms plus 80 kW Pool Filtration and Makeup Water pumps 109.4 kW peak Pool Latent Load 132.7 kW peak Pool Heating Load
Outdoor Air	As per ASHRAE 62.1-2010: DOAS: 10,420 cfm Pool: 12,460 cfm Fitness: 4,030 cfm Gym: 6,290 cfm
Infiltration	0.25 L/s/m^2 Exterior Wall Area, Code Options: 0.1 L/s/m^2 Exterior Area, Improved 0.01 L/s/m^2 Exterior Area, Passive house
Wall R-Value	Options: R-10 to R-30
Roof R-Value	Options: R-20 to R-60
Window U-Value	Options: 2.2 USI to 0.8 USI
Window SHGC	Typical: SHGC 0.3
Window Area %	Typical: 30% Varied 15% to 30%
Interior Lighting	13.4 W/m^2 Mechanical 13.2 W/m^2 Meeting, Multipurpose 11.9 W/m^2 Office 9.8 W/m^2 Pool, Change Rooms, Fitness, Gym 9.7 W/m^2 Lobby 7.1 W/m^2 Corridor Options: 50% to 70% Savings
Exterior Lighting	11.54 kW
HVAC Systems	Pool: Dehumidification Unit with Heat Recovery to Pool Water

Characteristic	Rec Centre
	Option: Single-Zone Constant Unitary Systems for Fitness, Multipurpose, and Gym VAV with baseboards for remainder of building Or Air-source heat pumps with DOAS throughout (except pool)
Supply and Ventilation Air	OA per ASHRAE 62.1-2010 Constant ventilation air supplied directly to zones through DOAS. Fan coil fans cycle to meet heating and cooling loads. Unitary Systems provide constant ventilation when occupied and variable volume for conditioning
Heat Recovery	Typical: 60% Heat Recovery Varied: 60% to 80% HR
Fans	0.93 W/cfm Pool Unitary 0.6 W/cfm Gym Unitary 0.5 W/cfm Fitness Unitary 0.9 W/cfm DOAS 0.2 W/cfm VRF
Cooling	VAV Option: Chiller, 8 seasonal COP (mag-bearing) Pool DX Coil, 3 seasonal COP VRF Option: 3.3 nominal COP
Heating	VAV Option: Condensing Boiler, 96% seasonal eff. ASHP Option: 4.15 nominal COP
Pumps	60 ft head, variable speed
DHW	96.7 kW Peak Load 90 W/person Fitness, Gym, Pool, Office, Meeting 45 W/person Multipurpose Condensing Boiler, 96% seasonal eff.

Table A-3. Fire Hall Simulation Input Summary

Characteristic	Fire Hall
Weather	Pearson Int'l CWEC 2016
Software	EnergyPlus v8.9
Climate Zone	5
Building Area	1,508 m^2 of which 566 m^2 Apparatus Bay Conditioned to 4°C
Operating Hours	NECB Schedule F occupancy, lighting and plug loads. Apparatus Bay and Kitchen exhaust 4h/day
Occupancy	25 m^2/person
Plug & Process Loads	2.5 W/m^2
Outdoor Air	DOAS: 1865 cfm, 1.06 L/s/m2 average App. Bay: 3,800 cfm exhaust Kitchen: 2,100 cfm exhaust
Infiltration	0.25 L/s/m^2 Exterior Wall Area, Code Options: 0.1 L/s/m^2 Exterior Area, Improved 0.01 L/s/m^2 Exterior Area, Passive house
Wall R-Value	Options: R-10 to R-30
Roof R-Value	Options: R-20 to R-60
Window U-Value	Options: 2.2 USI to 0.8 USI
Window SHGC	0.3
Window Area %	Typical: 15% Options: 15% to 30%
Interior Lighting	7.6 W/m^2 Options: 50% to 60% Savings
Exterior Lighting	None
HVAC Systems	App Bay MUA and gas-fired infrared heaters Options: HW Radiant Slab VRF and Dedicated Outdoor Air System (DOAS) elsewhere
Supply and Ventilation Air	Per ASHRAE 62.1-2010 Constant ventilation air supplied directly to zones through DOAS. VRF fans cycle to meet heating and cooling loads.
Heat Recovery	Typical: 60% DOAS Heat Recovery, No App Bay or Kitchen Exhaust HR Varied: 60% to 90% DOAS HR
Fans	0.75 W/cfm App Bay Exhaust 0.5 W/cfm Kitchen Exhaust 0.9 W/cfm DOAS 0.2 W/cfm VRF
Cooling	VRF 3.3 nominal COP
Heating	Gas-fired MUA and Infrared heater option: 80% eff. Radiant Floor Option: Condensing Boiler, 96% seasonal eff.

	VRF 3.4 nominal COP
Pumps	60 ft head, variable speed
DHW	400 W/person Options: 20% to 40% Load Savings Condensing Boiler, 96% seasonal eff. Option: Air Source Heat Pump

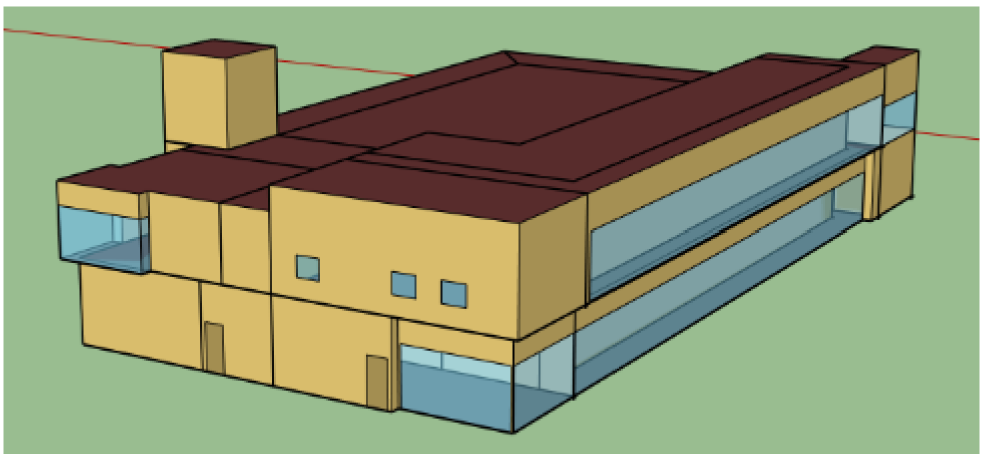

Table A-4. Administration Building Simulation Input Summary

Characteristic	Administration Building
Weather	Pearson Int'l CWEC 2016
Software	EnergyPlus v8.9
Climate Zone	5
Building Area	3,804 m^2
Operating Hours	NECB Schedule A occupancy, lighting and plug loads.
Occupancy	20 m^2/person Office 2 m^2/person Meeting 3.33 m^2/person Reception 10 m^2/person Lobby
Plug & Process Loads	7.5 W/m^2 Office 1 W/m^2 Meeting, Reception, Lobby, Storage/Mechanical Options: 0% to 25% Savings
Outdoor Air	Per ASHRAE 62.1-2010 DOAS: 5360 cfm, 0.664 L/s/m2 average
Infiltration	0.25 L/s/m^2 Exterior Wall Area, Code Options: 0.1 L/s/m^2 Exterior Area, Improved 0.01 L/s/m^2 Exterior Area, Passive house
Wall R-Value	Options: R-10 to R-40
Roof R-Value	Options: R-20 to R-60
Window U-Value	Options: 2.2 USI to 0.8 USI
Window SHGC	0.3
Window Area %	Typical: 15% Options: 15% to 45%
Interior Lighting	11.9 W/m^2 Office 13.2 W/m^2 Meeting 7.1 W/m^2 Corridor 9.7 W/m^2 Reception, Lobby 13.4 W/m^2 Storage/Mechanical Options: 0% to 50% Savings
Exterior Lighting	1000 W Options: 0% to 50% Savings
HVAC Systems	Hydronic Fan Coils and Dedicated Outdoor Air System (DOAS) Option: Ground-source variable refrigerant flow (VRF)
Supply and Ventilation Air	Constant ventilation air supplied directly to zones through DOAS. Fan coil fans cycle to meet heating and cooling loads.
Heat Recovery	Typical: 60% DOAS Heat Recovery Varied: 60% to 90% DOAS HR
Fans	1.0 W/cfm DOAS 0.2 W/cfm Fan Coils

Cooling	Boiler/Chiller Option: Screw Chiller, 2.9 seasonal COP GSVRF Option: Ground-source VRF, 5 seasonal COP
Heating	Boiler/Chiller Option : Condensing Boiler, 96% seasonal eff. GSVRF Option: Ground-source VRF, 3 seasonal COP Serves 100% of load
Pumps	60 ft head, variable speed
DHW	90W/person in Offices Same source as heating

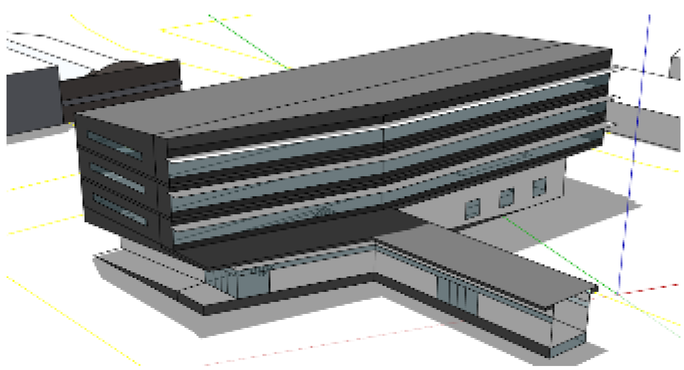

Table A-5. Transit Station Simulation Input Summary

Characteristic	Administration Building
Weather	Pearson Int'l CWEC 2016
Software	EnergyPlus v8.9
Climate Zone	5
Building Area	265 m^2
Operating Hours	NECB Schedule H (Transportation) for occupancy, lighting and plug loads.
Occupancy	200 m^2/person Electrical Room, Elevator Machine Room, Janitor Closet, Mechanical Room 1 m^2/person Waiting Area
Plug & Process Loads	1 W/m^2 Electrical Room, Janitor Closet, Mechanical Room 400W Elevator Machine Room 450W for Waiting Area
Outdoor Air	Per ASHRAE 62.1-2010 DOAS: 1,560 cfm
Infiltration	0.25 L/s/m^2 Exterior Wall Area, Code Options: 0.1 L/s/m^2 Exterior Area, Improved 0.01 L/s/m^2 Exterior Area, Passive house
Wall R-Value	Options: R-5 to R-40
Roof R-Value	Options: R-20 to R-60
Window U-Value	Options: 2.2 USI to 0.8 USI
Window SHGC	0.3 or 0.5
Window Area %	Typical: 70% Option: 40%
Interior Lighting	Average LPD of 8.3 W/m^2 Options: 30% to 70% Savings
Exterior Lighting	1000 W Options: 0% to 50% Savings
HVAC Systems	Radiant heaters in waiting area, unit heater in mechanical room, DX split A/C unit in electrical and elevator machine room. Outdoor air provided through DOAS with HRV. Option: VRF and Dedicated Outdoor Air System (DOAS)
Supply and Ventilation Air	Constant ventilation air supplied directly to zones through DOAS.
Heat Recovery	Typical: 70% DOAS Heat Recovery Varied: 70% to 90% DOAS HR
Fans	0.7 W/cfm DOAS 0.5 W/cfm DX cooling fans
Cooling	No cooling provided

Heating	Boiler Option : Condensing Boiler, 96% seasonal eff. VRF Option: 3.4 nominal COP
Pumps	40 ft head, variable speed
DHW	300W/person in Janitor Closet Same energy source as heating (Gas-fired condensing or electric resistance heater)

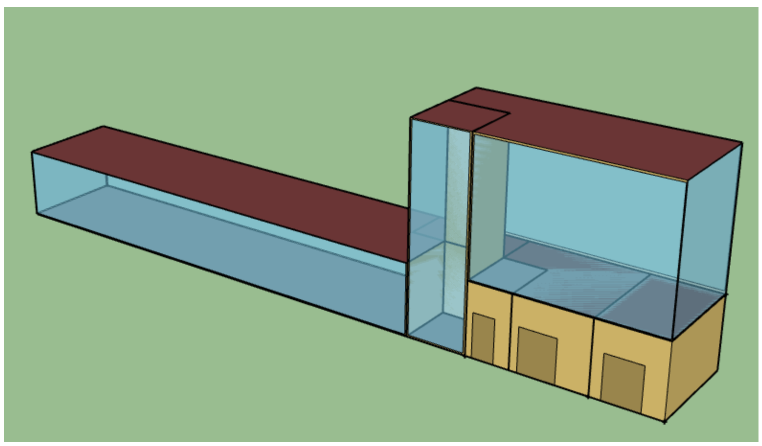

Table A-6. Transit Repair and Service Simulation Input Summary

Characteristic	Administration Building
Weather	Pearson Int'l CWEC 2016
Software	EnergyPlus v8.9
Climate Zone	5
Building Area	21,390 m^2
Operating Hours	NECB Schedule H (Transportation) for occupancy, lighting and plug loads in bus storage, fueling bay, parts storage, repair garage, wash bay and workshop NECB Schedule A for occupancy, lighting and plug loads in office area
Occupancy	1,000 m^2/person Bus Storage 20 m^2/person Fueling Bay, Office, Repair Garage, Wash Bay 30 m^2/person Workshop 100 m^2/person Parts Storage
Plug & Process Loads	1 W/m^2 Parts Storage 5 W/m^2 Fueling Bay, Repair Garage, Wash Bay 7.5 W/m^2 Office 10 W/m^2 Workshop Air Compressor: 2 x 100 hp air compressors (duty-standby), 50% average load factor Pressure Washer: 6 gpm flow, 25% load factor
Outdoor Air	Per ASHRAE 62.1-2010 Bus Storage: 0.75 cfm/ft^2 exhaust Fueling Bay, Repair Garage, Wash Bay, Workshop: 1.5 cfm/ft^2 exhaust Office: 5 cfm/person and 0.06 cfm/ft^2 Parts Storage: 10 cfm/person and 0.06 cfm/ft^2
Infiltration	0.25 L/s/m^2 Exterior Wall Area, Code Options: 0.1 L/s/m^2 Exterior Area, Improved 0.01 L/s/m^2 Exterior Area, Passive house
Wall R-Value	Options: R-5 to R-40
Roof R-Value	Options: R-20 to R-60
Window U-Value	Options: 2.2 USI to 0.8 USI
Overhead Door R-Value	Options: R-2 to R-8
Window Area %	Negligible
Interior Lighting	3.75 W/m^2 Bus Storage 6 W/m^2 Fueling Bay, Repair Garage, Wash Bay 7.4 W/m^2 Parts Storage 8.75 W/m^2 Office 12.3 W/m^2 Workshop Options: 30% to 70% Savings
Exterior Lighting	10,400 W
HVAC Systems	Admin Space: VAV Rooftop units with heat recovery/DX cooling/gas heating and perimeter hydronic radiators

	Repair and Storage Spaces: Gas-fired make-up air units with heat recovery, infrared unit heaters Option: Air-Source Heat Pumps with DOAS
Supply and Ventilation Air	Constant ventilation air supplied directly to zones through DOAS.
Heat Recovery	Typical: 70% DOAS Heat Recovery Varied: 70% to 90% DOAS HR
Fans	1.0 W/cfm DOAS 0.3 W/cfm ASHP terminal unit fans
Cooling	No cooling provided
Heating	Boiler Option: Condensing Boiler, 96% seasonal eff. ASHP Option: 4.15 nominal COP
Pumps	60 ft head, variable speed
DHW	90W/person in Fueling Bay, Office, Repair Garage, Wash Bay, Workshop 300 W/person Parts Storage Same energy source as heating (Gas-fired condensing heater or ASHP)

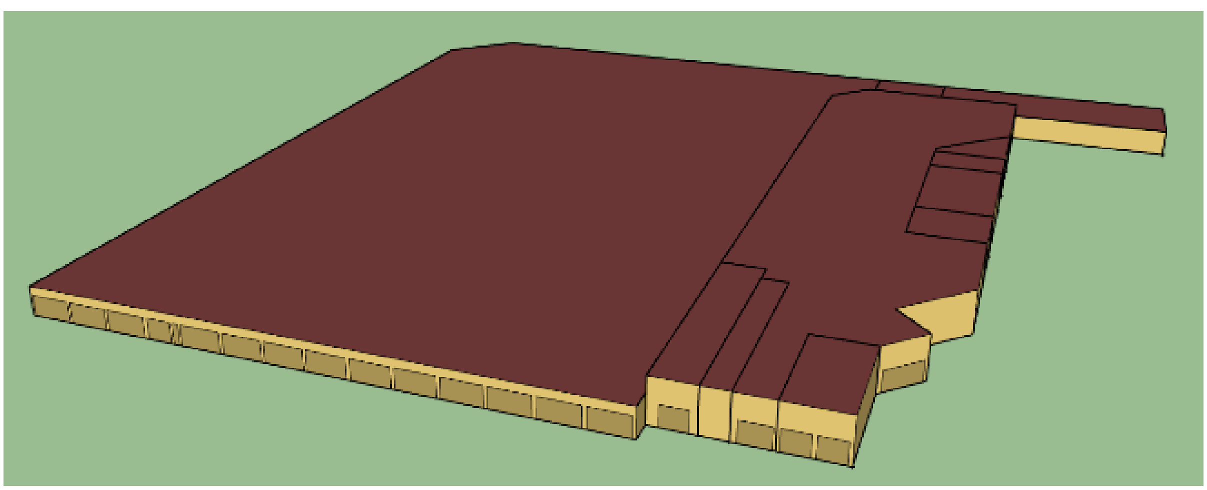

Table A-7. Ice Rink Simulation Input Summary

Characteristic	Arena
Weather	Toronto CWEC
Software	DOE2.2
Climate Zone	5
Building Area	11,832 m^2
# Rinks	3 ice surfaces
Operating Hours	NECB Schedule B occupancy, lighting and plug loads Operating 12 months/year
Occupancy	10 m^2/person Lobby, Change Rooms 5 m^2/person Arena, Seating Area
Plug & Process Loads	1 W/m^2 Rink, Meeting, Multipurpose, Lobby, Dining 2.5 W/m^2 Change Rooms 7.5 W/m^2 Office 10 W/m^2 Kitchen plus 3 x 25 HP Brine Pump (with VSD) Under slab heating, with 3.75 HP pump Resurfacing load Ice cooling load
Outdoor Air	RTUs and changeroom MUAs: 22,200 cfm Arena: ~6,700 cfm/rink (20,000 cfm total)
Infiltration	0.25 L/s/m^2 Exterior Wall Area, Code Options: 0.1 L/s/m^2 Exterior Area, Improved 0.01 L/s/m^2 Exterior Area, Passive house
Wall R-Value	Options: R-10 to R-30
Roof R-Value	Options: R-30 to R-60
Window U-Value	Options: 2.2 USI to 0.8 USI
Window SHGC	Typical: SHGC 0.3
Window Area %	8.5%
Interior Lighting	13.4 W/m^2 Mechanical 12.9 W/m^2 Arenas 9.8 W/m^2 Arena Change Rooms 9.7 W/m^2 Lobby 7.1 W/m^2 Corridor Options: 50% to 70% Savings
Exterior Lighting	2 kW
HVAC Systems	Arena: Unitary system with HRV, radiant heating under seats in seating area Other areas: RTUs with HRV

Supply and Ventilation Air	Arenas: 20,000 cfm (100% OA) (~6,700 each arena) Other areas: 31,250 cfm (43% OA) Change room MUAs: 8,750 cfm (100% OA)
Heat Recovery	Typical: 60% Heat Recovery Varied: 60% to 80% HR
Fans	RTUs 0.6 W/cfm (most areas) MUAs 0.9 W/cfm (changerooms) Kitchen MUA 0.5 W/cfm Ice rink system 1.1 W/cfm
Cooling	Ice cooling system: COP 2.4 (seasonal, varied) Loop head setpoint control has valve reset pressure control, with two-way valves on loop, with variable speed flow
Heating	Base option: Condensing Boiler, 95% seasonal eff. With refrigeration heat recovery
Pumps	Brine pump: 760 gpm/25 HP VSD (each rink) HW pump: 110 ft head, VSD
DHW	426 kW Peak Load 90 W/person Arena, Office, Meeting 45 W/person Multipurpose Condensing Boiler, 96% seasonal eff.

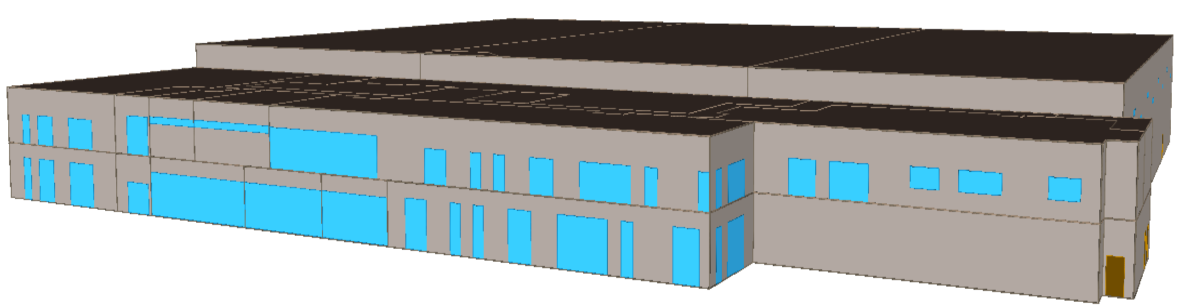

Table A-8. Pool Simulation Input Summary

Characteristic	Pool
Weather	Pearson Int'l CWEC 2016
Software	EnergyPlus v8.9
Climate Zone	5
Building Area	Main Pool: 795 m^2, of which 50% pool surface area. Leisure Pool: 600 m^2, of which 50% pool surface area. Whirlpool: 73.4 m^2, of which 50% pool surface area. All metrics reported per m^2 pool water surface area.
Operating Hours	Modified NECB Schedule B occupancy, lighting and plug loads to match typical operating hours: Friday and Saturday: 5:30 AM to 1:00 AM All Other Days: 6:00 AM to 12:00 AM
Pool Parameters	Average Pool depth: Main Pool: 2.7m Leisure Pool: 1.25 m Whirlpool: 7.2 m Pool Water Set Point Temperature Options: Main Pool: 27°C Main Pool: 30°C Leisure Pool: 34°C Whirlpool: 40°C Room Temperature Set Point Options: 27°C or 29.4°C Room RH Limit: 60% Pool Activity Factor: 1 Day, 0.6 Night Pool Cover Options: None, or liquid pool cover 50% convection and evaporation reduction at night
Occupancy	5 m^2/person
Plug & Process Loads	Recirculation Pumps: 310 kW/m^3/s Options: 2h or 4h pool volume turnover rate Filtration Tank Regeneration Makeup Water: Filtration tank volume, every 2 months Main Pool Tank Volume: 2.3 m^3 Leisure Pool Tank Volume: 1.7 m^3 Whirlpool Tank Volume: 0.6 m^3 Hygiene/Splashing Makeup Water: Pool volume, every 2 months

	Losses due to evaporation, convection and conduction modelled directly by Indoor Pool object in EnergyPlus, and change based on multiple factors including room air conditions, and pool water set point
Outdoor Air	Per ASHRAE 62.1-2010 2.5 L/s/m^2 room floor area
Infiltration	0.25 L/s/m^2 Exterior Wall Area, Code Options: 0.1 L/s/m^2 Exterior Area, Improved 0.01 L/s/m^2 Exterior Area, Passive house
Wall R-Value	R-5, model not sensitive to opaque envelope performance
Roof R-Value	R-20, model not sensitive to opaque envelope performance
Window U-Value	Options: 2.2 USI or 0.8 USI
Window Area %	Options: 15% or 80%
Interior Lighting	9.8 W/m^2 Options: 0% or 50% Savings
HVAC Systems	Single-zone VAV System
Supply and Ventilation Air	VAV system sized for 12.5 L/s/m^2 room floor area, 20% OA. Option: Yes or no OA economizer
Heat Recovery	Option: None, 70% or 90%
Fans	1.0 W/cfm total supply + return
Cooling	Options: DX Coil, 3.5 COP Dectron Unit w/condenser heat recovery to air, 3.5 COP Dectron Unit w/condenser heat recovery to HW plant, 3.5 COP Central Plant ASHP, 3.3 nominal COP
Heating	Options: Condensing Boiler, 96% seasonal eff. Dectron Unit, Condensing Boiler, 96% seasonal eff. Central Plant ASHP, 4.15 nominal COP
Pumps	72 ft head, variable speed
DHW	90W/person Condensing Boiler or Central ASHP, same as HW plant

APPENDIX B: CAPITAL COST DETAILS

Effective wall performance is calculated assuming that with intentional design, and low-cost, though not necessarily typical detailing, thermal bridging may be reduced such that it contributes only 10% of the heat loss through a wall assembly. High performance wall assemblies typically require exterior insulation with thermally broken clips or clips made of less thermally conductive materials supporting exterior cladding, and glazing that is aligned with the wall insulation plane.

Wall performance premiums are calculated based on the cost of the clear wall required to attain the effective performance after thermal bridging is accounted for. Clip performance can vary widely between manufacturers, and alternate insulation configurations can be used to obtain similar effective performance results.

The construction assembly costs are subjective and are order of magnitude estimates based on information provided by an external cost consultant. There are many variables and constraints on real projects that will overshadow some of the estimated cost differences between assemblies. The main point to remember is that construction costs vary quite widely in practice. This variability is part of the reason that construction projects typically have a bid process, where there can be a big difference between the highest and lowest bid. Consideration of the nature of this analysis and the fluidity of construction costs is required to reach meaningful conclusions. The construction cost estimates utilized in this analysis are broad cost estimates with more uncertainty than a Class D estimate, because the estimates were not arrived for a specific building, nor is there a comprehensive list of requirements to base assumptions. Accordingly, order of magnitude means that the construction cost estimates are +/- 50%.

Table B-1. Library, Fire Hall, Rec Centre Capital Cost Data

Category	Premium	
Air Leakage	Cost per building, dependent on air infiltration level attained Baseline: $0, no testing Code: $37,500 (Fire Hall), $50,000 (Rec Centre), $38,500 (Library) Improved: $60,000 (Fire Hall), $75,000 (Rec Centre), $57,750 (Library) Passive House: $75,500 (Fire Hall), $100,000 (Rec Centre), $70,500 (Library)	
	Baseline Assembly	Exterior insulated steel stud wall assembly, with typical bridging details
		R-21 ext. ins.
	Baseline Clear Wall R-Value (modelled)	20.4
	Baseline Effective Wall R-Value (with typical thermal bridging)	8.9
	R-5 Assembly	Likely window-wall or curtain wall, but costed as R-5.4 ext. ins.
	Effective R-5 Premium	-$30/$m^2$ wall
	R-10 Assembly	R-21 ext. ins. plus R-12 batt
	Effective R-10 Premium	$2/$m^2$ wall
	R-20 Assembly	R-46 ext. ins. plus R-19 batt, improved parapet, grade, and glazing transition
	Effective R-20 Premium	$60/$m^2$ wall
	R-30 Assembly	R-57.3 ext. ins. plus R-19 batt, further improved at grade and glazing transitions
	Effective R-30 Premium	$80/$m^2$ wall
	R-40 Assembly	Theoretical, R-136.5 ext. ins. plus R-19 batt
	Effective R-40 Premium	$255/$m^2$ wall
Roof Performance	R-20: $-18/$m^2$ roof Baseline: R-30 R-40: $18/$m^2$ roof R-60: $45/$m^2$ roof	
Glazing Performance	Baseline: USI to 2.2 USI-2.0: $17/$m^2$ window USI-1.6: $100/$m^2$ window USI-1.2: $230/$m^2$ window USI-0.8: $250/$m^2$ window	
Heat Recovery	Baseline: No Heat Recovery 70% efficient HRV: $5/cfm 90% efficient HRV: $8/cfm Low preheat temperature, +$1/cfm	
Lighting Power Reductions	Baseline: NECB 2011 Code Values, CFL design 50% reduction, full LED: $69/ m^2 floor (Fire Hall), $79/ m^2 floor (Rec Centre), $64/ m^2 floor (Library) 60% reduction, full LED: $88/ m^2 floor (Fire Hall), $101/ m^2 floor (Rec Centre), $69/ m^2 floor (Library) 70% reduction, full LED: $108/ m^2 floor (Fire Hall), $131/ m^2 floor (Rec Centre), $81/ m^2 floor (Library), targeting innovative design	
HVAC System	Firehall –	

	Baseline HVAC: $245/m² Option – Add hydronic radiant slab heating for apparatus bay: $261/m² Rec Centre – Baseline HVAC: $196/m² Option – Replace with DOAS and VRF-based system: $275/m² Library – Baseline HVAC: $100/m² Option – Replace with DOAS and VRF-based system: $190/m²
Base Costs	$4,908/m² ($456/ft²) – Library $5,016/m² ($466/ft²) – Fire Hall $4,155/m² ($386/ft²) – Rec Centre $6,372/m² ($592/ft²) - Pool

Table B-2. Admin Cost Summary

Category	Premium	
Air Leakage	Cost per building, dependent on air infiltration level attained Baseline: $0, no testing Code: $45,000 Improved: $66,500 Passive House: $85,000	
Wall Performance	Climate Zone	5
	Baseline Assembly	Exterior insulated steel stud wall assembly, with typical bridging details
		R-21 ext. ins.
	Baseline Clear Wall R-Value (modelled)	20.4
	Baseline Effective Wall R-Value (with typical thermal bridging)	9.8
	R-5 Assembly	Likely window-wall or curtain wall, but costed as R-5 ext. ins.
	Effective R-5 Premium	-$37/m² wall
	R-10 Assembly	R-21 ext. ins.
	Effective R-10 Premium	$0/m² wall
	R-20 Assembly	R-39 ext. ins. plus R-19 batt, improved parapet and glazing transition
	Effective R-20 Premium	$45/m² wall
	R-30 Assembly	R-50 ext. ins. plus R-19 batt, further improved glazing transitions
	Effective R-30 Premium	$80/m² wall
	R-40 Assembly	Theoretical, R-108 ext. ins. plus R-19 batt
	Effective R-40 Premium	$200/m² wall
Roof Performance	R-20: $-18/m² roof Baseline: R-30 R-40: $18/m² roof R-60: $45/m² roof	
Glazing Performance	Baseline, USI to 2.2 USI-2.0: $17/m² window USI-1.6: $100/m² window	

	USI-1.2: $230/m² window USI-0.8: $250/m² window
Heat Recovery	Baseline: No Heat Recovery 70% efficient HRV: $5/cfm 90% efficient HRV: $7/cfm Low preheat temperature, +$1/cfm
Lighting Power Reductions	Baseline: NECB 2011 Code Values, CFL design 50% reduction, full LED: $99/ m² floor 60% reduction, full LED: $127/ m² floor 70% reduction, full LED: $169/ m² floor, targeting innovative design
HVAC System	Baseline HVAC: $245/m² Option - Ground-source VRF: $370/m²
Base Costs	$4,080/m² floor($379/ft²)

Table B-3. Ice Rink Cost Summary

Category	Premium	
Air Leakage	Cost per building, dependent on air infiltration level attained Baseline: $0, no testing Code: $47,500 Improved: $70,000 Passive House: $88,750	
	Baseline Assembly	Exterior insulated steel stud wall assembly, with typical bridging details R-21 ext. ins.
	Baseline Clear Wall R-Value (modelled)	20.4
	Baseline Effective Wall R-Value (with typical thermal bridging)	11.6
	R-5 Assembly	R-4 ext. ins.
	Effective R-5 Premium	-$35/m² wall
	R-10 Assembly	R-16 ext. ins.
	Effective R-10 Premium	$10/m² wall
	R-20 Assembly	R-28.5 ext. ins. plus R-19 batt, improved parapet and glazing transition
	Effective R-20 Premium	$20/m² wall
	R-30 Assembly	R-61.4 ext. ins. plus R-19 batt, improved at grade transition
	Effective R-30 Premium	$90/m² wall
	R-40 Assembly	Theoretical, R-131 ext. ins. plus R-19 batt, no glazing
	Effective R-40 Premium	$245/m² wall
Roof Performance	R-20: $-18/m² roof Baseline: R-30 R-40: $18/m² roof R-60: $45/m² roof	
Glazing Performance	Baseline, USI to 2.2 USI-2.0: $17/m² window USI-1.6: $100/m² window USI-1.2: $230/m² window	

	USI-0.8: \$250/m^2 window
Heat Recovery	Baseline: No Heat Recovery 70% efficient HRV: \$5/cfm 90% efficient HRV: \$8/cfm Low preheat temperature, +\$1/cfm
Lighting Power Reductions	Baseline: NECB 2011 Code Values, CFL design 50% reduction, full LED: \$62/ m^2 floor 60% reduction, full LED: \$78/ m^2 floor 70% reduction, full LED: \$94/ m^2 floor, targeting innovative design
HVAC System	Baseline HVAC: \$409/m^2 Option 1, Improved Ice-plant Efficiency to COP 4.0: \$440/m^2 Option 2, Refrigeration heat recovery serving building heating loads in addition to subfloor/ DHW pre-heat, coupled with GSHP for remaining loads: \$515/m^2
Base Costs	\$3,789/m^2 (\$352/ft^2)

Table B-4. Transit Station Cost Summary

Category	Premium	
Air Leakage	Cost per building, dependent on air infiltration level attained Baseline: $0, no testing Code: $10,000 Improved: $20,000 Passive House: $33,500	
Wall Performance	Climate Zone	5
	Baseline Assembly	Exterior insulated steel stud wall assembly, with typical bridging details
		R-21 ext. ins.
	Baseline Clear Wall R-Value (modelled)	20.4
	Baseline Effective Wall R-Value (with typical thermal bridging)	9.4
	R-5 Assembly	Likely window-wall or curtain wall, but costed as R-5 ext. ins.
	Effective R-5 Premium	-$35.2/m² wall
	R-10 Assembly	R-17 ext. ins. plus R-12 batt
	Effective R-10 Premium	-$6.9/m² wall
	R-20 Assembly	R-28.4 ext. ins. plus R-19 batt, improved parapet and glazing transition
	Effective R-20 Premium	$19.3/m² wall
	R-30 Assembly	R-44.9 ext. ins. plus R-19 batt, further improved glazing transitions
	Effective R-30 Premium	$55.6/m² wall
	R-40 Assembly	Theoretical, R-93.3 ext. ins. plus R-19 batt
	Effective R-40 Premium	$160/m² wall
Roof Performance	R-20: $-18/m² roof Baseline: R-30 R-40: $18/m² roof R-60: $45/m² roof	
Glazing Performance	Baseline, USI to 2.2 USI-2.0: $17/m² window USI-1.6: $100/m² window USI-1.2: $230/m² window USI-0.8: $250/m² window	
Heat Recovery	Baseline: No Heat Recovery 70% efficient HRV: $4.5/cfm 90% efficient HRV: $7/cfm Low preheat temperature, +$1/cfm	
Lighting Power Reductions	Baseline: NECB 2011 Code Values, CFL design 30% reduction, partial LED: $66/ m² floor 50% reduction, full LED: $85/ m² floor 70% reduction, full LED: $139/ m² floor, targeting innovative design	
HVAC System	Baseline HVAC: $803/m² Option, VRF with dedicated outdoor air system (DOAS): $985/m²	
Base Costs	$2,260/m² floor ($210/ft²)	

Table B-5. Transit Repair and Maintenance Cost Summary

Category	**Premium**	
Air Leakage	Cost per building, dependent on air infiltration level attained Baseline: $0, no testing Code: $42,750 Improved: $65,000 Passive House: $85,500	
Wall Performance	Climate Zone	5
	Baseline Assembly	Exterior insulated steel stud wall assembly, with typical bridging details
		R-21 ext. ins.
	Baseline Clear Wall R-Value (modelled)	20.4
	Baseline Effective Wall R-Value (with typical thermal bridging)	10.6
	R-5 Assembly	R-4.4 ext. ins.
	Effective R-5 Premium	-\$36.5/m^2 wall
	R-10 Assembly	R-18.9 ext. ins.
	Effective R-10 Premium	-\$4.6/m^2 wall
	R-20 Assembly	R-30 ext. ins., wrapped parapet and door transition thermal break
	Effective R-20 Premium	\$19.8/m^2 wall
	R-30 Assembly	R-57 ext. ins., wrapped parapet and door transition thermal break
	Effective R-30 Premium	\$79.2/m^2 wall
	R-40 Assembly	Theoretical, R-68.9 ext. ins. further improved parapet and door frame transition
	Effective R-40 Premium	\$110/m^2 wall
Roof Performance	R-20: \$-18/m^2 roof Baseline: R-30 R-40: \$18/m^2 roof R-60: \$45/m^2 roof	
Door Performance	R-2: \$0/m^2 door R-4: \$20/m^2 door R-8: \$25/m^2 door	
Heat Recovery	Baseline: No Heat Recovery 70% efficient HRV: $4/cfm 90% efficient HRV: $7/cfm Low preheat temperature, +$1/cfm Demand Control Ventilation: $85,000	
Lighting Power Reductions	Baseline: NECB 2011 Code Values, CFL design 30% reduction, partial LED: \$22/ m^2 floor 50% reduction, full LED: \$27/ m^2 floor 70% reduction, full LED: \$42/ m^2 floor, targeting innovative design	
Base Costs	\$2,260/m^2 floor (\$210/ft^2)	

Table B-5. Archetype Costing Summary for Example Solutions – All Three Levels

Office							
Level	Air Leakage Premium	Wall Premium ($/m2)	Roof Premium ($/m2)	Window Premium ($/m2)	Mechanical Premium	Lighting Premium	Incremental Capital Cost ($/m2)
1	0	0	0	31	0	0	31
2	6	0	0	21	0	28	54
3	11	22	0	51	126	70	280
Fire							
Level	Air Leakage Premium	Wall Premium ($/m2)	Roof Premium ($/m2)	Window Premium ($/m2)	Mechanical Premium	Lighting Premium	Incremental Capital Cost ($/m2)
1	0	0	0	26	0	0	26
2	15	0	0	26	172	28	240
3	25	43	0	32	178	70	349
Library							
Level	Air Leakage Premium	Wall Premium ($/m2)	Roof Premium ($/m2)	Window Premium ($/m2)	Mechanical Premium	Lighting Premium	Incremental Capital Cost ($/m2)
1	0	0	0	38	0	0	38
2	15	0	0	25	0	5	46
3	25	35	0	64	91	17	232
Transit Station							
Level	Air Leakage Premium	Wall Premium ($/m2)	Roof Premium ($/m2)	Window Premium ($/m2)	Mechanical Premium	Lighting Premium	Incremental Capital Cost ($/m2)
1	0	-6	0	0	0	19	13
2	38	-6	0	86	0	19	137
3	89	29	0	215	21	73	427
Transit Repair							
Level	Air Leakage Premium	Wall Premium ($/m2)	Roof Premium ($/m2)	Door Premium ($/m2)	Mechanical Premium	Lighting Premium	Incremental Capital Cost ($/m2)
1	0	0	0	0	5	0	5
2	0	0	0	0	15	0	15
3	0	5	0	0	84	15	104
Recreation Centre							
Level	Air Leakage Premium	Wall Premium ($/m2)	Roof Premium ($/m2)	Window Premium ($/m2)	Mechanical Premium	Lighting Premium	Incremental Capital Cost ($/m2)
1	0	0	0	33	0	0	33
2	3	0	0	22	0	0	25
3	6	30	46	55	81	52	270
Ice Rink							
Level	Air Leakage Premium	Wall Premium ($/m2)	Roof Premium ($/m2)	Window Premium ($/m2)	Mechanical Premium	Lighting Premium	Incremental Capital Cost ($/m2)
1	0	19	0	0	0	0	0
2	0	19	18	6	31	0	74

3	0	19	18	6	96	52	191
Pool							
Level	Air Leakage Premium	Wall Premium ($/m2)	Roof Premium ($/m2)	Window Premium ($/m2)	Mechanical Premium	Lighting Premium	Capital Cost ($/m2)
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	582	194	0	776

APPENDIX C: UTILITY COST RATES

Electricity

Commodity: $/kWh	Spot	0.100	0.095	0.121	0.122	0.123	0.124	0.125	0.127	0.128	0.129	0.130	0.131
	ToU OnPk	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132
	ToU MidPk	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
	ToU OffPk	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065

Rate Structure		Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
Residential	Admin	22.780	22.780	22.780	22.780	23.110	23.110	23.110	23.110	23.110	23.110	23.110	23.110
Residential	kWh	0.022	0.022	0.022	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Residential	kW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Small Commercial	Admin	9.310	9.310	9.310	9.310	9.390	9.390	9.390	9.390	9.390	9.390	9.390	9.390
Small Commercial	kWh	0.035	0.035	0.035	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
Small Commercial	kW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Less than 50 kW	Admin	45.660	45.660	45.660	45.660	46.300	46.300	46.300	46.300	46.300	46.300	46.300	46.300
Less than 50 kW	kWh	0.031	0.031	0.031	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Less than 50 kW	kW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50 to 499 kW	Admin	79.410	79.410	79.410	79.410	82.760	82.760	82.760	82.760	82.760	82.760	82.760	82.760
50 to 499 kW	kWh	0.011	0.011	0.011	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
50 to 499 kW	kW	10.127	10.127	10.127	10.127	10.716	10.716	10.716	10.716	10.716	10.716	10.716	10.716
500 to 4999 kW	Admin	1808.420	1808.420	1808.420	1808.420	1836.250	1836.250	1836.250	1836.250	1836.250	1836.250	1836.250	1836.250
500 to 4999 kW	kWh	0.011	0.011	0.011	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
500 to 4999 kW	kW	7.662	7.662	7.662	7.662	7.925	7.925	7.925	7.925	7.925	7.925	7.925	7.925
StreetLighting	Admin	1.560	1.560	1.560	1.560	1.580	1.580	1.580	1.580	1.580	1.580	1.580	1.580
StreetLighting	kWh	0.011	0.011	0.011	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
StreetLighting	kW	15.724	15.724	15.724	15.724	15.540	15.540	15.540	15.540	15.540	15.540	15.540	15.540
Load Factor		1.036	1.036	1.036	1.036	1.036	1.036	1.036	1.036	1.036	1.036	1.036	1.036

Natural Gas		Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
Admin		70.000	70.000	70.000	70.000	70.000	70.000	70.000	70.000	70.000	70.000	70.000	70.000
Commodity	$/m^3$	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148
Transportation													
Delivery	500	0.106	0.106	0.106	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104
	1050	0.084	0.084	0.084	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082
	4500	0.070	0.070	0.070	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068
	7000	0.060	0.060	0.060	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
	15250	0.056	0.056	0.056	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054
	Over 28300	0.055	0.055	0.055	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
Carbon Tax		0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035

APPENDIX D: ACRONYMS AND DEFINITIONS

AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigeration, Air-Conditioning Engineers
BB	Used as Baseboards in parametric maps, also considered as in-floor heating
CHP	Combined Heat and Power
CO2e	Carbon dioxide equivalent
COP	Coefficient of Performance
DCV	Demand Controlled Ventilation
DHW	Domestic (service) hot water
DOAS	Dedicated outdoor air system
DX	Direct expansion
ECM	Energy conservation measure
ekWh	Equivalent kilowatt hours (common nomenclature for energy unit conversion from Joules for Natural Gas for comparison with electricity)
GHG	Greenhouse gas
GHGI	Greenhouse gas intensity
HRV	Heat recovery ventilators
HVAC	Heating, Ventilation, and Air-Conditioning
IR	Infrared
LED	Light-emitting diode
LEED	Leadership in Energy and Environmental Design
MAU	Make-up air unit
MH	Morrison Hershfield Limited
NECB	National Energy Code for Buildings

NPV	Net present value. The values presented in this report are incremental to the NPV of the existing or baseline building (business as usual case).
OA	Outdoor air
PV	Photovoltaic
RTU	Rooftop Units
SHGC	Solar heat gain coefficient
TEDI	Thermal energy demand intensity
(T)EUI	(Total) Energy use intensity
UH	Unit heaters
VAV	Variable air volume
VFD	Variable frequency drive
VRF	Variable refrigerant flow
WSE	Waterside economizer

APPENDIX E: ENERGY CONSULTANT SCOPE OF WORK

The primary objective of the Building Energy Consultant will be to recommend and support design decisions related to building performance through the use of computer simulation and engineering judgement. The Building Energy Consultant will also be required to document compliance with LEED certification and building code, as applicable. The overall goal is to assist the design team in designing a building that operates well and as expected for the City of Mississauga.

Specifically, the Building Energy Consultant will be required to undertake the following tasks. All energy modelling is to be completed using one of the following energy modelling software programs: EnergyPlus, IES/VE, eQUEST, CanQUEST, or an equivalently capable DOE-2 based program. EE4 as a stand-alone tool will not be permitted, as it severely limits the type of options that can be directly explored. Note that software selection shall not be a limitation in exploring any measure deemed appropriate by the City and design team. The consultant shall use whatever tools necessary to provide accurate feedback on building performance as necessary according to the detailed scope identified below.

Phase 1: Conceptual Design

During the Conceptual or Planning phase of the project, the Building Energy Consultant will:

- Assess the impact of up to three massing options presented by the architect, if applicable, and provide feedback on the following metrics:
  - Relative energy use or building loads based on ideal air loads analysis, broken down by end uses
  - Relative peak heating and cooling loads for the building and for the worst performing zones (on a W/m^2 or Btu/h/sq ft basis)
  - Daylight potential and excessive illuminance levels (i.e. glare) in zones of interest, as determined by City and/or Architect
  - Renewable energy potential, as applicable from RFP
  - Alignment of City goals as defined in the RFP, for the target TEUI, TEDI and GHGI metrics for the performance level being targeted

To reduce the number of variables that differentiate between each iteration of the model, plug loads, ventilation rates, and schedules (occupancy, lighting, plug, fans, thermostatic setpoints) are to be kept constant between options and are to be appropriate for the building based on occupancy.

If mechanical systems are known at this stage, they shall be modelled directly. However, absence of mechanical information shall not hold up this phase. In lieu of actual HVAC design parameters at conceptual design, mechanical systems are to be modelled as heating, cooling, and ventilation delivered directly to the zones (i.e. 100% OA with terminal heating and cooling), or as per the best judgement of the modeller. The model shall also take into account the daylighting potential of the building by directly modelling the impact of daylight sensors in applicable zones. The intent of this phase is to comment only on the impact of architecture on indicative building performance metrics.

Based on the findings from the analysis conducted above, the Building Energy Consultant will work with the architect to recommend strategies around massing, location and amount of glazing, and shading to improve the outcome based on the metrics identified above. Allow for an additional round of energy modelling to assess the impact of resulting recommendations for only one of the massing options.

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.

The Building Energy Consultant shall prepare a report that clearly identifies the energy modelling strategy employed, a summary of key inputs used, a summary of results based on the above metrics and any recommendations. Units shall be reported in kWh for electricity and GJ for natural gas, as well as an ekWh and ekWh/m2 for total energy and GHG emissions in kg/m^2. Current utility costs shall be retrieved from the City of Mississauga's Energy Management Office. GHG emissions factors shall be derived from the City's Energy Modelling Guidelines.

Include for a minimum of 2 meetings during this phase with the project team, one to identify energy modelling approach with project team, and one to present the findings of this phase. This phase would also contribute to meeting the Integrative Process credit under LEED v4.

Phase 2: Schematic Design

For the purposes of the Building Energy Consultant's work, this phase will begin when the final architectural massing and programming is set. At this stage, the Building Energy Consultant will:

- Assess the impact of the building systems listed below, in isolation and in combination, on the following metrics:
    - Energy use, broken down by end uses (at minimum heating, cooling, lighting, plug loads, fans, and pumps)
    - Energy Cost, broken down by end uses and Utility (including utility rates used)
    - Peak delivered heating and cooling for the building and for the worst performing zones, if applicable
    - City compliance metrics and targets (TEUI, TEDI and GHGI)

If the consultant is using a software that auto-generates a baseline, the appropriate modifications must be made to ensure compliance with the NECB as it applies to the Ontario Building Code and/or LEED v4.

- Building systems to be analyzed shall include at minimum:
    - Wall performance, based on effective R-values and taking into account heat loss from not only assemblies, but also interface details as per the Building

Envelope Thermal Bridging Guide (located at www.bchyrdro.com/thermalguide)

- Window performance, based on Solar Heat Gain Coefficient, Visible Transmittance, and overall U-value (including framing)
- Roof performance
- Lighting power density ranges, as appropriate
- Variations in mechanical system types if under consideration for the project (ex. Air-based heating and cooling with recirculation versus 100% OA with Radiant Heating)
- Mechanical equipment efficiencies, including boiler efficiency, chiller and heat pump COPs, fan and pump static pressures and efficiencies, motor efficiencies, presence of heat recovery and heat recovery efficiency
- Impact of potential renewable energy options, as applicable in the RFP
- Building-type specific innovative measures (ex. Chiller heat recovery for data centre spaces or specialized refrigeration such as ice rinks or innovative dehumidification and reheat strategies in swimming pools, etc.)

The inputs to be used for the analysis in this phase shall be considered by the Building Energy Consultant based on previous experience with similar buildings and discussion and coordination with design team members, including the architect, mechanical and electrical engineers. The intent of this phase is to inform design. Therefore, this exercise is intended to be an input into developing a detailed design that addresses energy as a parameter in design considerations.

For this phase, the Building Energy Consultant shall prepare a report that clearly identifies the energy modelling strategy employed, a summary of key inputs used, a summary of results based on the above metrics and any recommendations. Units shall be reported in kWh for electricity and GJ for natural gas, as well as an ekWh and ekWh/m2 for total energy and GHG emissions in kg/m^2. Current utility costs shall be retrieved from the City of Mississauga’s Energy Management Office. GHG emissions factors shall be derived from the City’s Energy Modelling Guidelines.

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.

This phase shall include an energy charrette with the project team led by the Building Energy Consultant. The intent of this meeting will be to explain the results of the schematic design energy model and set direction for the remainder of design.

Phase 3: Design Development

During design development, the Building Energy Consultant will review the drawings and specifications at each of two major milestones (approximately 50% DD Package and Issued for Building Permit) and provide an update on energy performance.

The Building Energy Consultant shall prepare a brief memo to the design team reporting back on the findings of this phase.

For Building Permit, the Building Energy Consultant shall provide all documentation required by The City of Mississauga, Inspections and Permits.

Include for one meeting during this phase to explain updated energy results and answer any questions from the project team.

Phase 4: Compliance

Upon completion of final construction documents (i.e. Issued for Construction drawings and specifications), the Building Energy Consultant shall prepare one final energy model for the purposes of LEED (if applicable) and all supporting documentation as required by the governing authority of the LEED program. The Building Energy Consultant will also respond to review comments by the governing authority to ensure successful achievement of the Energy and Atmosphere Pre-requisite 2 *Minimum Energy Performance* and Credit *1 Optimize Energy Performance*, if applicable.

It is not the expectation of the City for the Building Energy Consultant to review and monitor Shop Drawings during construction. However, it is expected that the Building Energy Consultant clearly communicate to the Prime Consultant and/or the design professionals reviewing shop drawings on what criteria should be reviewed and when and how the Building Energy Consultant should be notified of any relevant changes. If the changes are significant enough to warrant additional iterations to the energy model, this will be completed on a Time and Materials basis.

In compliance with the City of Mississauga's Master Consulting Terms & Conditions, all reports, discussion summaries, meeting minutes, and modelling files will be provided to The City of Mississauga's Project Manager.

Phase 5: As Built Energy Model

A final as-built energy model, reflecting all of the changes from the compliance model to the construction of the building shall be captured in a final energy model that may be used for post-occupancy verification of energy savings at a later date.

Phase 5: Post-Occupancy Verification

The energy and thermal comfort performance of actual buildings will depend on many factors that can vary from the assumptions in spite of multiple model evaluations during the design including hours of use, occupancy, occupant behaviour, and variations in plug and process loads.

The City of Mississauga will compare energy performance results with the As Built Energy Model results using actual metered energy use during the first 12 months of post occupancy data, or to coincide with the schedule prescribed in an approved Measurement & Verification Plan (approved in the Design Development Phase). It is up to the project consultant team to retain a qualified individual for the development of the M&V Plan, but it is expected that the

Building Energy Consultant will contribute in the review of the Plan to ensure that the appropriate metering is in place to facilitate post-occupancy calibration, if required.

The focus of post-occupancy verification is on corrective action for operations, rather than on verifying savings of specific ECMs. The level of effort for such a process may be somewhat variable, however the intent would be an outcomes-based investigation to ensure building operational energy savings are as designed.

If actual results are within 15% of the As Built Energy Model, no further follow up will be required.

If actual TEUI results vary from the model by ≥15% of the as-built model results and the discrepancies are not as a result of operational issues (change in occupancy, schedules, unique events, etc.), the Project Consultant Team shall allow for the calibration of the as-built energy model with post-occupancy metering data, and prepare a written report to investigate the discrepancy between modelled and actual performance.

The Project Consultant Team shall allow for a follow-up meeting with the City of Mississauga to review the explanation and recommend reconciliation measures to help align building operations with the as-designed energy efficiency of the building.

APPENDIX F: ENERGY MODELLING GUIDELINES

This document is intended to provide clarity on energy modelling inputs for the purposes of showing compliance with the Municipal 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.

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.

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

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[1],[2]
Purchased Renewable Energy: 0 g/kWh[3]

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).

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[1] The emissions factor of a district energy system shall be as provided by the utility (and as agreed by the utility and the AHJ).
[2] 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.
[3] 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.

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).

Acceptable Energy Modelling Software

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

Weather File

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

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.

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.

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

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.

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)

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.

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 exists 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.

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.

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%.

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.

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.

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

2019-2022 Environmental Action Committee Work Plan

WORK PLAN ITEM	ACTION FOR EAC MEMBERS	TIMING	PROGRESS *Action Taken or Date Completed*	
Climate Change	Support approval and implementation of the Climate Change Action Plan.	Ongoing	***July 9/2019***	Deep dive discussion surrounding the Climate Change Action Plan with the EAC members gaining insightful comments and feedback for consideration during the finalization of the overall plan.
			July 25/2019	The Climate Change Stakeholder Panel workshop was held, where several EAC members participated. Comments received at this workshop were incorporated in the draft Climate Change Action Plan (CCAP). The updated CCAP will go to Council at the September 18th meeting for information. If public consultation for this draft CCAP is approved by Council at this meeting, public consultations will run from Mid-September to October.
Volunteering	Participate in volunteering opportunities as members of the Community Green Leaders volunteer program.	Ongoing		
Support City Action on Environment	Be prepared to comment on City-led items brought forward to EAC meetings (E.g., strategic plans, by-laws).	At EAC meetings		
Report on Committee Progress	Report to General Committee annually on progress on EAC's work plan and activities. (Includes the EAC Actions Summary as an appendix)	Once per year		
Additional/Other				