ATTACHMENT 1

Conserving Energy in New Construction

Integrated Design Process

Prepared for: **TO Live**

Meridian Hall Carbon Reduction Projects

Savings by Design Workshop Summary

IDP Workshop Date: August 3, 2022
IDP Report Date: October 7, 2022

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SBC SUSTAINABLE BUILDINGS CANADA

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[1] A link to the workshop presentations has been provided separately to members of the proponent team

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A special thank you is owed to TO Live and each of the guest experts for their time, open dialogue, and contributions to the day.

Note that the information presented herein highlights the discussions that occurred on the day of the workshop. In some cases, subsequent research, including energy modeling was undertaken to augment the information. As a research activity, the intent of the workshop is to provide the best available information through the engagement of subject matter experts. The reader is encouraged to verify the information through their own research and market sources and seek second opinions as required.

1. EXECUTIVE SUMMARY

Sustainable Buildings Canada is pleased to present the findings of an integrated design process (IDP) workshop undertaken on behalf of Enbridge's Savings by Design (SBD) program for TO Live. Since the "Meridian Hall Carbon Reduction Projects" (Meridian Hall) is located within the City of Toronto and is subject to the Toronto Green Standard, the project will be required to meet a minimum Savings by Design energy performance target of 35% better than the Ontario Building Code (OBC) to meet the incentive requirements for the SBD program.[2]

The SBD program was developed to encourage builders to improve energy and environmental performance in new construction projects. The aim of the program is to help builders *"Design it right. Build it right. Run it right."* The SBD program allows developers to explore solutions attributed to high performance buildings. Builders also have the opportunity to market green features and energy performance goals of their project under the SBD program banner.

BETTER BUILDING DESIGNS CONSIDER:

- DURABILITY
- CONSTRUCTABILITY
- WATER EFFICIENCY
- ENVIRONMENTAL IMPACT
- HEALTH AND WELL-BEING
- OCCUPANT SATISFACTION

The program is delivered by SBC on behalf of Enbridge and includes a planning session and a full day design workshop. The facilitated workshop held for TO Live provided an opportunity for a multi-disciplinary dialogue within an open forum to explore sustainability innovation and test energy efficiency concepts using energy performance simulation modelling. Various stakeholders, in addition to the SBD program staff and industry experts, attended the session. The group also explored considerations for low impact development and stormwater management.

The main objective of the workshop discussion was to examine alternative designs and technologies that could achieve a projected annual energy performance that is at least 35% better than OBC, consistent with the requirements of the SBD program. Energy performance must be demonstrated using energy performance modelling to ensure that qualified projects meet the program goal.

Real-time energy modeling was performed during workshop. The energy modeling determined that energy performance for the "Meridian Hall" project is **38.2% better than the OBC (modified by SB-10, 2017)** which meets the goal set by the SBD program. The cumulative annual energy cost savings are expected to be $2,196[3] with a reduction in total greenhouse gas (GHG) emissions of 257,484 kg CO_2Eq.

[2] Please refer to incentive structure on page 8

[3] Cost savings are based on electricity and natural gas rates that are an average used for the SBD Program and may not accurately reflect the pricing for the particular project. Proponents should validate prices with their Utility.

MODEL SIMULATION RESULTS SUMMARY

Overall Energy Performance

Modeled Area: 181,310 ft² 16,844 m²	Total Annual Projected Energy Consumption	Energy Utilization Intensity	Annual Electricity Consumption	Annual Natural Gas Consumption	Annual Greenhouse Gas (GHG) Emissions	Energy Performance as Compared to OBC
	ekWh/yr *and* (GJ/yr)	ekWh/ft^2-yr and ekWh/m^2-yr	kWh	m^3	Kg CO_2eq	%
OBC Reference Building[4]	3,319,922 (11,952)	18.3 (197.1)	1,771,750	146,653	367,082	–
Baseline Building[5]	4,786,878 (17,233)	26.4 (284.2)	2,443,892	221,943	543,664	-44.2
Savings by Design Building[6]	2,050,221 (7,381)	11.3 (121.7)	1,995,664	5,168	109,597	38.2[7]

Several energy conservation measures (ECMs) were analyzed. The additional measures incorporated into the building design to create the SBD Building include:

- Improve performance of exterior walls with recladding to include exterior insulation, thermally efficient cladding attachments: R-16 Effective
- Add exterior insulation at foundation walls: R-18 Effective
- Improve roof insulation, mitigate thermal bridging: R-35 Effective
- Enhanced aluminum curtain wall with fibreglass pressure plate or 4-way SSG, IG with side 4 ITO coating: USI-1.75 W/m²·K, SHGC 0.33

[4] Just meets the Building Code, using OBC 2017 SB-10 code requirements (NECB 2015, as modified by SB-10 Division 3, Chapter. 3)
[5] Baseline building represents the existing building; The primary fuel source for space heating and water heating is district steam for the Baseline Building.
[6] As determined through the IDP Workshop – representative path towards SBD Program goal. **The primary fuel source for water heating is natural gas for the SBD Building.**
[7] Some of the energy conservation measures in the SBD Building would necessitate and change to the OBC Reference Building for SB-10 purposes but are not considered in the results table.

- Entry doors with thermally broken aluminum frames & sash, IG: USI-2.90 W/m²·K, SHGC 0.30
- Enable variable fan control with fan speed drives connected building automation system
- Energy recovery ventilation in washrooms and other conditioned spaces
- Convert steam system serving air handlers to water cooled heat pump served by Enwave Deep Lake Water system (seasonal COP 4.3)
- Enwave district cooling to provide low-carbon chilled water to building
- Convert electric boiler and steam domestic hot water to a 95% efficient gas boiler that serves the domestic hot water needs of the building.

A host of potential activities, technologies, and opportunities, which the TO Live team might consider as part of the project have been identified. Further discussion and analysis will be required to identify the optimal solution. It is important to note that the success of any measures will depend upon proper installation and commissioning, the application of the appropriate control systems, and occupant behaviour.

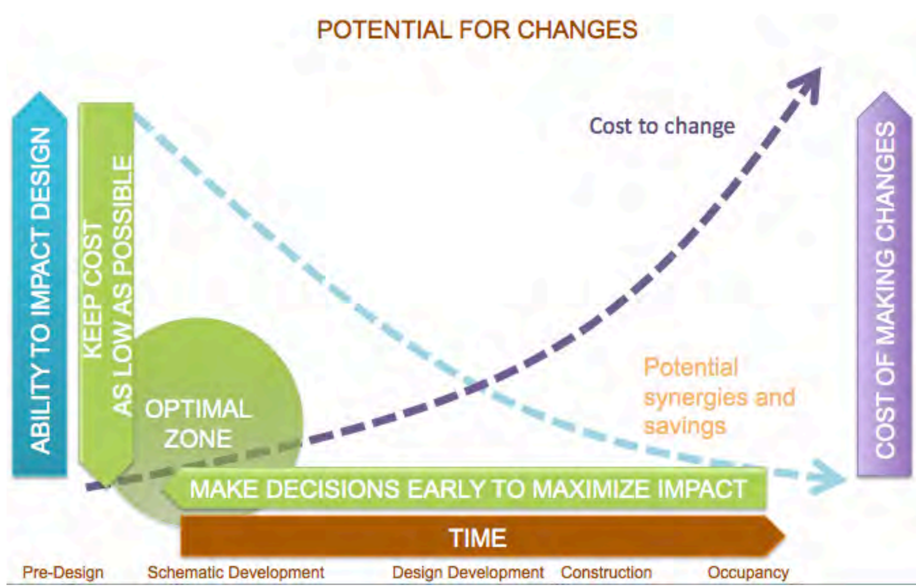
The measures modelled and the SBD Building have been presented for demonstrative purposes to show one path towards meeting the SBD program goal.

2. INTRODUCTION AND BACKGROUND

The August 3, 2022, IDP workshop was facilitated by SBC staff and attended by representatives from TO Live and their team/contractors, SBD program staff, Enbridge staff, and a number of external experts who provided specific insights related to energy efficiency and other environmental aspects of the project. The workshop focused on the identification of opportunities to enhance the energy and environmental performance of the new building as well as alternative design approaches to implement those opportunities and provide enhanced sustainability. A planning session, during which TO Live team identified the goals and objectives for the project preceded this full day activity.

Constantine Eliadis of SBC started the workshop by welcoming the group. Mary Sye welcomed the group on behalf of Enbridge. The SBD program was developed by Enbridge in response to the Ontario Energy Board's direction to integrate market transformation into their Demand-side Management Programs. Between 1995 and 2016 demand side management programs operated by Enbridge have saved 22 million tonnes of carbon dioxide emissions. Constantine presented the agenda for the day and following a round introductions, he identified the goals of the day's activities. Everyone at the workshop was encouraged to participate and offer ideas and suggestions. SBC would like to thank all those who attended for their valuable input and insights.

The integrated design process (IDP) is a way of designing new buildings and houses to achieve higher performance targets through the participation of all stakeholders in a manner that acknowledges the inherent inter-relationships between the function and features of the building and the resulting environmental impacts. Recognizing that these relationships are part of an integrated design activity, opportunities to minimize energy and water use, and other related environmental impacts can be identified and the evaluation of the performance benefits of new design solutions considered.



SAVINGS BY DESIGN PROGRAM

Using a holistic approach, SBD promotes market transformation with the goal of achieving an improvement in overall energy performance while facilitating low impact development along with and other innovative environmental performance solutions for the project.

The Savings by Design is a process-based approach involving:

1 Visioning Session
- Up to a half-day session where sustainability priorities and opportunities are defined

2 Building Energy Modeling
- Performance baseline is evaluated

3 IDP Workshop
- Full day session with industry experts to identify and evaluate strategies to meet sustainability goals and the SBD energy reduction target
- Real-time energy modelling
- Final IDP Workshop Summary report

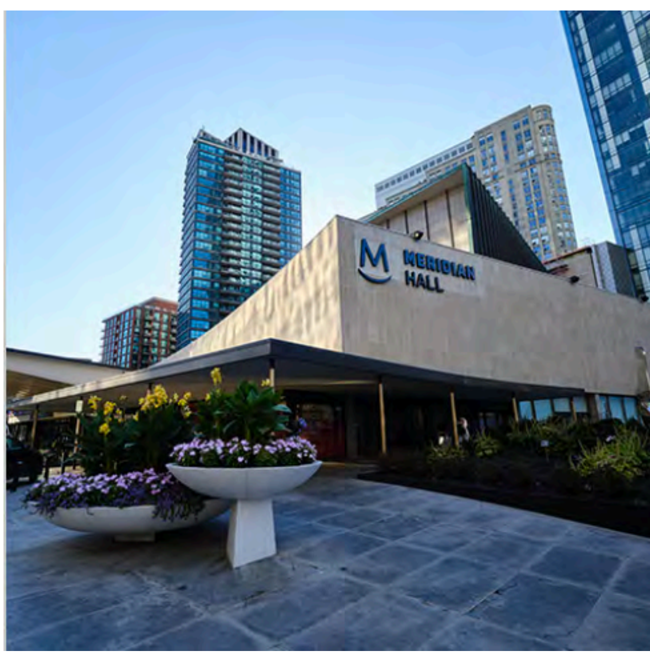
4 Energy Modelling and Final Design Stage Incentives
- Incentive of $15,000 for a completed "As Designed Energy Model" which demonstrates that the building has been designed to achieve the SBD program energy performance target

5 As-Built and Commissioning Incentives
- Incentive of $15,000 for buildings that achieve the SBD program energy performance target of 35% energy reduction versus OBC SB-10 2017 Energy Model, or 5% better than the Baseline Building (if the Baseline Building is already $\geq$ 35%)
- Final "As Built Energy Model "[8] and Commissioning Report must be submitted and approved.

[8] Incentives are provided to the proponent. "As Designed" and "As Built" Energy Models must follow the SBD Energy Modelling Protocols. http://commercial.savingsbydesign.ca/programoverview.php

3. PROJECT OVERVIEW

- Meridian Hall is a major performing arts venue located at 1 Front Street East in the St. Lawrence Market neighbourhood of downtown Toronto, ON;
- The project is a deep energy retrofit for the building, which was opened in 1960;
- The building construction is primarily steel trusses and concrete; It includes many different materials such as limestone, granite, marble, copper, and bronze; The interior features a double-height lobby;
- The centre is owned by the City of Toronto and managed by TO Live;
- The transformation project is being done in partnership with Create TO and will expand the adjoining facility and add thousands of square feet to create a state-of-the-art cultural and community hub;
- While there have been some renovations and restoration work done over the years, none have impacted building operations and plant equipment technologies have not been updated;
- In addition to the auditorium, the current building includes, offices, dining room/lounge, rehearsal hall, and other supporting spaces;
- The project is subject to the City of Toronto stormwater management requirements and is being executed in conjunction with the redevelopment of the St. Lawrence Centre for the Performing Arts;
- The plan calls for the creation of an outdoor public plaza by closing a portion of Scott Street and connecting it to Meridian Hall and Berczy Park;
- Transform TO is targeting a 50% reduction in energy use, a way forward to achieved Toronto's net zero climate strategy.



4. ENERGY MODELLING AND PRE-WORKSHOP RESULTS

Ryan Evans of EVNA Engineering presented the results of the energy performance simulation model developed using specifications provided by the proponent design team in advance of the Design Workshop.

Calculations were performed using the eQUEST v.3.65-7173 DOE 2.2 energy simulation tool. The software is designed to allow professionals to perform detailed analysis of the whole building including electrical, mechanical, ventilation and envelope systems. The energy performance simulation program calculates energy consumption for each source every hour of the year using weather data called CWEC (Canadian Weather for Energy Calculations), occupancy rates and schedules and internal loads that are provided in the software as appropriate for the building type. The CWEC 2020 weather file for Toronto (CAN_ON_TORONTO-CITY_6158355_CWEC.BIN), Ontario was used as it was the closest weather station.

The energy modelling is based on the design drawings by RHD Premium Services Inc dated December 3, 2018, planning session notes, and Baseline model assumptions provided by the subject matter experts (SMEs). Where information has not been made available assumptions have been made as appropriate with respect to the modelling inputs for the Baseline Building.

Following the modelling protocol, a Reference Building was created that just meets the current Ontario Building Code. The guidelines in NECB 2015 Part 8 as modified by Supplementary Standard SB10-2017 Division 3, Chapter 3 and the SBD Modeling Guide, were followed in generating the Reference and Baseline Building models.

It is important to understand what energy modelling can and cannot do. Energy modelling is performed on rated efficiencies and assumes a perfectly constructed and commissioned building; it does not account for occupant/operator behaviour and the occupancy schedules used may not reflect true occupancy of the building. It is important that the building is operated properly to achieve targeted outcomes.

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BUILDING OVERVIEW – KEY FEATURES OF THE PROJECT[9]

- Architect: Earl C Morgan and Page Steele Architects.
- Building footprint: 6,291 m² / 67,689 ft²
- Modeled Area[10]: 16,844 m² / 181,310 ft²
- 4-storey multi-purpose live event theatre with offices and amenities on each floor + mechanical penthouse
- Exterior stone-clad wall with 8” brick backup: Clearfield R-3: Effective R-2
- Conventional flat roof design: Effective R-20
- Window to wall ratio: 9% vision glass (N: 2%, E: 5%, S: 0%, W: 2%)
- Fenestration: Double pane, metal frame curtain wall windows: U-2.85 W/m²-°K, SHGC 0.38
- Below grade walls: uninsulated concrete: R-3
- Overall R-value of entire enclosure[11]: R-3.7
- LED lighting fixtures: set based on available electrical drawings and calibrated to utility consumption
- Electrical equipment power densities: calibrated to utility consumption
- Space cooling & dehumidification: chilled water coils; water-cooled chiller with COP 4.2
- Space heating & humidification: steam-to-hot water heat exchanger supplying reheat coils; Enwave district steam plant
- DHW heating: Enwave district steam in shoulder and winter seasons, electric domestic hot water heater in summer
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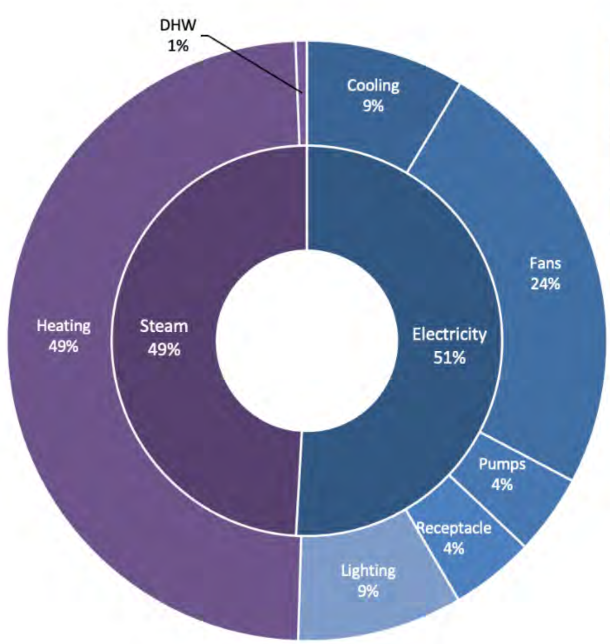
[9] Detailed Reference Building and Baseline Building inputs can be found in Section 9.
[10] Modeled square footage may typically vary slightly from the actual GFA due to modeling rules that exclude certain non-heated or non-regulated spaces, and variation in measurement techniques from official site statistics
[11] **Overall R-value** ($R_{overall}$) entire enclosure type (walls, roofs, windows, doors), excludes slab on grade.

REFERENCE AND BASELINE MODEL DEVELOPMENT AND SIMULATION RESULTS

Modeled Area: 181,310 ft² 16,844 m²	Total Annual Projected Energy Consumption	Energy Utilization Intensity	Annual Electricity Consumption	Annual Natural Gas Consumption	Annual Greenhouse Gas (GHG) Emissions	Energy Performance as Compared to OBC
	ekWh/yr *and* (GJ/yr)	ekWh/ft^2-yr and ekWh/m^2-yr	kWh	m^3	Kg CO_2eq	%
OBC Reference Building	3,319,922 (11,952)	18.3 (197.1)	1,771,750	146,653	367,082	–
Baseline Building	4,786,878 (17,233)	26.4 (284.2)	2,443,892	221,943	543,664	-44.2

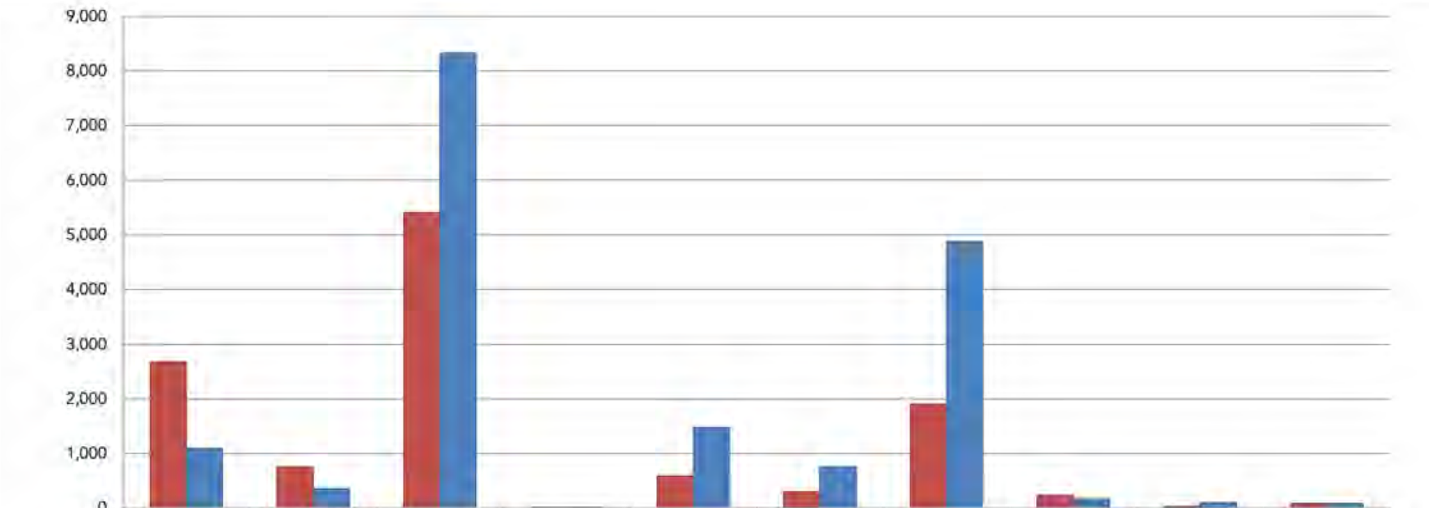
The Baseline Building performs 44.2% worse than the Reference Building. As a 62-year-old building, this is to be expected as many of the design and equipment specifications of the building have energy performance characteristics below what the current building code requires.



EUI (kWh/m²-yr)	284.2
TEDI (kWh/m²-yr)	138.5
GHGI (ekg CO_2/m²-yr)	32.3
Energy Cost ($/m²-yr)	$34.64

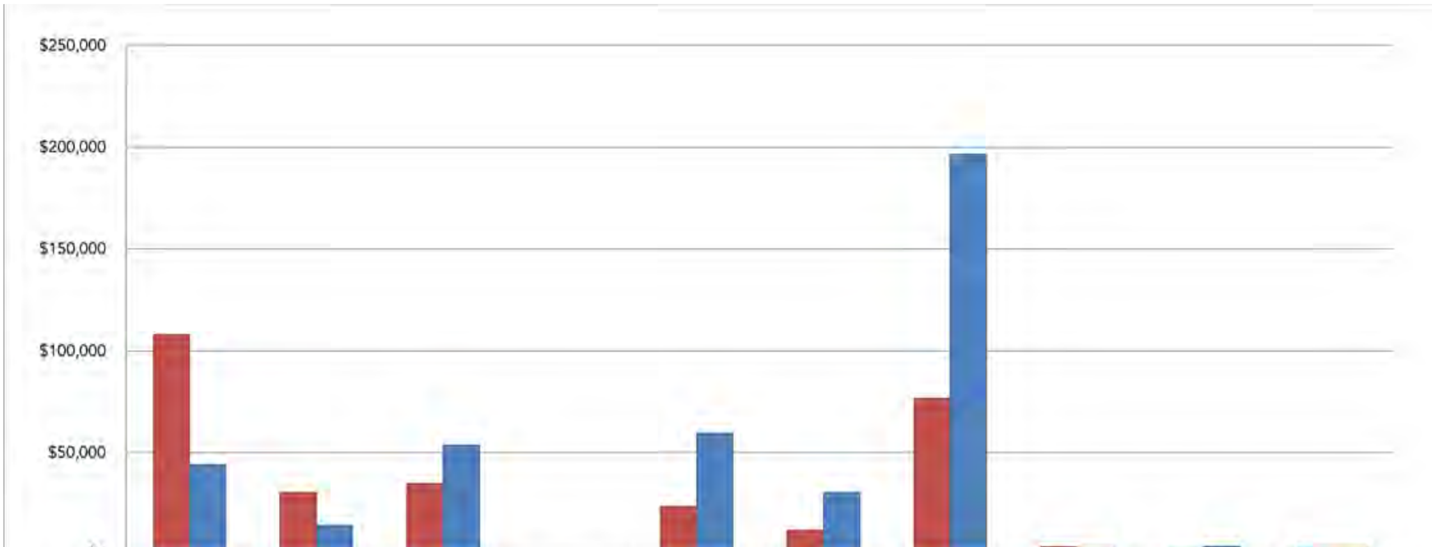
IDP Workshop Summary

Annual Energy Use by Component (GJ)



	Lighting	Miscellaneous Equipment Electric	Space Heating Gas	Space Heating Electric	Cooling	Pumps	Fans	Domestic/Service Hot Water	Heat Rejection	Exterior Lights
Reference	2,677	754	5,407	0	583	294	1,903	230	23	79
Baseline	1,096	354	8,333	0	1,475	752	4,878	165	99	79

Annual Energy Cost by Component ($)



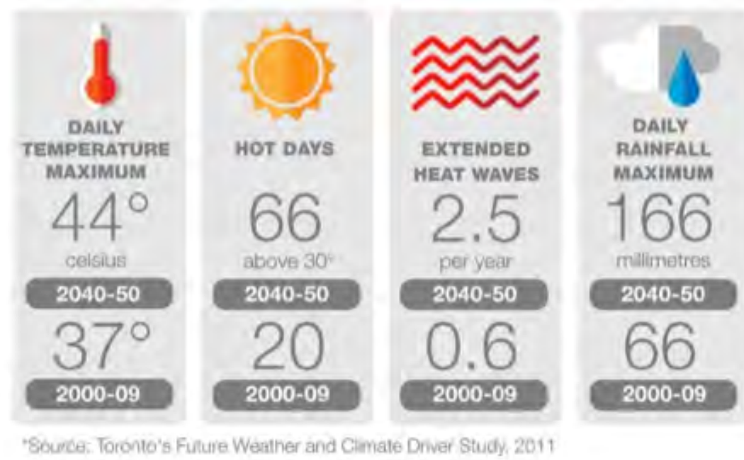
	Lighting	Miscellaneous Equipment Electric	Space Heating Gas	Space Heating Electric	Cooling	Pumps	Fans	Domestic/Service Hot Water	Heat Rejection	Exterior Lights
Reference	$107,843	$30,370	$34,854	$0	$23,499	$11,861	$76,652	$3,635	$917	$3,201
Baseline	$44,147	$14,277	$53,722	$0	$59,427	$30,305	$196,470	$3,211	$3,979	$3,201

5. CLIMATE CHANGE CONSIDERATIONS

Future Weather Patterns

It is important to consider "future proofing" of the building to address future weather patterns and the need for adaptable building performance. The expected impact of climate change is an increase in:

- Extended heat waves and higher summertime temperatures
- Mild winters
- Freeze-thaw cycles
- Winter Rain
- Warm nights
- Severe storms
- Year-to-year variability of weather

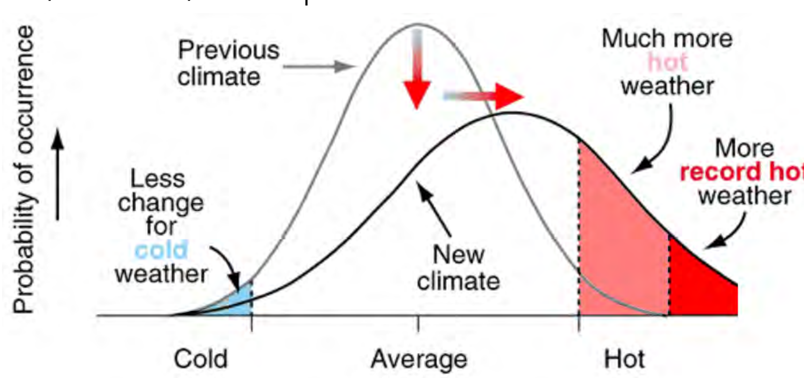


TORONTO'S FUTURE WEATHER

Builders/developers need to consider how these will affect our buildings. As an example, the number of heating degree-days is decreasing. Toronto has already shifted from Climate Zone 6 to Zone 5 and is expected to become Zone 4, which is where Washington DC is. Mechanical systems will need to be performing to different peaks and longer periods of hotter weather. The question becomes "How do we make buildings resilient to this change?"

Occupant Comfort

Occupant comfort also needs to be considered as part of the climate change conversation. There can be challenges of occupant thermal comfort and control strategies. The most commonly used indicator of thermal comfort is air temperature; however, air temperature alone is not an accurate indicator of thermal comfort. Radiant temperature, relative humidity, air velocity, activity rate, and amount of clothing must all be considered.

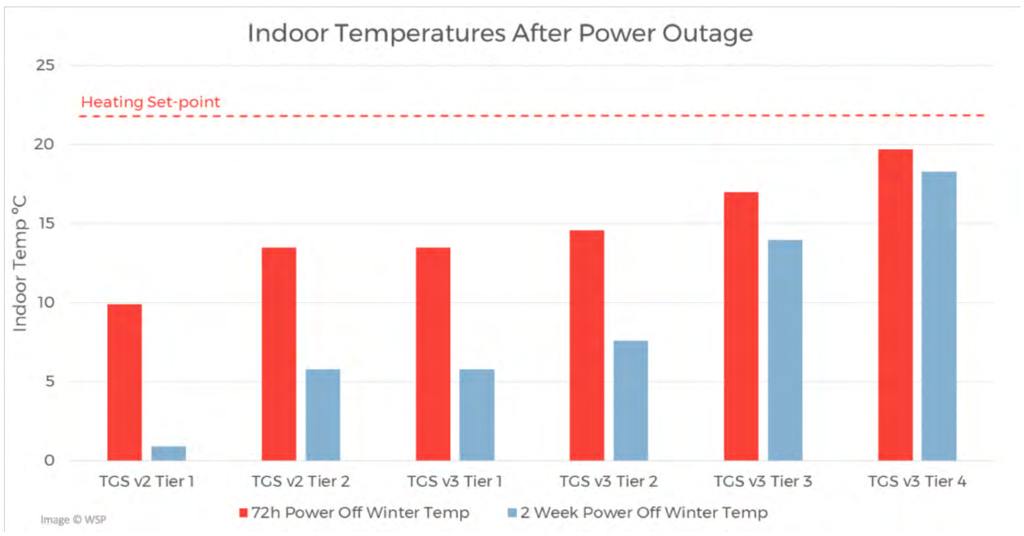


A complete assessment of expected occupant comfort can help identify 'un-anticipated' comfort issues, reducing the number of dissatisfied/uncomfortable occupants, and help design teams consider incorporating appropriate thermal controls. There are tools available to help assess thermal comfort early during design process.[12]

Passive Survivability

Passive survivability is a performance indicator that describes the building's ability to maintain an acceptable indoor condition despite the failure of active building systems.

During a midsummer blackout, a building with cross-ventilated suites will maintain a much lower indoor temperature (under 26° C for all the 200 hottest hours of the year) regardless of glazing type. Low-rise buildings benefit from cross ventilation. Different strategies must be employed for mid-rise and high-rise buildings to achieve optimal conditioning. With a "just-code" compliant envelope, a typical multi-residential north-facing suite can experience temperatures dropping below 0° C during a power failure on a cold winter day. With a better performing envelope (~R-15), these suites can maintain livable indoor temperatures (above 15° C) through a multi-day midwinter blackout.



As temperature changes become more erratic and more extreme, it is important that the building have a strategy to address passive survivability requirements.

Reducing energy loads in buildings, encouraging passive design strategies, providing protection/self-recovery during power disruptions, and providing low carbon energy sources of supply are core to achieving a green building and sustainable building.

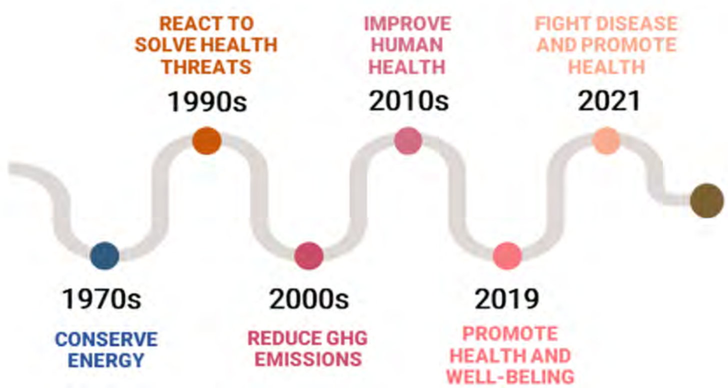
[12] CBE Thermal Comfort Tool: http://comfort.cbe.berkeley.edu/

6. DESIGNING FOR OCCUPANT COMFORT, HEALTH, AND WELLBEING

A large body of research links specific building design and operation attributes with health outcomes. Bettina Hoar of Sage Living, Toronto led the discussion on the impact buildings have on health and wellness and presented strategies for better indoor environmental quality (IEQ) and promoting wellness.

Key topics presented:

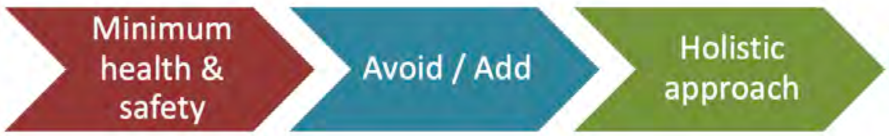
- The role of buildings in promoting occupant health and wellness;
- 4 Ps of Sustainability;
- Growing interest and approaches to health vs wellbeing;
- Indoor environmental quality (IEQ);
- New research and technology;
- Enhanced certifications and measurement.



Discussion Highlights:

- There is a growing recognition of the role of buildings in health and the evolution of priorities in green building;
- Sustainable buildings consider purpose, people, planet, in addition to profit; Formula for a successful integrated approach means focusing "people" as a priority to project goals;
- Approximately 90% of our time is spent indoors; The number of people working from home has increased, as has the desire for more flexible living spaces to accommodate multigenerational and diverse family types;
- There is an increased awareness by the public of the importance of the indoor environment, e.g., the impact of chemicals on health; Recognition that poor indoor air quality (IAQ) can lead to problems involving health and wellbeing;
- A large body of research links specific building design and operation attributes with health outcomes; How the built environment facilitates unhealthy lifestyles;
- Recognizing and understanding disabilities; Disabilities can be invisible and many people with disabilities have more than one disability;
- Various design standards are incorporated into the OBC but many of these address minimum requirements;
- Accessible (focuses on mobility, evaluates select components vs universal design (meaningful access for all, site focused);
- Benefits of a holistic approach to enhancing functionality and providing dignity and independence;

- Universal Design provides enhanced accessibility and equitable access; Importance of future proofing and the flexibility in design for future uses/requirements, e.g., social distancing requirements has put a focus on space requirements for occupants;
- Advanced planning and flexibility result in cost avoidance, better use of resources, and less waste associated with renovations and retrofits; The market for universal design is growing and there are more products available with comparable pricing;



- Importance of comfort which is more than thermal comfort; Indoor environmental quality (IEQ) refers to the characteristics of the space inside our homes and buildings as measured by the occupant such as comfort, health, safety, and functionality; There are many factors to consider such as acoustics, lighting, ergonomics, and biophilia (access/views to green spaces);
- Many indoor stressors can affect the health and wellbeing of the occupants which is especially important for vulnerable peoples, e.g., people with mobility issues and chronic illnesses; Mental and physical health are linked;
- Covid-19 has stimulated new guidelines for prevention and preparedness;
- While the building Code is driving towards increasingly energy efficient buildings, it is not aggressive in regulating for human health in the built environment and in many cases provides standards for “minimum acceptable” health and safety standards;
- There are many contaminants in buildings due to off-gassing of construction materials, décor, and furnishings, etc., that can have a profound impact on our health; Of particular concern are Volatile Organic Compounds (VOCs) – which are organic chemicals that evaporate at room temperature; VOCs can negatively affect the air quality of a space for many years; VOCs can also be introduced from cleaning products; Suppliers/contractors should be asked to use products that are environment and human friendly – there should be no premium for using these products;
- There are many good on-line checklists and resources that can be used to help determine the direction for the project; Commissioning of both enclosure and mechanicals systems is critical;
- Considerations for measuring the outcomes of “people centric” design strategies in addition to building performance targets such energy consumption and ongoing maintenance costs; Determining metrics for intangibles
- With the growing recognition of the role of buildings in health, there are many different labelling programs which focus on different aspects of the health and wellbeing;
- Review of WELL and Fitwel certification requirements;
- Procedures and controls do need to be in place to ensure human comfort, health and wellbeing; Consider a “well-being champion” for the project; The importance of enhanced commissioning;

IDP Workshop Summary

	WELL	Fitwel	Common themes
How created?	R&D, with peer review by scientific, practitioner and medical professionals.	Evidence based on CDC data of health improvements of chronic diseases.	✓ Air ✓ Water ✓ Food / nutrition ✓ Activity/fitness ✓ Rest ✓ Cater to all abilities ✓ Connection to community ✓ Minimize pollutants/toxins ✓ Light quality ✓ Integrated Pest Management
Who created? Who certifies?	Delos / IWBI/CaGBC	CDC&GSA/CAD/BOMA	
How certified?	10 concepts, 100 features. point earned (P/O) per feature, features are weighted. Requires documentation and testing.	7 impact categories, 12 sections, 60+ design strategies. Points calculated using algorithm that weights proven health impact and body of research. Documentation only.	
What are they certifying?	Multiple Attributes of Individual Health (within the concept of health and well being) based on the various body systems	Multiple Attributes of Public Health (within concept of health and well being) based on public health outcomes.	
Certification	Prescriptive & performance at completion, commissioned by WELL AP. Recertification @3 yrs.	Prescriptive, at completion, commissioned by Fitwel Ambassador. Recertification @3 years.	
Cost	Formula based on size of building; subscription available. Max USD20,000	Max USD6,500	

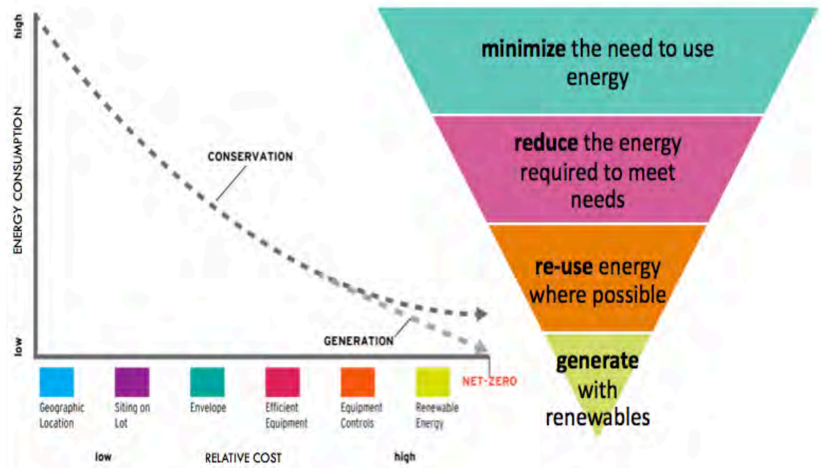
Building healthy doesn't have to cost more, but priorities must be set at the very beginning of the project and integrated into the design process.

7. SAVINGS BY DESIGN ENERGY DISCUSSION

The single largest contributor to climate change is GHG emissions which have a significant impact on global warming. In Ontario the residential and commercial building sector contributes to >20% of the emissions and continue to rise. Along with energy performance improvements, GHG emissions and future weather considerations should be part of the conversation for new construction.

The format of the energy discussion is to explore passive design techniques, which are then complimented by efficient active technologies, e.g., mechanical systems.

The report flow follows the hierarchy of low energy design. The following section highlights the discussion points from the workshop.



BUILDING ENCLOSURE

The overall thermal performance of the enclosure is the most important factor to consider when designing to minimize heating loads; window solar heat gain coefficient (SHGC) and window-to-wall ratio (WWR) are the most important factors to consider with designing to minimize cooling loads.

From an energy performance perspective, an optimized building enclosure can have a greater impact than other energy use components. Amy Montgomery of RDH Building Science and Dave Petersen of Outside In Design + Build led the group through a discussion on opaque assembly and fenestration considerations.

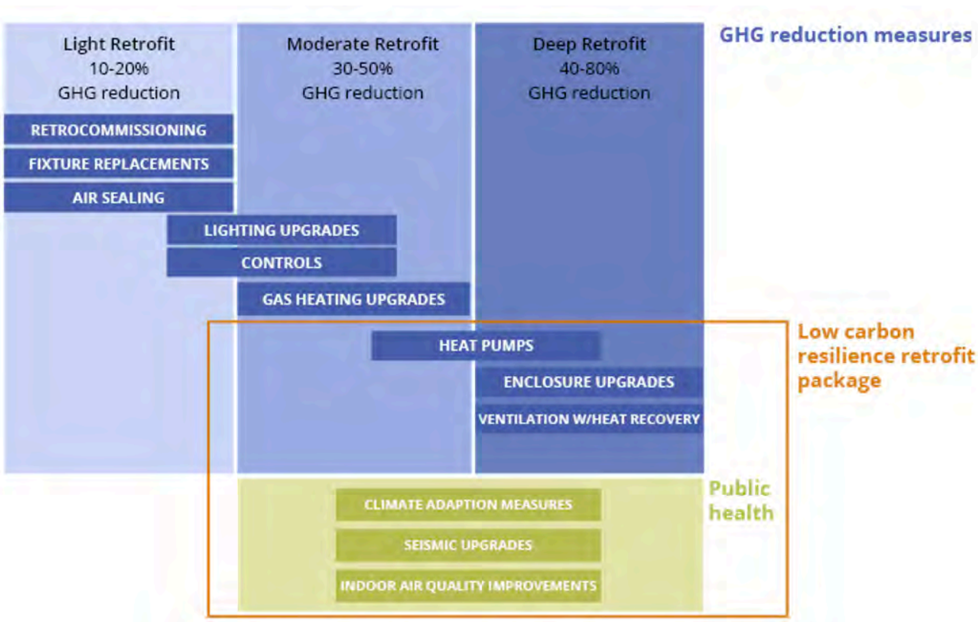
The enclosure session provided an overview of durability, moisture safety, thermal performance, air leakage, and water management as it pertains to opaque enclosure elements and window systems.

Key topics presented:

- Characteristics of deep energy retrofits;
- Strategies for increasing thermal performance;
- The importance of mitigating thermal bridging;
- Air tightness;
- High performance window systems;
- Heat loss through frames and high-performance framing systems;
- Passive and high-performance glazing;
- Window installation.

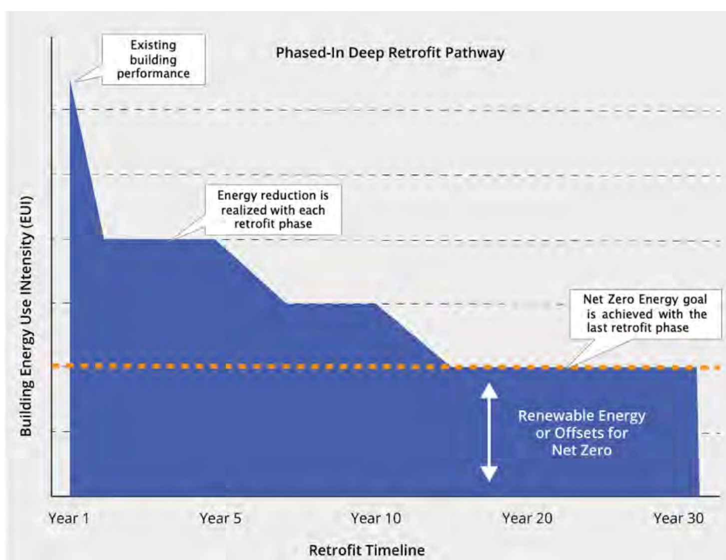
Discussion Highlights:

- Characteristics of deep energy retrofits projects include more than a 50% reduction in total operating energy and or GHG emissions and require a systems approach which integrates the building enclosure, HVAC, water, and electrical designs resulting in a market transformation;
- Availability of new products and technologies demands new expertise;
- Resiliency and the importance and considerations durability and longevity of the assembly itself and the durability of the materials used – determining how the building continues to perform over time, especially as the climate changes (higher wind loads, more severe precipitation events);
- Strategies should address building an additional 30–40-year lifecycle;



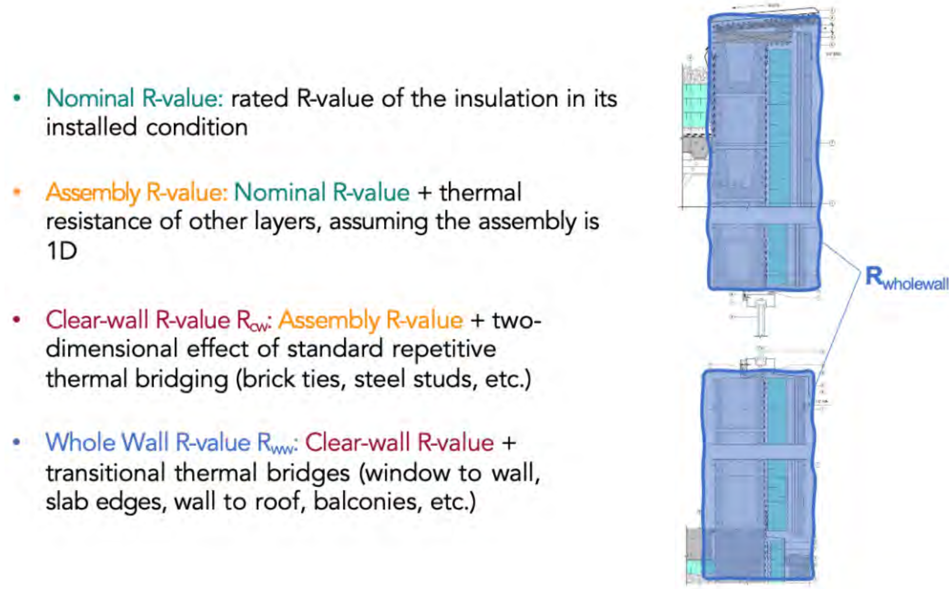
- Opaque envelope thermal performance has a significant impact on the heating loads, and window design (window-to-wall ratio and solar heat gain) will impact cooling loads; A good building enclosure can help to downsize or right size heating and cooling equipment that will be installed; A poor building enclosure will impact the performance of the mechanical system;
- Best practices for achieving net zero;

ARTICULATE A PATHWAY AND CO-ORDINATE EFFORTS TO ACHIEVE EFFICIENCY OVER TIME

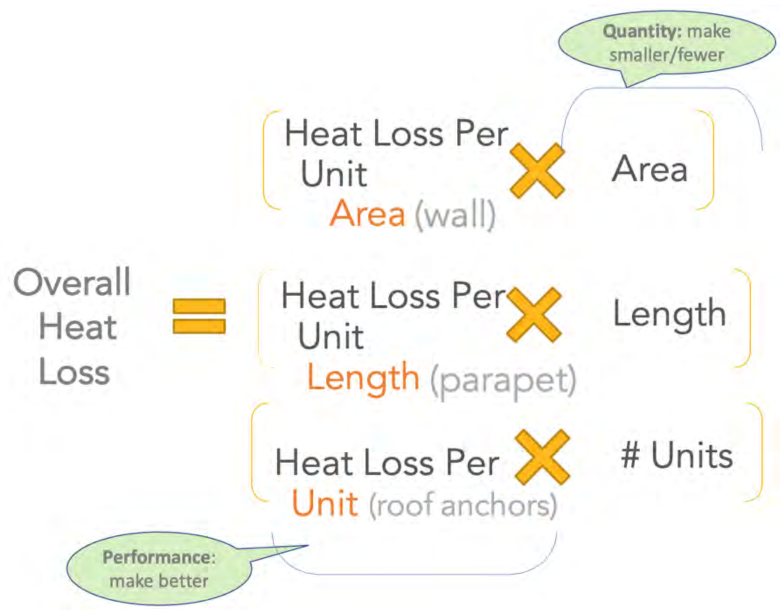


IDP Workshop Summary

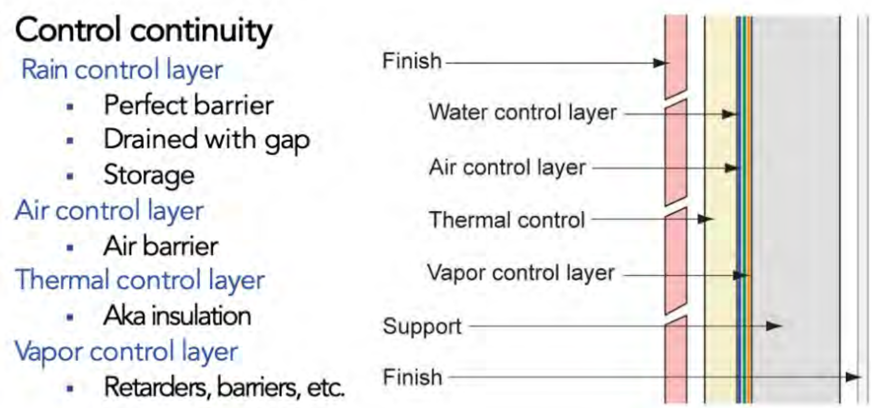
- Absolute target performance is evaluated more holistically; Measuring TEDI encourages better building enclosures, better heat recovery, improves occupant comfort, and enhances resilience;
- Understanding insulation and R-values and the significance of the whole wall R-value and the importance of the components that make up the entire assembly;
- The impacts of heat flow through building components – heat loss (through ventilation, thermal bridging, slabs, windows, etc., and heat gains (solar and internal); Ensuring a comfortable environment and the importance of balancing/controlling heat losses and heat gains;



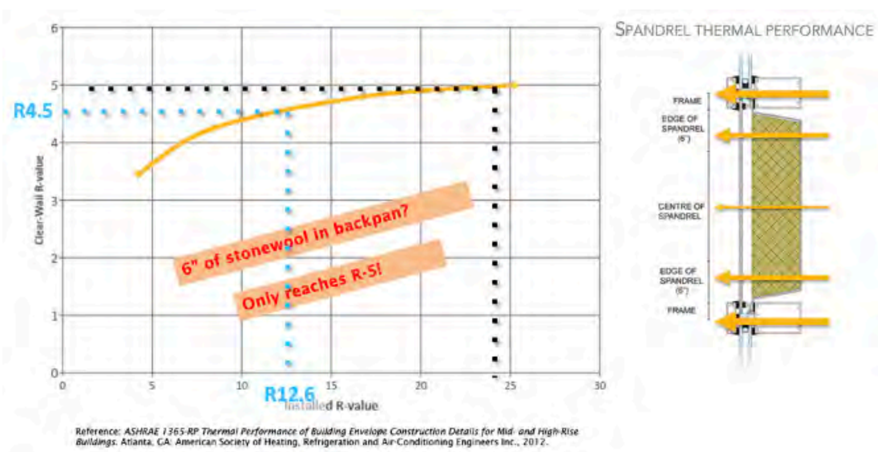
- There are many ways to achieve a high-performance, durable enclosure and there are also many key considerations e.g., ease of construction, materials, labour costs;
- Review of Baseline Building (existing assembly): some sections of the exterior wall with no insulation and some with some foam glass insulation; limestone masonry (no insulation), the vertically corrugated metal siding with fins (no insulation); Unmitigated thermal bridging; Below grade walls have some perimeter insulation with the slab on grade uninsulated;



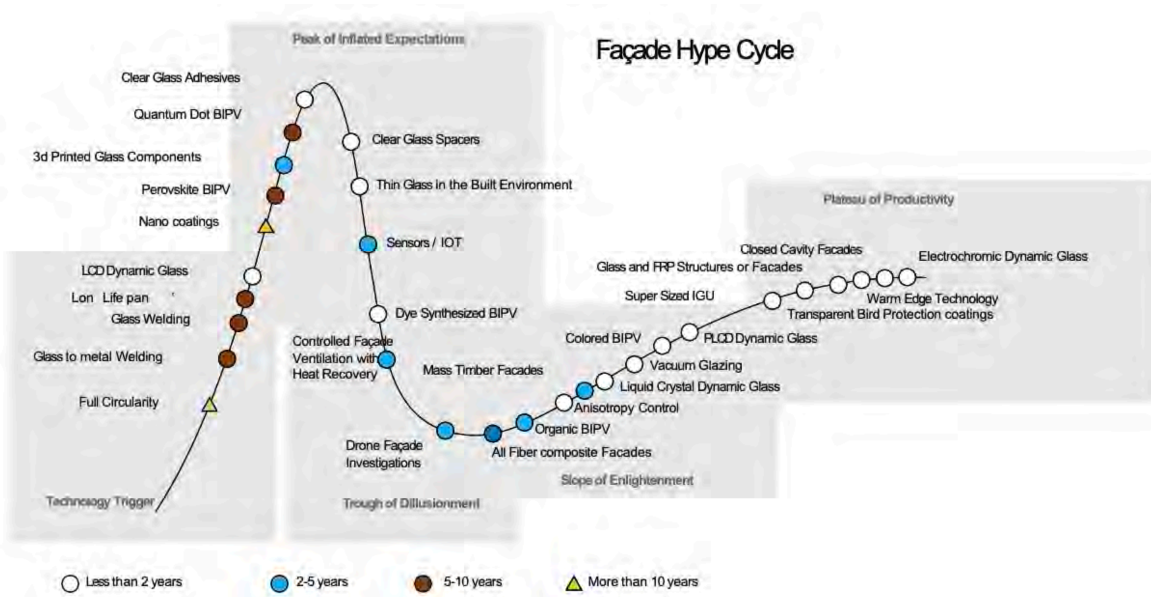
- A roof renovation has been performed;
- Opportunities to improve performance, durability, and reduce thermal bridging
- The primary function of the enclosure is to protect the interior from the elements; The different layers of the assembly have different functions; Importance of the continuity of the control layers; All the control layers should be external of the structure;
- The membrane keeps the wall airtight and watertight with the insulation outboard of the membrane;



- Thermal bridging is defined as an area or component of an object which has higher thermal conductivity than the surrounding materials, creating a path of least resistance for heat transfer; Examples of common thermal brides in existing buildings:
- The overall thermal transmittance of opaque building assemblies accounts for the heat loss of both the clear field performance, as well as the heat loss from interface details (installed conditions that include thermal bridging), e.g., studs, window;
- Examples of typical wall assembly construction for masonry veneer and metal panel rainscreen and metal panels – assessing opportunities for reusing or replacing materials; Examining strategies for accommodating membrane installation and new exterior insulation outboard of the structure;
- Different strategies will have different unique challenges which must be assessed including types of materials to be used, product availability, constructability, and costs; Considerations for environmental conditions;
- Low conductivity and/or thermally broken cladding attachments should also be considered for light-weight cladding; Thermally efficient cladding attachments improve the value of the insulation; Continuous Z-girts de-rate the value of the insulation significantly and a thermal break only offers a slight improvement; Recommendation for clip and rails systems; Percent insulation effectiveness of various attachments and the recommendation to maintain an >80% effectiveness
- Example of fibreglass clips, thermally broking clip systems, galvanized clips with holes; Some cladding suppliers will have their own clip, rail, and cladding; Some systems may be proprietary, and others may be a specific installation of an assembly of preferred components;
- Poor thermal performance of spandrel sections: the spandrel sections are considered part of the opaque assembly, but they do not perform as "real walls"; The effective value of the clear wall is limited because of the conductive framing elements; Insulation added to the interior needs to be fully continuous and applied in a moisture safe way; Mitigating the risk of condensation on the interior face of the back pan; Moisture management is project specific;

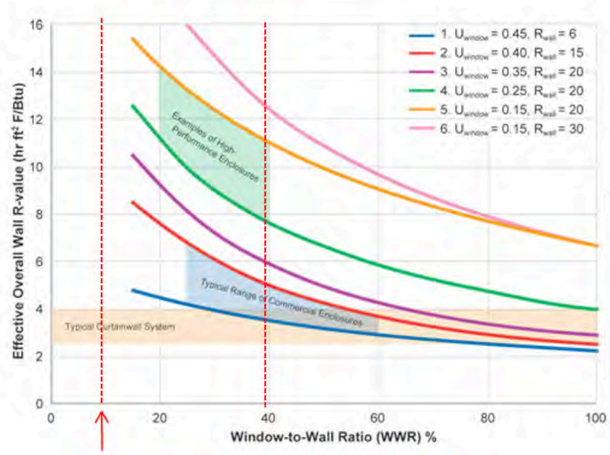


- The project should evaluate the need for spandrel panels and converting to a "real wall";
- Considerations for this project: heritage implications of deeper walls (overall massing, deeper window reveals, etc.); grading and testing of materials for re-use; design of cladding attachment; exterior insulation recommended for durability and resiliency strategy but interior insulation approaches also possible (need to consider condensation risks);
- Improvements to the foundation wall would only be feasible if excavating for below grade repairs and renewals; Exterior insulation is recommended for durability; interior insulation approaches also possible;
- Considerations for at-grade transitions at sidewalk level – requires durability and resistance to de-icing salts; Materials need to be carefully selected;
- The roof plays an important role for low rise buildings; While there has been a roof renovation, there can still be significant heat loss at roof parapets;
- Considerations for the roof include limits to insulation depth due to curb heights, parapet heights, cladding, etc., insulating around parapet may increase parapet height and impact sight lines (i.e., heritage consideration), co-ordination with other possible roof uses or amenities (solar PV, green roof, etc.);
- Air control is important because it affects heat loss and moisture control because air is a transport mechanism for moisture; insulation needs to be continuous around the entire enclosure, even small gaps can be problematic; Impacts of infiltration and exfiltration on building energy consumption, indoor air quality, building durability, and occupant comfort, sound transmission;
- Demonstration of airtightness testing; Comparison of air tightness performance targets;
- Examining and determining what parts of the building can be examined to make it more airtight;
- Upcoming technologies for facades including mounting systems, surface finishing, and colour technologies:



- Examples of building integrated photovoltaic (BIPV) façades and transparent various PV technologies;

- Importance of the window to wall ratio (WWR) for thermal performance, passive daylight in select spaces, aesthetics, and durability;
- Considerations for maintaining the aesthetic of the building while improving the thermal performance of the windows and their durability; Importance of condensation resistance;
- The Baseline Building has a very modest 9% WWR; Although the WWR is only 2% on the west, glazing on this façade can still impact thermal and visual comfort;
- The U-value of the window assembly measures the insulating characteristics of the glass, or how much heat flow or heat loss occurs through the glass due to the difference between indoor and outdoor temperatures, and accounts for the whole window, including glazing, frame, and spacers; Center-of-glass (COG)

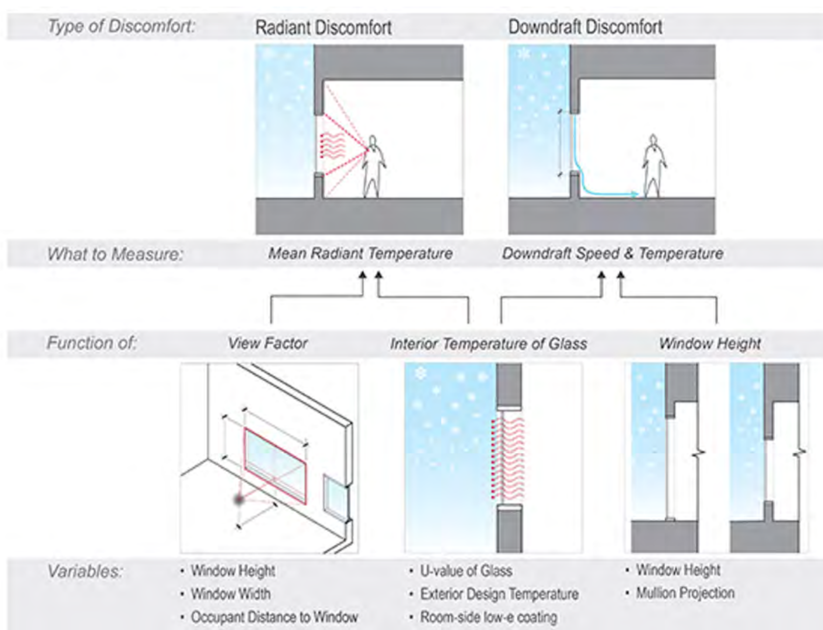


9% WWR for the Baseline Building

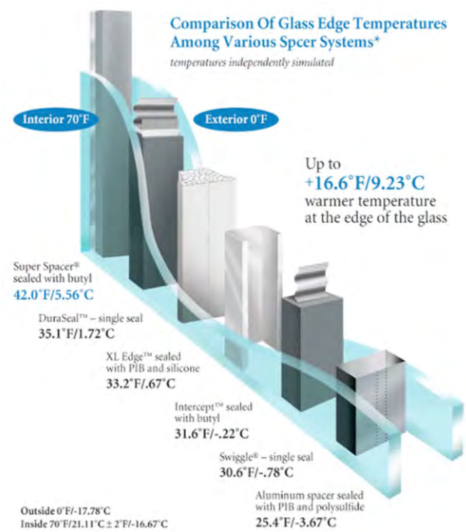
	Window Area	WWR
North	945 ft²	2%
East	2,945 ft²	5%
South	0 ft²	0%
West	1,350 ft²	2%
Overall	**5,240 ft²**	**9%**

describes the performance of the glazing alone without the effects of the frame; U-values are effective and take into consideration the thermal bridging through the frame elements;

- Window and wall combination choices affect the performance of the entire building; Consideration for products to meet the challenging Toronto Green Standard (TGS); While the energy performance gains of fenestration upgrades will be modest, because of the low WWR of the building, the impact on improved air tightness should be considered;
- The performance of the window systems is an important input to the mechanical design team such that the mechanical systems can be sized appropriately – often the mechanical systems must make up for poor performing window/door systems;
- The curtain entry system has been upgraded – importance of being able to upgrade components, e.g., weather stripping, weather seals, operating components, etc.; Life expectancy of sealed units; Durability is important for lifecycle costs and the impact on the carbon footprint of the building; Considerations for material selection;
- Thermal bridging and condensation are also issues that must be considered for the window system; While frames are only 5% of the window system, they have a significant impact on performance, it is important to understand how heat can be lost through the frame;
- While aluminum is non-combustible, lightweight, strong, and flexible, it is also highly conductive; Aluminum windows are typically poorer performing frames and the heat loss through these can impact the functionality of the space; The benefits of the curtain wall upgrade that was performed is limited because of the use of aluminum components;
- Double skin façades can be used effectively to maintain the integrity of the original aesthetic, however there can be challenges with air tightness, humidity, pressure differentials which can result in a more complex mechanical strategy being employed;
- Occupant Comfort Winter: addressing radiant losses and convective downdraft discomfort; Enhancing wellbeing by mitigating discomfort at perimeter spaces;
- Harvesting passive solar heat gain can be beneficial to heating dominated spaces; Must be integrated with a mechanical strategy that can distribute the heat throughout the space as appropriate; Unfortunately, passive solar gain is not possible on this project because there is no glazing on the south façade;



- Occupant Comfort Summer: overheating, especially radiant heat gains on the west elevations, can cause discomfort; This will not be an issue for this building because the building's architecture provides protection/ integrated shading, however understanding how diffused daylight can be harvested deeper into the floorplate and addressing glare should be considered;
- Light-to-solar gain (LSG) is the ratio of visible light transmittance (VLT) to solar heat gain coefficient (SHGC); A higher LSG ratio means the sunlight entering the room is more efficient for daylighting;
- Challenges with retrofits where things are done in phases and understanding how the window to wall connections, and replacement of components within the window system must be addressed; There must be strategy to ensure the integrity of the assembly; Thermal alignment of windows with insulation plane to mitigate flanking losses;
- Windows and doors are key penetrations to the building envelope; Proper installation and detailing of windows to ensure air tightness and water management is critical;
- Considerations for durability and comfort: addressing heat flow through conduction and convection losses;
- It is particularly important to consider spacer design as part of the window specification; A thermally improved spacer (warm edge technology) could result in temperature increases at the window sightline which provides an important improvement to the weakest link of the window and raises the center of glass temperature – this will address comfort concerns and mitigate the risk of condensation; Stainless steel spacers are the standard; Non-metal, e.g. foam, spacers are used in high-performance MURBs; It also important to have input from the structural engineer as to what is appropriate for the building;

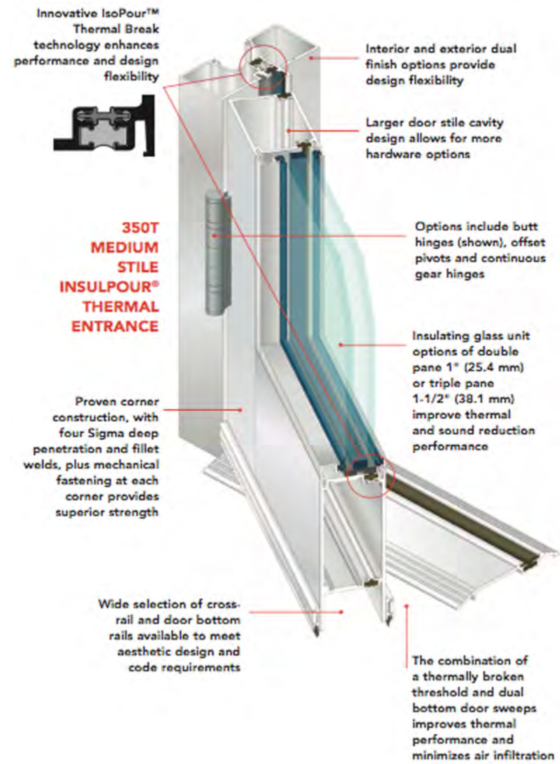


- Convective losses and considerations for gas fills; Argon is typically used because it represents the optimal balance between performance and cost. A denser gas will perform better as an insulator, so argon offers better performance than ordinary air for only a marginal increase in cost – do not let argon be value engineered out of the project. High-performance systems include a combination of triple glazing with krypton; There are both structural and convective looping considerations for the thickness of the spacer;
- Opportunities for improving the curtain wall system by removing the aluminum pressure plate and replacing it with a fibreglass option which can result in an increase in efficiency of the frame by 8-10%;

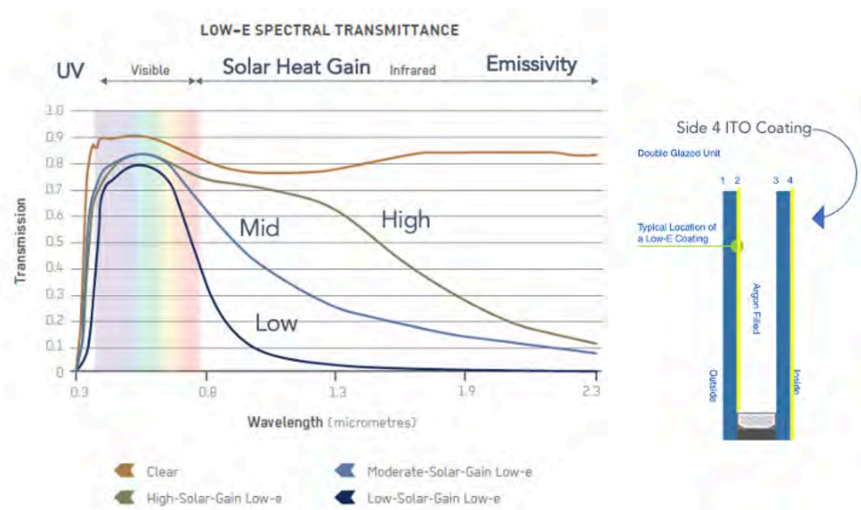
COMBINATION OF PUNCHED WINDOWS AND HIGH-PERFORMANCE FIBREGLASS CURTAIN WALL

IDP Workshop Summary

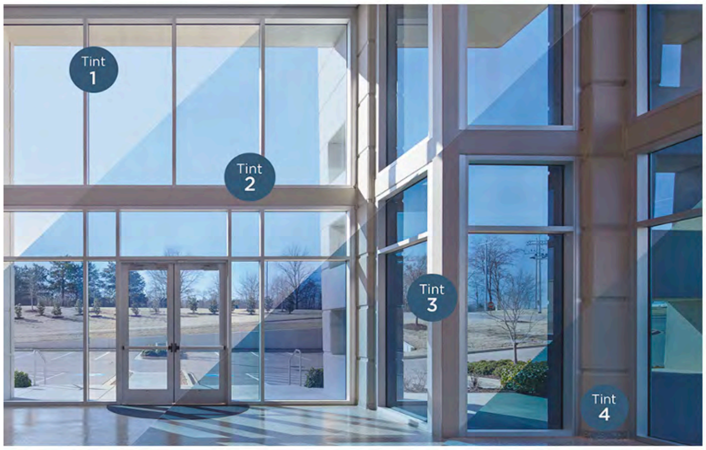
- High-performance pultruded fibreglass curtain wall – these have the same design pressures as an aluminum system and are designed to work with a baseplate cap or 4-way SSG; Unitized system with typical installation; The resin components used in the pultrusion meet the criteria of non-combustible with respect to smoke and flame spread; This product is manufactured in Canada and is only supplied with triple glazing not insulating glass (IG); Good condensation resistance; Interior finishes including metallic finishes to emulate the look of the existing aesthetic;
- Air infiltration challenges with the current entry door system; Considerations for energy performance and indoor air quality;
- Thermal performance may have to be compromised because there are often accessibility challenges with high-performance door systems;

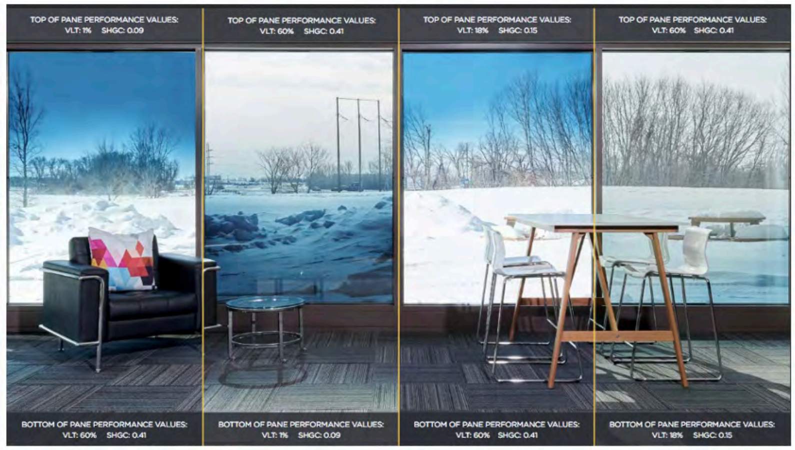


- The benefits of low-emissivity (Low-E coatings) sputter coatings include the ability of the glass to reduce radiative heat loss (from the inside of the building in the winter/at night) and prevent or accept heat gain as depending on the type chosen; Low-E coatings minimize the infrared and ultraviolet light that comes through the glass while still providing good visible light transmittance (VLT); While the solar heat gain (SHG) may not be important for this building, the emissivity to reduce radiant losses is;
- Side 4 coatings for double glazed systems with similar performance parameters to triples;
- Challenges with triple glazed systems include the added weight which can be problematic for operation, often prohibitive first costs, and the maintenance and durability of the operating components within the window system;
- It is important to ensure that the doors and window systems can be easily replaced/upgraded;



- Active glazing solutions include electrochromic glass which provides a switchable tint state with the ability to change the SHGC (switchable Low-E coating); Available products that function differently (sun path analysis vs sun sensor triggered); They also provide different looks and use different control systems; Newer products provide a wider range of tint stages and can change state more instantaneously; however they require more electricity;





- Daylighting and light diffusing glazing technology present opportunities to reduce the overall lighting power density indoors; Diffused glazing allows light to penetrate deeper into the floorplate providing more usable and effective daylight in the occupied space (consider for upper-level glazing on the west elevation); Diffused glass is not used in vision areas; Benefits of diffused glazing system to avoid glare;
- Window installation best practices for both air and water management; Importance of aligning the key control layers; Keeping the metal components to the outside, considerations for end dams to ensure water is driven away from the wall, issues with relying on sealants;
- Installation strategy should include thermally efficient components, e.g., urethane standoffs for curtain wall – these should address thermal, condensation, and structural requirements/targets.

The following building enclosure energy performance options were modelled for consideration:[13]

Upgrades:	**Improvement**[14][15]
Option 1 – Enhanced aluminum curtain, IG: USI-1.95 W/m²·K, SHGC 0.30	0.3%

[13] See Appendix for more detail on specific ECMs

[14] % Improvement over Baseline Building shown. Please note that some modelled energy conservation measures (ECMs) may also necessitate a corresponding change to the Reference Building and as such the performance improvement vs Code would correspondingly be recalculated for submission purposes. Particular attention should be paid to those ECMs denoted with an asterisk (*).

[15] It is important to note that while some ECMs may show a modest/no change to energy performance (and may even show a negative energy performance) these options may have a positive impact on cost savings, occupant comfort, durability, or GHG emissions. Please refer to the Incremental Chart for additional details re each option.

Option 2 – Enhanced aluminum curtain wall with fibreglass pressure plate or 4-way SSG, IG with side 4 ITO coating: USI-1.75 W/m²·K, SHGC 0.33 0.3%

Option 3 – Enhanced aluminum curtain wall with fibreglass pressure plate or 4-way SSG, triple glazing: USI-1.45 W/m²·K, SHGC 0.30 0.4%

Option 4 – Pultruded fibreglass curtain wall, triple glazing, non-metal spacer: USI-0.85 W/m²·K, SHGC 0.30 0.4%

Option 5 – Entry doors with thermally broken aluminum frames and sash, IG: USI-2.90 W/m²·K, SHGC 0.30 0.01%

Option 6 – Entry doors with thermally broken aluminum frames and sash, triple glazing: USI-2.55 W/m²·K, SHGC 0.30 0.04%

Option 7 – Improve performance of exterior walls with recladding to include exterior insulation, thermally efficient cladding attachments, mitigate thermal bridging: R-16 Effective 4.8%

Option 8 – Add exterior insulation at foundation walls: R-18 Effective 0.5%

Option 9 – Improve roof insulation, mitigate thermal bridging: R-35 Effective 1.9%

Option 10 – Improve infiltration rate to 50% better than Code* 0.8%

Options 2, 5, and 7 to 9 were incorporated into the SBD Building increasing the Overall R-Value of the building enclosure from Effective R-3.7 to R-17.6.

	Performance		Annual Energy Consumption			Energy Intensity		GHG Emissions	Annual Energy Costs			Annual Savings vs Baseline		
Upgrade Description	Incremental Improvement **over Baseline** %	Energy Reduction **over Reference** %	Electricity (kWh)	Natural Gas (m3)	Total (ekWh)	EUI (ekWh/m2)	TEDI (ekWh/m2)	(KgCO2Eq)	Electricity $	Natural Gas $	Total $	Energy Savings ekWh	Cost Savings ($)	%
OBC SB-10 Reference Building	-	-	1,771,750	146,653	3,319,922	197.1	68.5	367,082	$ 256,904	$ 35,930	$292,834	-	-	-
Baseline/Proposed Building	-	**-44.2%**	2,443,892	221,943	4,786,878	284.2	138.5	543,664	$ 354,364	$ 54,376	$408,740	-	-	-
Fenestration and Opaque Enclosure ECMs														
Enhanced aluminum curtain wall, IG: USI-1.95 W/m2-°K, SHGC 0.30	0.3%	-43.8%	2,444,655	220,644	4,773,928	283.4	137.7	541,236	$ 354,475	$ 54,058	$408,533	12,950	$ 208	0.1%
Enhanced aluminum curtain wall, with fibreglass pressure plate or 4-way SSG, IG with side 4 ITO coating: USI-1.75, SHGC 0.33	0.3%	-43.8%	2,443,599	220,722	4,773,695	283.4	137.8	541,331	$ 354,322	$ 54,077	$408,399	13,183	$ 342	0.1%
Enhanced aluminum curtain wall, with fibreglass pressure plate or 4-way SSG. USI-1.45, SHGC 0.30	0.4%	-43.6%	2,443,646	220,190	4,768,126	283.1	137.4	540,323	$ 354,329	$ 53,947	$408,275	18,752	$ 465	0.1%
Tripled glazed fiberglass curtain wall USI-0.85, SHGC 0.30	0.4%	-43.6%	2,443,639	220,153	4,767,728	283.0	137.4	540,253	$ 354,328	$ 53,937	$408,265	19,150	$ 475	0.1%
Enhanced double glazed aluminum entry doors USI-2.90, SHGC 0.30	0.01%	-44.2%	2,443,759	221,898	4,786,270	284.1	138.5	543,572	$ 354,345	$ 54,365	$408,710	608	$ 30	0.0%
Enhanced triple glazed aluminum entry doors USI-2.55, SHGC 0.30	0.04%	-44.1%	2,443,749	221,790	4,785,120	284.1	138.4	543,367	$ 354,344	$ 54,339	$408,682	1,758	$ 58	0.0%
Improve exterior wall performance to effective R-16	4.8%	-37.2%	2,443,241	200,051	4,555,119	270.4	124.9	502,059	$ 354,270	$ 49,012	$403,282	231,759	$ 5,458	1.3%
Improve underground wall performance to effective R-18	0.5%	-43.5%	2,443,112	219,926	4,764,805	282.9	137.3	539,795	$ 354,251	$ 53,882	$408,133	22,073	$ 607	0.1%
Improve roof thermal performance to R-35	1.9%	-41.5%	2,451,386	212,650	4,696,268	278.8	132.8	526,392	$ 355,451	$ 52,099	$407,550	90,610	$ 1,190	0.3%
Improve air tightness 50% better than code *	6.4%	-35.0%	2,436,381	193,800	4,482,270	266.1	121.0	489,845	$ 353,275	$ 47,481	$400,756	304,609	$ 7,984	2.0%

ACTIVE SYSTEMS

Optimization between envelope loads and HVAC systems may allow for reduced upfront capital costs associated with equipment and is important for the reduction of costs associated with operations and maintenance. Proper sizing, sealing, pressure testing, and balancing of the mechanical systems is critical to obtain optimized efficiencies.

Mechanical expert Cara Sloat of Hammerschlag & Joffe presented the group with considerations for efficient mechanical systems.

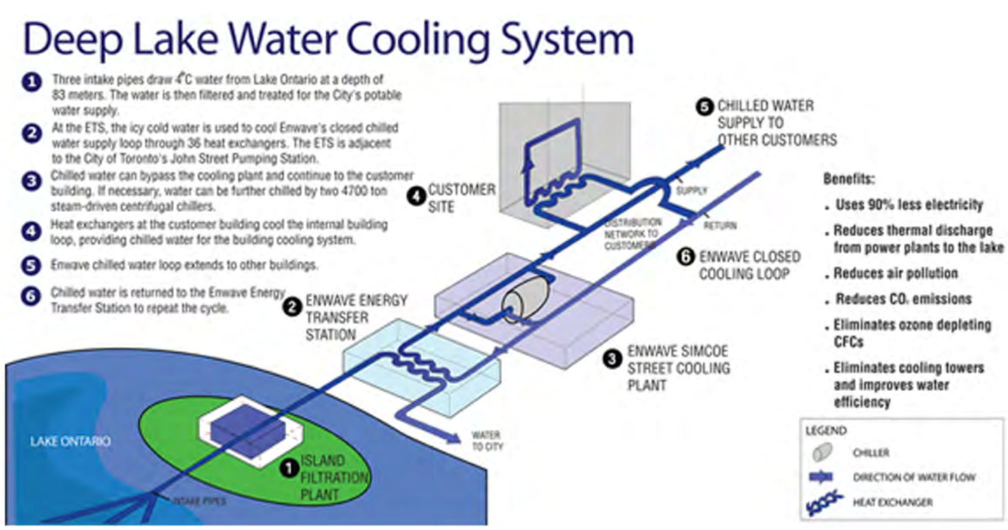
Key topics presented:

- Best practices for efficient lighting;
- Purchasing and operating policies for equipment and fixtures;
- HVAC retrofits;
- Reducing fan energy;
- Ventilation effectiveness;
- Energy recovery ventilation options;
- Low carbon heating alternatives.

Discussion Highlights:

- Review of the Baseline Building energy consumption; Space heating and fans are the largest components of energy consumption;
- Recommendation to stay abreast of best-in-class lighting power density recommendations for specific space types; Refer to International Energy Conservation Code (IECC); Benefits of daylight and how to reduce energy using architecture and design; Efficient lighting design includes:
    - High performance fixtures (LEDs for common areas)
    - Occupancy controls (recommendation for fixtures with integrated sensors)
    - Daylight sensors
    - Task lighting
    - Reflective finishes
    - Efficient fixture layout (benefits of photometric information);
- Recommendation to consider ENERGY STAR appliances; Online tools to evaluate performance; ENERGY STAR certification is as important for water consumption savings as it is for energy savings;
- Equipment and fixture purchasing plan – setting targets and specifications for new purchases, e.g., flow rates, ENERGY STAR performance rating;

- Pumping and fan motor upgrades and replacements - pre-select best-in-class replacements for pumps and fans; Approach major pump and fan representatives for assistance in characterizing the efficiency of your existing pumps and fans;
- Address high fan use by programming the fan control on the air handlers to operate according to the load requirements, i.e., controlling air volume to match the space heating/cooling demand.
- Demand control ventilation to provide fresh air to a space only when required and significantly reduce outside air requirements when there are no occupants; CO_2 levels in a building are a proxy for actual occupancy levels; Recommendation to install a damper and airflow sensor at fresh air intake and CO_2 sensor in the return duct;
- In high-density areas a separate CO_2 sensor should be mounted in the breathing zone; The CO_2 sensor measures and monitors the air allowing the building automation system to modulate the dampers; The VFDs are attached to the building automation to control the fan speed;
- Providing localized heating capacity - carbon and cost goals need to be assessed;
- Controlling air leakage to ensure that the air being heated is getting to the intending space – duct sealing spray to address holes in the ductwork; Can be used in existing buildings to either reduce energy costs or improve air quality through better air delivery levels;
- Energy recovery system (ERV) options:
  - Centralized energy recovery systems are commonly seen in new ultra-high-performance buildings – would be difficult as a retrofit;
  - Dedicated in-space ERVs – replace exhaust fans in washrooms; can be mounted in a dropped ceiling space or on a roof;
  - Run around coils to address all intakes in the building recovering energy from a central exhaust only'
- A major upgrade would be to purchase low carbon heating from Enwave; The steam coils/distribution would be replaced with hot water coils/distribution; There would also be a new connection to Enwave's deep lake water cooling system with a new heat recovery chiller to generate hot water;



- The cooler water also provides better efficiencies for the system (better delta T);
- If a geo-exchange system is not possible, another alternative to consider is an air source heat pump (ASHP), with the plant on the roof; The steam coils/distribution would be replaced with hot water coils/distribution; There would be a new connection to the ASHP system; A backup heat source for cold temperatures would be required (steam or natural gas boiler);
- Convert perimeter heating to low temperature to support a decarbonization solution for the HVAC system; This would require a custom install inside the existing perimeter brass heating covers but helps preserve the architectural intent of the delivery system;
- ASHP can also be used for domestic hot water (DHW);
- Displacement ventilation provides fresh air directly to the breathing zones using diffusers, and reduce the overall ventilation rates to the space; Patrons would be less exposed to recirculated air; In performance halls, the retrofit is to supply diffusers under each seat;
- Destratification ceiling fans in double height spaces to better distribute fresh air in the occupied space and more even temperature control and improve occupant comfort; These can also reduce the heat loss at the top of the building and increase the cooling setpoint temperature;
- Transpired solar collection to preheat makeup air; Ideally installed on the mechanical penthouse that has a south facing wall near the MUA; Solar exposure is very limited on this project because of adjacent buildings; However, where there is good solar exposure, this technology could be combined with and PV installation in that area.

The following building performance options were modelled for consideration:[16]

Upgrades:	Improvement[17]
HVAC, Electrical, and Water Heating Systems:	
Option 1 – Connect installed fan speed drives to building automation system	12.1%
Option 2 – Dedicated energy recovery ventilators in washrooms, ensure heat recovery for all conditioned spaces	5.7%
Option 3 – Convert steam system serving air handlers to hot water loop supplied by an air-source heat pumps to building to serve heating water for shoulder seasons *	26.9%

[16] See Appendix for more detail on specific ECMs

[17] % Improvement over Baseline Building shown. Please note that some modelled energy conservation measures (ECMs) may also necessitate a corresponding change to the Reference Building and as such the performance improvement vs Code would correspondingly be recalculated for submission purposes. Particular attention should be paid to those ECMs denoted with an asterisk (*).

Option 4 – Convert steam system serving air handlers to water cooled heat pump served by Enwave Deep Lake Water system (seasonal COP 4.3) * 29.0%

Option 5 – Enwave district cooling to provide chilled water to building (SEER 20) * 1.5%

Option 6 – Convert DHW system to 95% efficient gas boiler -0.2%

Options 1, 2, and 4 to 6, were incorporated into the SBD Building resulting in a significant energy performance improvement vs the currently proposed/Baseline Building.

Upgrade Description	Performance		Annual Energy Consumption			Energy Intensity		GHG Emissions	Annual Energy Costs			**Annual Savings vs Baseline**		
	Incremental Improvement **over Baseline** %	Energy Reduction **over Reference** %	Electricity (kWh)	Natural Gas (m3)	Total (ekWh)	EUI (ekWh/m2)	TEDI (ekWh/m2)	(KgCO2Eq)	Electricity $	Natural Gas $	Total $	Energy Savings ekWh	Cost Savings **($)**	%
OBC SB-10 Reference Building	-	-	1,771,750	146,653	3,319,922	197.1	68.5	367,082	$ 256,904	$ 35,930	$292,834	-	-	-
Baseline/Proposed Building	-	**-44.2%**	2,443,892	221,943	4,786,878	284.2	138.5	543,664	$ 354,364	$ 54,376	$408,740	-	-	-
Mechanical / Electrical / DHW														
Connect installed fan speed drives to building automation system	12.1%	-26.7%	1,659,497	241,177	4,205,530	249.7	150.3	540,970	$ 240,627	$ 59,088	$299,715	581,348	$ 109,025	26.7%
Dedicated ERVs in washrooms ventilation recovery in conditioned spaces	5.7%	-38.0%	2,634,489	178,014	4,513,729	268.0	111.3	469,773	$ 382,001	$ 43,613	$425,614	273,149	$ (16,874)	-4.1%
Use air-source heat pumps to serve heating water for shoulder seasons with steam as back up *	26.9%	-5.3%	3,447,717	4,691	3,497,238	207.6	133.5	181,294	$ 499,919	$ 1,149	$501,068	1,289,640	$ (92,328)	-22.6%
Convert steam system serving air handlers to water cooled heat pump served by Enwave Deep Lake Water system (seasonal COP 4.3) *	29.0%	-2.4%	3,372,275	2,670	3,400,462	201.9	133.7	173,684	$ 488,980	$ 654	$489,634	1,386,416	$ (80,894)	-19.8%
Enwave district cooling to provide chilled water to building (SEER 20) *	1.5%	-42.0%	2,365,198	222,504	4,714,106	279.9	138.5	540,795	$ 342,954	$ 54,513	$397,467	72,772	$ 11,273	2.8%
Convert DHW system to 95% efficient gas boiler	-0.2%	-44.5%	2,426,256	224,448	4,795,686	284.7	138.5	547,540	$ 351,807	$ 54,990	$406,797	(8,808)	$ 1,944	0.5%

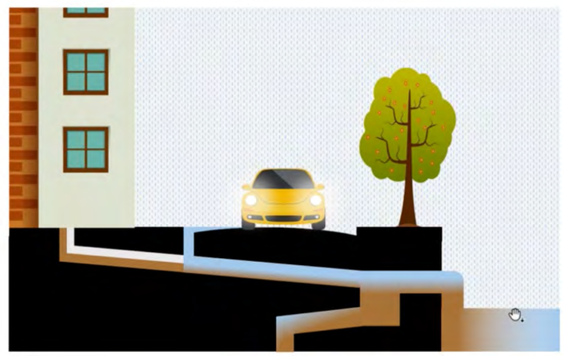
8. GREEN ROOFS AND RAINWATER HARVESTING

Jenny Hill, Assistant Dean at the University of Toronto School of Architecture led the discussion on green roofs and low impact development (LID).

Key topics presented:

- Stormwater drainage
- Best practices for green roofs;
- Toronto Green Standard water balance;
- Rainwater harvesting systems strategies;

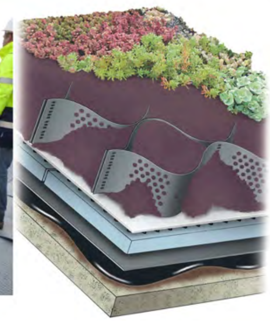
Discussion Highlights:



- The site context was reviewed; Stormwater and rainwater currently flow into the municipal sewar drains; In downtown Toronto, the city has only one pipe handling both sewage/sanitary waste and rainwater/stormwater; On a rainy day the excess water, this type of system will have an overflow into natural bodies of water like Lake Ontario in this case;
- Importance of preventing stormwater from going into the system so that sewage water does not end up in the lake;
- The slope of the roof is estimated at 23% and is overlooked by neighbouring condos; Presentation of case studies for green roofs on sloped roofs;

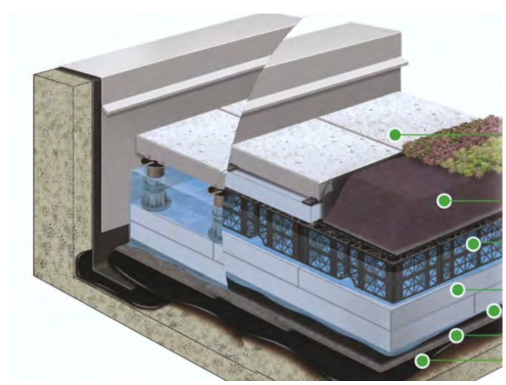
- How green roofs evolve – in time a significant amount of natural vegetation will take place; Important to be aware of what the roof will look like to surrounding buildings; A highly landscaped roof may be difficult to maintain; Designing for low maintenance includes embracing weeds and flowering plants
- The roof at the Native Child and Family Services of Toronto has an intensive green roof, which is about 9-inches deep; It is an accessible roof with many components to connect the people who use it with nature and special spaces that are used for public assemblies and ceremonies;
- High maintenance intensive green roofs are not recommended;
- New products on the market to support the construction of highly sloped green roofs;

- The hydrologic functions of green roofs to both capture and retain water; Because this is a retrofit project, shallow, lightweight systems that are only about 2.5-inches deep will address the structural capacity considerations (dry and saturated weight);
- Lightweight systems tend to be the least bio-diverse – a deeper roof allows for a wider variety of shrub and flowering plants to grow, becoming more biodiverse, and support pollinators;
- The project team will need to assess if there are any areas that could support a heavier weight;
- Optimizing slope and force against the roof edge;
- Example of extruded polystyrene foam board that is good for shallow extensive roofs;
- Example of system to prevent erosion and securing the plants in place on steep pitches;

- A deeper green roof will store more water than a shallow roof; Water on a sloped roof will flow downhill quickly and plants will receive less water so irrigation must be managed;
- Lightweight roof systems that provide detention and retention of stormwater on flat or low-slope roofs;
- Water retention capabilities of absorbent surfaces and absorbent paving;
- With a purpose-built green roof PV system, the green roof is used as the ballast for the solar racking, avoiding penetrations to the roof membrane; The air flow under the racking and the evapotranspiration of green roofs can facilitate the efficiency of the solar panel by keeping it cool; The green roof should be regularly irrigated to facilitate the evapotranspiration;

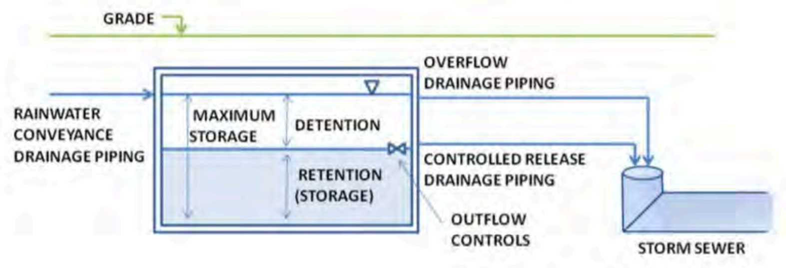

- Municipal stormwater retention targets; A target of 10mm would address 70% of all storm events;
- Hybrid rainwater harvesting and green roof option - water retention on a protected membrane assembly; Void space between concrete pavers on a flat roof to store large quantities of stormwater;
- Importance of irrigation for lightweight roofs; Irrigate all green roofs every day all summer using an irrigation distribution system empty the excess water that has been stored in a reservoir; Examples of roofs that are frequently irrigated;



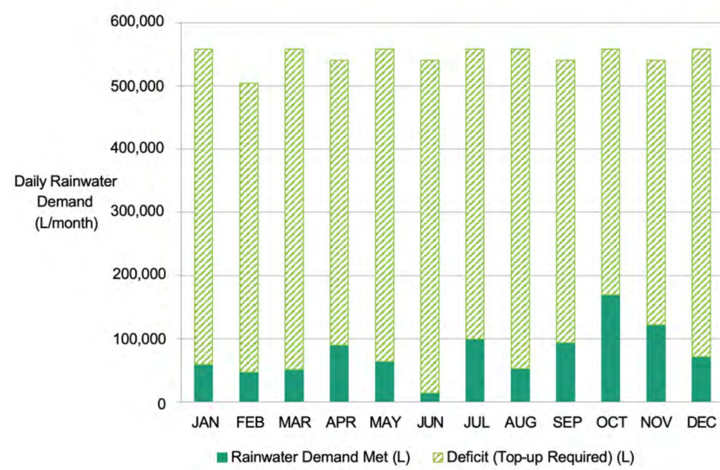
- Rainwater harvesting to manage precipitation on site or reduce water use for landscape irrigation and reduce the consumption of municipally supplied water; Toronto Green Standard Water

Balance targets; For water harvesting and reuse, applicants must demonstrate that the water demand would be equal or greater than the rainfall over the site;

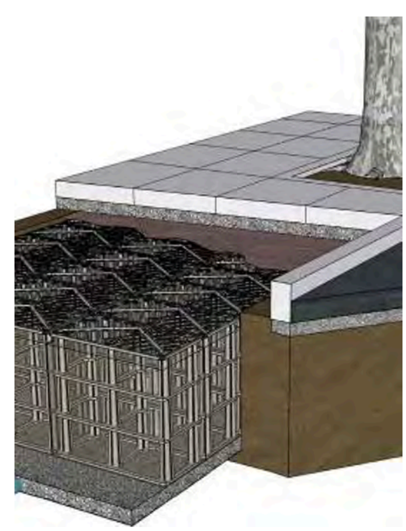
- Rainwater vs stormwater; Rainwater is water collected from inaccessible areas such as rooftop at Meridian Hall; Water from accessible areas such as terraces or patios is stormwater; Considerations for rainwater harvesting;



- Permitted uses of rainwater vs stormwater; Rainwater treatment will depend on the reuse application; Considerations for energy associated with treating water for various applications;
- Using rainwater for toilet flushing; Informing and educating staff and patrons on the reasons for discolouration to promote Meridian Hall's commitment to the environment; Rough calculation of how much water could be saved for the project – the amount of harvested water collected to flush toilets is low compared with the demand, but the stormwater management performance is good;



- Considerations for tree planting areas and soil volumes; Trees need space for roots to grow laterally and it is important to protect the roots; Soil cells systems can support much larger shade trees, and may capture/filter rainwater; This technology was used at Sugar Beach despite the compacted urban soil;
- Importance of tree selection given climate change; Resources for selecting plants and trees;
- Sustainable Sites Initiative which is supported by the U.S. Green Building Council (USGBC). USGBC has incorporated certain SITES credit content into iterations of the LEED green building rating system. There are free online tools that can be referenced to facilitate decision making; The SITES resources are available at no charge.



9. ENERGY MODEL SUMMARY

The inputs to the model related to the building envelope, mechanical systems, and lighting systems are summarized in the following tables. These inputs were used to generate the SB-10 Reference Model, representing a building which meets the energy performance levels of the OBC, the Baseline Model, which represents the current design of the building, and the SBD Building which represents the outcome of the SBD workshop discussion.

Measures highlighted in green represent changes to the building as currently proposed.

MODEL INPUTS SUMMARY

Building Enclosure

Component	Assembly Thermal Transmittance[18]		
	Reference Building	Baseline Building	SBD Building
Opaque Wall	SB-10 (2017) Climate Zone 5: U-0.049 **Effective R-20.4**	Exterior Stone-Clad Wall with 8" Brick Backup: Nominal R-3 **Overall: R-2**	Increased Exterior Above-Grade Wall Performance to R-20 clear field Overall Opaque Assembly: (U-0.063) Effective R-16
Roof	SB-10 (2017) Climate Zone 5: U-0.027 **Effective R-37**	Insulated Roof (U-0.050) **Effective: R-20**	Insulated Roof (U-0.029) Effective R-35
Fenestration (Effective)	SB-10 (2017) Climate Zone 5: USI: 1.9 **U-value: 0.335** **SHGC: 0.40**	Curtain Wall Windows & Glass Doors USI: 2.85—4.15 **U-value: 0.502—0.731** **SHGC: 0.38—0.6**	USI: 1.75—2.90 U-value: 0.308—0.51 SHGC: 0.33

[18] The model uses the **Effective R-value** in its simulations which accounts for thermal bridging and long-term thermal resistance (LTTR) value of insulation.

Window-to-Wall Ratio	9%	9%	9%
Overall R-Value[19]	(U-0.061) R-19.5	(U-0.074) R-3.7	(U-0.057) R-17.6

Lighting

Zone	Lighting Power Density (W/m^2) and (W/ft^2)		
	Reference Building[20]	Baseline Building	SBD Building
Stairs	0.58 (6.2)	0.29 (3.1)	0.29 (3.1)
Corridor	0.66 (7.1)	0.33 (3.6)	0.33 (3.6)
Amenity / Lounge	0.62 (6.7)	0.31 (3.4)	0.31 (3.4)
Office	0.93 (10.0)	0.47 (5.0)	0.47 (5.0)
Mechanical Room	0.43 (4.6)	0.22 (2.3)	0.22 (2.3)
Storage	0.63 (6.8)	0.32 (3.4)	0.32 (3.4)
Stage	2.43 (26.2)	0.59 (6.4)	0.59 (6.4)
Auditorium	2.43 (26.2)	0.59 (6.4)	0.59 (6.4)
Total	0.94 (10.1)	0.38 (4.1)	0.38 (4.1)

[19] Overall R-value ($R_{overall}$) entire enclosure type (such as wall, or roof) including Whole-Wall R-value (R_{ww}) plus windows, doors, and curtainwalls.

[20] Reference Building: As per SB-10 Average 10.1 W/m^2; Baseline and SBD Buildings as per As per Electrical Design Drawings & SB-10 Average 4.1 W/m^2

IDP Workshop Summary

Mechanical Systems

Component		Reference Building	Baseline Building	SBD Building
Plant	Heating	Boilers: 90% Condensing Supply T: 180°F Loop ΔT: 28.8°F	Enwave District Steam	Enwave Low-Carbon Heating
	Cooling & Heat Rejection	Type: Centrifugal Cond.: Water Eff.: COP 5.5	Type: Multistack Centrifugal Cond.: Water Eff.: COP 4.2	Enwave Deep Lake Water Cooling (DLWC)
	Chilled Water Loop Circulation	N/A	Air cooled scroll chiller, COP 3.0 44F supply, 54F return	
Pumping	Loop Pumps	HW Loop: Constant HW Power: 19 W/gpm CHW Loop: Constant CHW Power: 19 W/gpm CW Loop: Constant CW Power: 20 W/gpm	HW Loop: Variable HW Power: 12 W/gpm CHW Loop: Variable CHW Power: 19 W/gpm CW Loop: Variable CW Power: 20 W/gpm	HW Loop: Variable HW Power: 12 W/gpm CHW Loop: Variable CHW Power: 19 W/gpm CW Loop: Variable CW Power: 20 W/gpm
HVAC	Offices & Auditorium	Packaged SZ RTU (Sys-3) Heating: gas furnace Heating Eff.: 80% Cooling: Air-Cooled DX Cooling Eff.: COP 3.5 Fan Control: Constant SF Power: 0.51 W/cfm RF Power: 0.1 W/cfm ERV: 55% effectiveness	Air Handling Unit (AHU) Heating: HW Coils Cooling: CHW Coils Fan Control: Constant SF Power: 0.51 W/cfm RF Power: 0.1 W/cfm	ECM-MECH-6a,6b Air-Water Heat Pump CW Loop Served by Enwave HEX Heating: COP 4.3 Cooling: COP 11 Fans: Variable SF Power: 0.51 W/cfm RF Power: 0.1 W/cfm

IDP Workshop Summary

	Other Regularly Occupied Areas	Multi-zone System (Sys-6) Heating: HW baseboards Cooling: CHW Coils Fan Control: Constant SF Power: 0.86 W/cfm RF Power: 0.4 W/cfm ERVs: 55% effectiveness	Air Handling Unit (AHU) Heating: HW Coils Cooling: CHW Coils Fan Control: Constant SF Power: 0.51 W/cfm RF Power: 0.1 W/cfm	Air-Water Heat Pump CW Loop Served by Enwave HEX Heating: COP 4.3 Cooling: COP 11 Fans: Variable SF Power: 0.51 W/cfm RF Power: 0.1 W/cfm
Domestic Hot Water Heater	Heater	Gas fired Modulating 90% efficient	Steam (Oct-May) Electric boiler (Jun-Sept)	Gas fired Condensing 95% efficient
	DHW Fixtures	Per Code (LPM): Showers l Kitchen l Lav. 7.6 l 8.35 l 5.7	Per Code (LPM): Showers l Kitchen l Lav. 7.6 l 8.35 l 5.7	Per Code (LPM): Showers l Kitchen l Lav. 7.6 l 8.35 l 5.7
Fresh Air	Whole Building	Total OA: 33,400 cfm	Total OA: 33,400 cfm	Total OA: 33,400 cfm

MODEL SIMULATION RESULTS SUMMARY

Overall Energy Performance

Modeled Area: 181,310 ft² 16,844 m²	Total Annual Projected Energy Consumption	Energy Utilization Intensity	Annual Electricity Consumption	Annual Natural Gas Consumption	Annual Greenhouse Gas (GHG) Emissions	Energy Performance as Compared
	ekWh/yr *and* (GJ/yr)	ekWh/ft^2-yr and ekWh/m^2-yr	kWh	m^3	Kg CO_2eq	%
OBC Reference Building	3,319,922 (11,952)	18.3 (197.1)	1,771,750	146,653	367,082	–
Baseline Building	4,786,878 (17,233)	26.4 (284.2)	2,443,892	221,943	543,664	-44.2
Savings by Design Building	2,050,221 (7,381)	11.3 (121.7)	1,995,664	5,168	109,597	38.2

Utility Cost and GHG Emission Reduction

Component	Reference Building SB-10	Baseline Building	Savings by Design
Electricity Consumption Savings (kWh)	–	-672,142	-223,914
Electricity Savings ($)	–	($97,461)	($32,467)
Natural Gas Consumption Savings (m^3)	–	-74,290	141,485
Natural Gas Savings ($)	–	($18,446)	$34,664
Energy Consumption Savings (ekWh)	–	-1,466,956	1,269,701
Total Annual Savings ($)	–	($115,907)	$2,196
Total GHG Emissions Reduction from Reference (Kg CO_2Eq)	–	-176,583	257,484

Incremental Performance Summary[21],[22]

Energy conservation measures highlighted in green were incorporated into Savings by Design model. Measures not highlighted were assessed as options for consideration but not adopted. Please note, there may be interdependencies between discrete incremental measures and the final result may be different than the sum of the chosen measures. ***A larger version of the chart below is also included as an Appendix.***

Upgrade Description	Performance: Incremental Improvement **over Baseline** %	Performance: Energy Reduction **over Reference** %	Annual Energy Consumption: Electricity (kWh)	Annual Energy Consumption: Natural Gas (m3)	Annual Energy Consumption: Total (ekWh)	Energy Intensity: EUI (ekWh/m2)	Energy Intensity: TEDI (ekWh/m2)	GHG Emissions (KgCO2Eq)	Annual Energy Costs: Electricity $	Annual Energy Costs: Natural Gas $	Annual Energy Costs: Total $	**Annual Savings vs Reference**: Electricity Savings from Reference (kWh)	Natural Gas Savings from Reference (m3)	Total Energy Savings from Reference (ekWh)	Cost Savings **($)**
OBC SB-10 Reference Building	-	-	1,771,750	146,653	3,319,922	197.1	68.5	367,082	$ 256,904	$ 35,930	$292,834	-	-	-	-
Baseline/Proposed Building	-	**-44.2%**	2,443,892	221,943	4,786,878	284.2	138.5	543,664	$ 354,364	$ 54,376	$408,740	(672,142)	(75,290)	(1,466,956)	$ (115,907)
Fenestration and Opaque Enclosure ECMs															
Enhanced aluminum curtain wall, IG: USI-1.95 W/m2-°K, SHGC 0.30	0.3%	-43.8%	2,444,655	220,644	4,773,928	283.4	137.7	541,236	$ 354,475	$ 54,058	$408,533	(672,905)	(73,991)	(1,454,006)	$ (115,699)
Enhanced aluminum curtain wall, with fibreglass pressure plate or 4-way SSG, IG with side 4 ITO coating: USI-1.75, SHGC 0.33	0.3%	-43.8%	2,443,599	220,722	4,773,695	283.4	137.8	541,331	$ 354,322	$ 54,077	$408,399	(671,849)	(74,069)	(1,453,773)	$ (115,565)
Enhanced aluminum curtain wall, with fibreglass pressure plate or 4-way SSG. USI-1.45, SHGC 0.30	0.4%	-43.6%	2,443,646	220,190	4,768,126	283.1	137.4	540,323	$ 354,329	$ 53,947	$408,275	(671,896)	(73,537)	(1,448,204)	$ (115,442)
Tripled glazed fiberglass curtain wall USI-0.85, SHGC 0.30	0.4%	-43.6%	2,443,639	220,153	4,767,728	283.0	137.4	540,253	$ 354,328	$ 53,937	$408,265	(671,889)	(73,500)	(1,447,807)	$ (115,431)
Enhanced double glazed aluminum entry doors USI-2.90, SHGC 0.30	0.01%	-44.2%	2,443,759	221,898	4,786,270	284.1	138.5	543,572	$ 354,345	$ 54,365	$408,710	(672,009)	(75,245)	(1,466,348)	$ (115,876)
Enhanced triple glazed aluminum entry doors USI-2.55, SHGC 0.30	0.04%	-44.1%	2,443,749	221,790	4,785,120	284.1	138.4	543,367	$ 354,344	$ 54,339	$408,682	(671,999)	(75,137)	(1,465,198)	$ (115,848)
Improve exterior wall performance to effective R-16	4.8%	-37.2%	2,443,241	200,051	4,555,119	270.4	124.9	502,059	$ 354,270	$ 49,012	$403,282	(671,491)	(53,398)	(1,235,198)	$ (110,449)
Improve underground wall performance to effective R-18	0.5%	-43.5%	2,443,112	219,926	4,764,805	282.9	137.3	539,795	$ 354,251	$ 53,882	$408,133	(671,362)	(73,273)	(1,444,883)	$ (115,299)
Improve roof thermal performance to R-35	1.9%	-41.5%	2,451,386	212,650	4,696,268	278.8	132.8	526,392	$ 355,451	$ 52,099	$407,550	(679,636)	(65,997)	(1,376,347)	$ (114,717)
Improve air tightness 50% better than code *	6.4%	-35.0%	2,436,381	193,800	4,482,270	266.1	121.0	489,845	$ 353,275	$ 47,481	$400,756	(664,631)	(47,147)	(1,162,348)	$ (107,923)
Mechanical / Electrical / DHW															
Connect installed fan speed drives to building automation system	12.1%	-26.7%	1,659,497	241,177	4,205,530	249.7	150.3	540,970	$ 240,627	$ 59,088	$299,715	112,253	(94,524)	(885,608)	$ (6,882)
Dedicated ERVs in washrooms ventilation recovery in conditioned spaces	5.7%	-36.0%	2,634,489	178,014	4,513,729	268.0	111.3	469,773	$ 382,001	$ 43,613	$425,614	(862,739)	(31,361)	(1,193,807)	$ (132,781)
Use air-source heat pumps to serve heating water for shoulder seasons with steam as back up *	26.9%	-5.3%	3,447,717	4,691	3,497,238	207.6	133.5	181,294	$ 499,919	$ 1,149	$501,068	(1,675,966)	141,962	(177,316)	$ (208,234)
Convert steam system serving air handlers to water cooled heat pump served by Enwave Deep Lake Water system (seasonal COP 4.3) *	29.0%	-2.4%	3,372,275	2,670	3,400,462	201.9	133.7	173,684	$ 488,980	$ 654	$489,634	(1,600,525)	143,983	(80,540)	$ (196,800)
Enwave district cooling to provide chilled water to building (SEER 20) *	1.5%	-42.0%	2,365,198	222,504	4,714,106	279.9	138.5	540,795	$ 342,954	$ 54,513	$397,467	(593,448)	(75,851)	(1,394,184)	$ (104,633)
Convert DHW system to 95% efficient gas boiler	-0.2%	-44.5%	2,426,256	224,448	4,795,686	284.7	138.5	547,540	$ 351,807	$ 54,990	$406,797	(654,506)	(77,795)	(1,475,764)	$ (113,963)
Enbridge Savings by Design Building	**57.2%**	**38.2%**	**1,995,664**	**5,168**	**2,050,221**	**121.7**	**105.9**	**109,597**	**$ 289,371**	**$ 1,266**	**$290,637**	**-223,914**	**141,485**	**1,269,701**	**$ 2,196**

The measures modelled and the SBD Building have been presented for demonstrative purposes to show **one path towards meeting the SBD program goal**. The measures modelled nor the final solution address every potential option or pathway towards the SBD target. This information is not intended to be used for the design phase of the SBD program.

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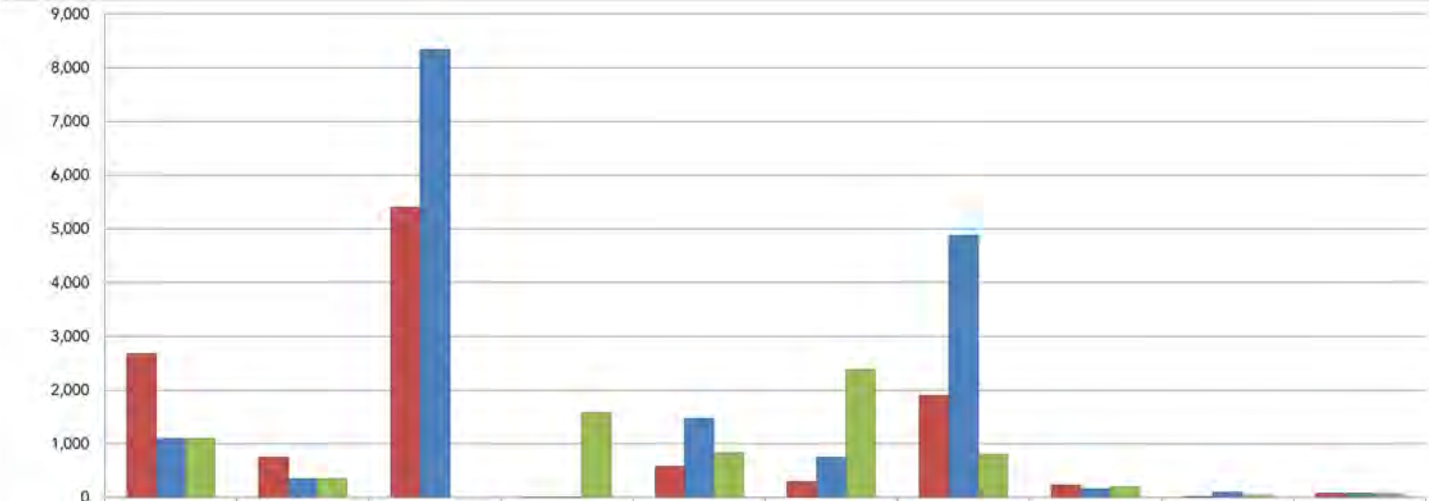
[21] Electricity is priced at $0.15/kWh; Natural Gas is priced at $0.25/m^3$. This may not reflect the actual pricing available to the proponent.

[22] Energy modelling is performed on rated efficiencies – it is important that the building is operated properly to achieve targeted outcomes. Actual energy consumption depends on commissioning, operation, and occupant behaviour.

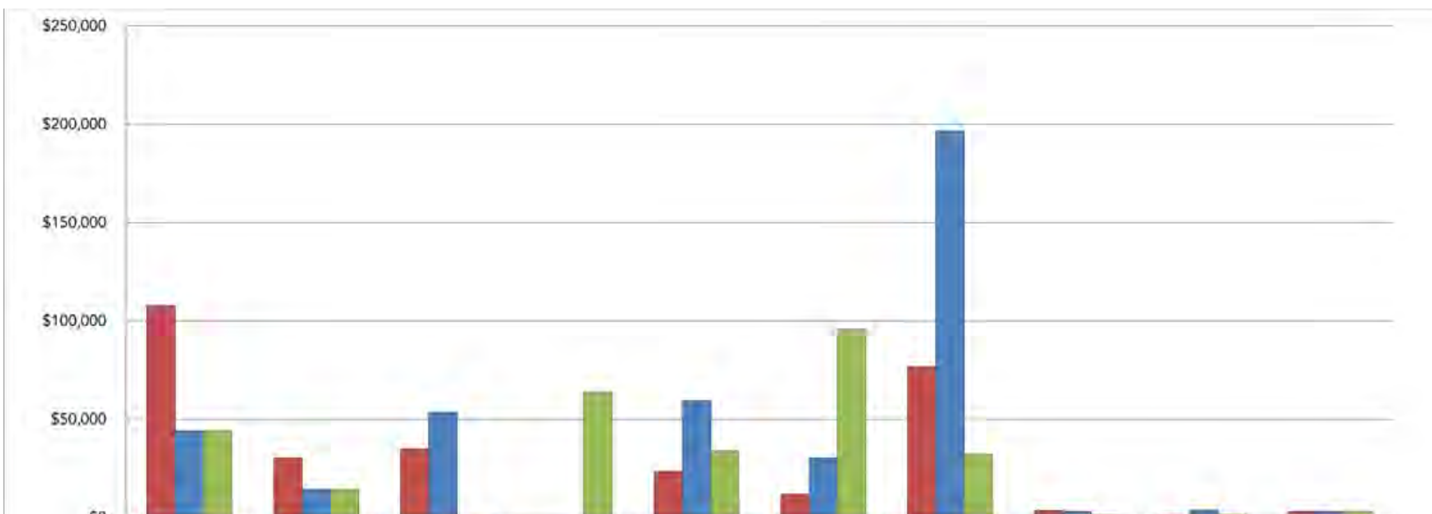
IDP Workshop Summary

Energy Use by Component (GJ)



	Lighting	Miscellaneous Equipment Electric	Space Heating Gas	Space Heating Electric	Cooling	Pumps	Fans	Domestic/Service Hot Water	Heat Rejection	Exterior Lights
Reference	2,677	754	5,407	0	583	294	1,903	230	23	79
Baseline	1,096	354	8,333	0	1,475	752	4,878	165	99	79
SBD	1,097	354	0	1,582	843	2,380	802	196	45	79

Energy Cost by Component ($)



	Lighting	Miscellaneous Equipment Electric	Space Heating Gas	Space Heating Electric	Cooling	Pumps	Fans	Domestic/Service Hot Water	Heat Rejection	Exterior Lights
Reference	$107,843	$30,370	$34,854	$0	$23,499	$11,861	$76,652	$3,635	$917	$3,201
Baseline	$44,147	$14,277	$53,722	$0	$59,427	$30,305	$196,470	$3,211	$3,979	$3,201
SBD	$44,192	$14,277	$0	$63,727	$33,959	$95,880	$32,316	$1,266	$1,818	$3,201

10. CONCLUSION

The IDP workshop undertaken for the TO Live design team was very successful. It provided a forum for bringing together the ideas of stakeholders and subject matter experts to work interactively and exchange ideas and concerns.

Energy modeling determined that the energy performance for "Meridian Hall Carbon Reduction Projects" is 38.2% better than the OBC SB-10 2017, which meets the goal set by the Savings by Design program.

APPENDIX – ADDITIONAL ENERGY MODELLING SIMULATION INFORMATION

MODEL 3D GEOMETRY

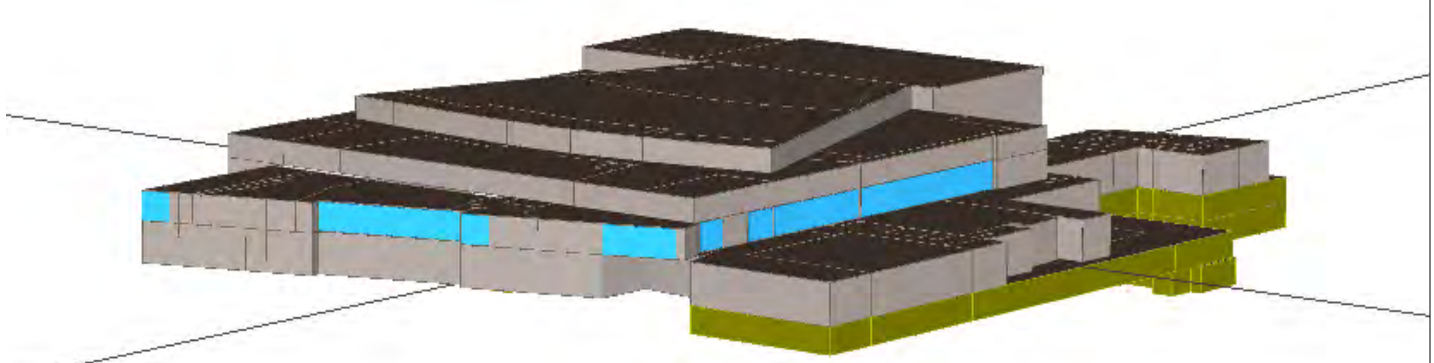


Figure 1 – North-West Elevation

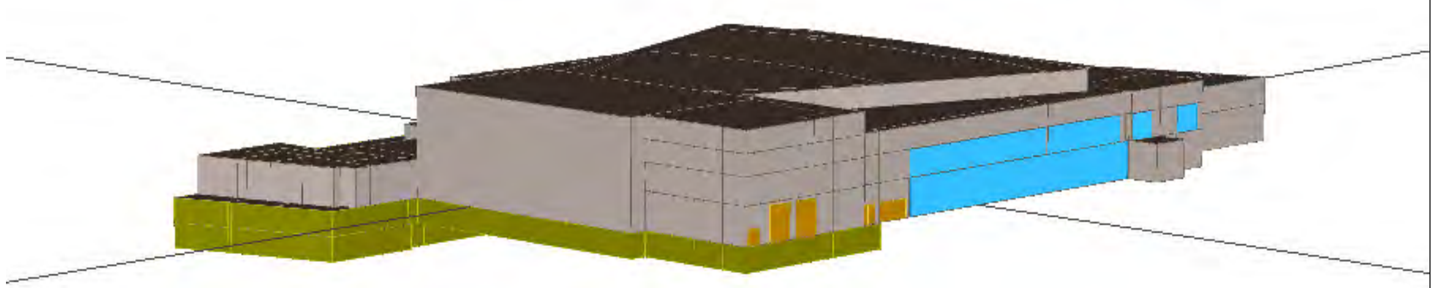


Figure 2 – South-East Elevation

Reference and Baseline Building Inputs

The following inputs are the same for both Reference and Baseline buildings:

- Key Schedules:
  - Custom schedules to replicate baseline operation year—based on 2019 pre-COVID historical data
- Equipment Loads – Per Utility Calibration
- Elevators – Per SBD guidance for loads
- Occupancy:
  - 1,130 peak occupancy (NECB 2015 occupancy loads)
- Outdoor air
  - 33,400 cfm per utility calibration and mechanical drawings
- Lighting – Per utility calibration, and provide electrical drawings
- Service Hot Water: Reference and Baseline Building use Code fixtures
  - 7.6 LPM showers
  - 5.7 LPM lavatory faucets
  - 8.35 LPM kitchen sink

APPENDIX – DETAILED ENERGY CONSERVATION MEASURE DESCRIPTIONS

Measure	Detailed Description
ECM-FEN-1: Enhanced double-glazed aluminum curtain wall. **USI-1.95, SHGC 0.30**	Enhanced aluminum curtain wall windows. Double glazed unit to have lowE-coating on side #2, argon gas cavity filled, and warm edge stainless steel spacer. (USI 1.95 W/m2-°K, SHGC 0.30)
ECM-FEN-2: Enhanced aluminum curtain wall. **USI-1.75, SHGC 0.33**	Enhanced aluminum curtain wall windows with fiberglass PP or 4-way SSG. Double glazed unit to have lowE-coating on side #2, argon gas cavity filled, and warm edge stainless steel spacer. (USI 1.75 W/m2-°K, SHGC 0.33)
ECM-FEN-3: Enhanced aluminum curtain wall. **USI-1.45, SHGC 0.30**	Enhanced aluminum curtain wall windows with fiberglass PP or 4-way SSG. Triple glazed unit to have lowE-coating on side #2 and #5, argon gas cavity filled, and warm edge stainless steel spacer. (USI 1.45 W/m2-°K, SHGC 0.30)
ECM-FEN-4: Triple glazed fiberglass curtain wall **USI-0.85, SHGC 0.30**	Fiberglass curtain wall windows. Triple glazing to have lowE coating on sides #2 and 5, low solar gain, stainless steel spacer, argon gas cavity filled. (USI-0.85 $W/m^2 \cdot K$ | SHGC 0.30)
ECM-FEN-5: Enhanced double-glazed aluminum entry doors **USI-2.90, SHGC 0.30**	Entry doors with thermally broken aluminum frames and sash. Double glazed with lowE-coating on side #2, argon gas cavity filled, and warm edge stainless steel spacer. (USI 2.90 W/m2-°K, SHGC 0.30)
ECM-FEN-6: Enhanced tripled glazed aluminum entry doors **USI-2.55, SHGC 0.30**	Entry doors with thermally broken aluminum frames and sash. Triple glazed with lowE-coating on side #2 and #5, argon gas cavity filled, and warm edge stainless steel spacer. (USI 2.55 W/m2-°K, SHGC 0.30)
ECM-ENC-1 Improve exterior wall performance to effective R-16	Improve the Clearfield and thermal bridge performances to increase overall exterior wall performance to effective R-16

ECM-ENC-2 Improve underground wall performance to effective R-18	Improve the Clearfield and thermal bridge performances to increase overall below grade wall performance to effective R-18
ECM-ENC-3 Improve roof performance from R-30 to R-35	Improve conventional flat roof performance from R-30 to R-35. Effective thermal performance of R-35
ECM-ENC-4 Increase air tightness: Infiltration rate equal to code	Increased air tightness of the entire envelope resulting in a total infiltration rate decrease from 3 L/s-m² (75 Pa) to 1.5 L/s-m² (75 Pa) of exterior surface area. Note: This measure is shown for information purposes only and is not a valid ECM to achieve savings through the Savings by Design program.
ECM-MECH-1: Add VFDs to fan	Connect installed fan speed drives to building automation system to enable variable fan control to meet heating and cooling loads
ECM-MECH-2: Add heat recovery in conditioned spaces	Added heat recovery with ERV effectiveness in Washrooms at 78% and a 45% effective run-around glycol loop for remaining fresh air systems.
*ECM-MECH-4: An air-source heat pumps to building to serve heating water for shoulder seasons	Convert steam system serving air handlers to hot water loop supplied by an air-source heat pumps to building to serve heating water for shoulder seasons, backed up by steam when ASHP are not available (outdoor temperature lower than -15°C.) Seasonal COP- 2.4 Note: This change would result in a different SB10 Reference HVAC system.
*ECM-MECH-6a: Convert steam system serving air handlers to water cooled heat pump served by Enwave Deep Lake Water system	Replace the existing air handling units with water cooled heat pump served by Enwave Deep Lake Water system. Seasonal COP – 4.3 Note: This change would result in a different SB10 Reference HVAC system.

*ECM-MECH-6b: Enwave district cooling to provide chilled water to building	Chilled water from Enwave's deep lake water cooling (DLWC) is used to exchange heat from the building's chilled water loop to Lake Ontario (Modeled as a chiller with a Seasonal Energy Efficiency Rating, SEER-20 or COP-11)
*ECM-MECH-7: 95% efficient condensing gas domestic hot water boiler	Convert electric boiler and steam domestic hot water to a 95% efficient gas boiler that serves the domestic hot water needs of the building.

APPENDIX – INCREMENTAL PERFORMANCE CHART[23]

[23] Electricity is priced at \$0.15/kWh; Natural Gas is priced at \$0.25/m^3. This may not reflect the actual pricing available to the proponent.

IDP Workshop Summary

Upgrade Description	Performance: Incremental Improvement **over Baseline** %	Performance: Energy Reduction **over Reference** %	Annual Energy Consumption: Electricity (kWh)	Annual Energy Consumption: Natural Gas (m3)	Annual Energy Consumption: Total (ekWh)	Energy Intensity: EUI (ekWh/ft2)	Energy Intensity: EUI (ekWh/m2)	Energy Intensity: TEDI (ekWh/m2)	GHG Emissions (KgCO2Eq)	Carbon Intensity (kgCO2Eq/m2)	Annual Energy Costs: Electricity $	Annual Energy Costs: Natural Gas $	Annual Energy Costs: Total $	Annu… Electricity Savings from Reference (kWh)	Natu… Sa… f… Refe… (
OBC SB-10 Reference Building	-	-	1,771,750	146,653	3,319,922	18.3	197.1	68.5	367,082	21.8	$ 256,904	$ 35,930	$292,834	-	
Baseline/Proposed Building	-	**-44.2%**	2,443,892	221,943	4,786,878	26.4	284.2	138.5	543,664	32.3	$ 354,364	$ 54,376	$408,740	(672,142)	(75
Fenestration and Opaque Enclosure ECMs															
Enhanced aluminum curtain wall, IG: USI-1.95 W/m2-°K, SHGC 0.30	0.3%	-43.8%	2,444,655	220,644	4,773,928	26.3	283.4	137.7	541,236	32.1	$ 354,475	$ 54,058	$408,533	(672,905)	(73
Enhanced aluminum curtain wall, with fibreglass pressure plate or 4-way SSG, IG with side 4 ITO coating: USI-1.75, SHGC 0.33	0.3%	-43.8%	2,443,599	220,722	4,773,695	26.3	283.4	137.8	541,331	32.1	$ 354,322	$ 54,077	$408,399	(671,849)	(74
Enhanced aluminum curtain wall, with fibreglass pressure plate or 4-way SSG. USI-1.45, SHGC 0.30	0.4%	-43.6%	2,443,646	220,190	4,768,126	26.3	283.1	137.4	540,323	32.1	$ 354,329	$ 53,947	$408,275	(671,896)	(73
Tripled glazed fiberglass curtain wall USI-0.85, SHGC 0.30	0.4%	-43.6%	2,443,639	220,153	4,767,728	26.3	283.0	137.4	540,253	32.1	$ 354,328	$ 53,937	$408,265	(671,889)	(73
Enhanced double glazed aluminum entry doors USI-2.90, SHGC 0.30	0.01%	-44.2%	2,443,759	221,898	4,786,270	26.4	284.1	138.5	543,572	32.3	$ 354,345	$ 54,365	$408,710	(672,009)	(75
Enhanced triple glazed aluminum entry doors USI-2.55, SHGC 0.30	0.04%	-44.1%	2,443,749	221,790	4,785,120	26.4	284.1	138.4	543,367	32.3	$ 354,344	$ 54,339	$408,682	(671,999)	(75
Improve exterior wall performance to effective R-16	4.8%	-37.2%	2,443,241	200,051	4,555,119	25.1	270.4	124.9	502,059	29.8	$ 354,270	$ 49,012	$403,282	(671,491)	(53
Improve underground wall performance to effective R-18	0.5%	-43.5%	2,443,112	219,926	4,764,805	26.3	282.9	137.3	539,795	32.0	$ 354,251	$ 53,882	$408,133	(671,362)	(73
Improve roof thermal performance to R-35	1.9%	-41.5%	2,451,386	212,650	4,696,268	25.9	278.8	132.8	526,392	31.3	$ 355,451	$ 52,099	$407,550	(679,636)	(65
Improve air tightness 50% better than code *	6.4%	-35.0%	2,436,381	193,800	4,482,270	24.7	266.1	121.0	489,845	29.1	$ 353,275	$ 47,481	$400,756	(664,631)	(47
Mechanical / Electrical / DHW															
Connect installed fan speed drives to building automation system	12.1%	-26.7%	1,659,497	241,177	4,205,530	23.2	249.7	150.3	540,970	32.1	$ 240,627	$ 59,088	$299,715	112,253	(94
Dedicated ERVs in washrooms ventilation recovery in conditioned spaces	5.7%	-36.0%	2,634,489	178,014	4,513,729	24.9	268.0	111.3	469,773	27.9	$ 382,001	$ 43,613	$425,614	(862,739)	(31
Use air-source heat pumps to serve heating water for shoulder seasons with steam as back up *	26.9%	-5.3%	3,447,717	4,691	3,497,238	19.3	207.6	133.5	181,294	10.8	$ 499,919	$ 1,149	$501,068	(1,675,966)	14
Convert steam system serving air handlers to water cooled heat pump served by Enwave Deep Lake Water system (seasonal COP 4.3) *	29.0%	-2.4%	3,372,275	2,670	3,400,462	18.8	201.9	133.7	173,684	10.3	$ 488,980	$ 654	$489,634	(1,600,525)	14
Enwave district cooling to provide chilled water to building (SEER 20) *	1.5%	-42.0%	2,365,198	222,504	4,714,106	26.0	279.9	138.5	540,795	32.1	$ 342,954	$ 54,513	$397,467	(593,448)	(75
Convert DHW system to 95% efficient gas boiler	-0.2%	-44.5%	2,426,256	224,448	4,795,686	26.5	284.7	138.5	547,540	32.5	$ 351,807	$ 54,990	$406,797	(654,506)	(77
Enbridge Savings by Design Building	**57.2%**	**38.2%**	**1,995,664**	**5,168**	**2,050,221**	**11.3**	**121.7**	**105.9**	**109,597**	**6.5**	**$ 289,371**	**$ 1,266**	**$290,637**	**-223,914**	**14**