CREATE TO

REPORT FOR ACTION

Integrating a Climate Action Approach to City Real Estate Decisions - Mass Timber Pilot Program - Progress Update

Date: March 6, 2023
To: Board of Directors, CreateTO
From: Chief Executive Officer
Wards: All

SUMMARY

On June 20, 2022, the Board of Directors, CreateTO (CreateTO Board) received Item 2022.RA32.5 "Integrating a Climate Action Approach to City Real Estate Decisions - Mass Timber Pilot Program" and directed staff to report back to the CreateTO Board on the progress of the Mass Timber Affordable Housing Pilot Program (the "Pilot Program").

The Pilot Program explores using mass timber construction (such as cross-laminated timber (CLT) or glue-laminated timber structural materials to reduce carbon emissions in the delivery of affordable and market housing. Mass timber, contrary to production of other structural materials such as steel and concrete, stores rather than emits carbon which results in a lower carbon development.

The primary goal of the Pilot Program has been to assess the feasibility of delivering affordable rental housing within a mass timber form. The overall goal of the Pilot Program is to deliver a new, scalable affordable and market housing solution that can be developed with the objective of replicating the delivery method across other City-owned (and privately-owned) sites in the future to support climate action while expediting the delivery of affordable and market housing in the City.

The initial report provided an overview of the program, its goals and objectives, and work plan. This report will present the conclusions of the pilot program which examine the mass timber and hybrid building typologies against the following:

- Energy Performance, (TGS Version 4, Tier 1 vs Tier 3) and Life Cycle Assessment of Embodied Carbon
- Cost Analysis (TGS Version 4, Tier 1 vs Tier 3)
- Mass Timber vs Concrete Construction Costs

The analysis demonstrated the following key conclusions.

1. Energy Performance
   - TGS Tier 3 energy use is achieved with the 10-Storey and 12-Storey Typologies meeting the Energy Use Intensity and Green House Gas Intensity performance standards and operating as efficient low-carbon buildings.
   - Capital investments in geothermal, air source heat pumps, photovoltaics and enhanced building envelopes are key drivers contributing to successfully achieving the energy performance standards.
   - Geothermal should be pursued wherever possible as it:
     - Improves energy performance;
     - Generates greater utility savings and a shorter payback time; and
     - Enables potential partnership with energy providers.

2. Embodied Carbon
   - Each of the Typologies are on track to achieve low-embodied carbon values with a mass timber structure.
   - The findings for all three typologies are below the TGS Tier 3 requirement and would meet the most aggressive Toronto Green Building Council's Zero Carbon Building Design Standard Version 3, June 2022 with a greater than 40% reduction in Embodied Carbon Intensity.

3. Tier 1 vs Tier 3 Cost Premium
   - On average, the analysis found a 3% premium to deliver a mass timber building that targets TGS Tier 3, Version 4 as compared to Tier 1.
   - The key capital cost drivers for the Tier 3 premium are:
     - A high-performance enclosure (e.g. triple glazed windows instead of double);
     - Mechanical systems that use electrically-driven heat pumps instead of conventional chillers and gas boilers; and
     - Rooftop PV panels installed as opposed to being PV-ready only.
   - Upfront investment to achieve Tier 3 performance standards will minimize the risk associated with future required retrofit and bring on stream energy efficient buildings to support climate action initiatives.

4. Concrete versus Mass Timber Construction
   - Given the current state of the market with inflated costs particularly in form work, rebar and concrete, mass timber construction costs are less than conventional concrete construction.
   - As there is a stabilization of materials (concrete) and form work, it is anticipated that mass timber construction will be price competitively with conventional construction in concrete and steel.

5. Construction Schedules
   - Discussions with industry leaders and suppliers indicate that mass timber allows for a significantly reduced construction timing which, can result in financing and capital cost savings that could add to the cost effectiveness of mass timber construction and become a material of choice for mid-rise developments.

- While construction schedules are reduced with mass timber construction, it should be noted that successful delivery of mass timber buildings requires an upfront integrated approach to design that requires architects, engineers, contractors and manufactures to work closely together starting on day one.

As this report demonstrates, CreateTO staff, collaborating with our colleagues in the Environment and Climate Division and City Planning, conclude that this Pilot Program has potential benefits for the City, both from a housing delivery and sustainability and climate action perspective.

Should the CreateTO Board adopt the recommendations of this report, CreateTO will begin working with City Planning to advance rezoning applications for the Typology 1, 10-storey mass timber project on the City lands at 1113-1117 Dundas Street West.

RECOMMENDATIONS

The Chief Executive Officer, CreateTO recommends that the Board of Directors of CreateTO:

1. Accept the conclusions from the Mass Timber pilot project analysis, as outlined in this report;

2. Direct the Chief Executive Officer, CreateTO, in collaboration with the Executive Director, Housing Secretariat and the Chief Planner and Executive Director, City Planning, to advance a rezoning application of the property at 1113-1117 Dundas Street West for a mass timber building;

3. Direct the Chief Executive Officer, CreateTO, to report on the business case of a mass timber building for 1113-1117 Dundas Street West in first quarter of 2024; and

4. Direct the Chief Executive Officer, CreateTO, to report to the Board of Directors on future City real estate assets suitable for mass timber construction in delivering affordable and market rental housing based on the findings of the Mass Timber Pilot Program in the first quarter of 2024.

FINANCIAL IMPACT

There is no financial impact to CreateTO arising out of the recommendation in this report.

CreateTO is recovering due diligence costs for the Pilot Program from the City's Environment and Climate Division in line with the division's current approved budget.

CreateTO is recovering costs associated with completing planning approvals and market offering from the City's Housing Secretariat associated with City Council item 2022.PH33.7 in line with the division's current approved budget.

Staff time to complete this work program has been budgeted and allocated and approved within the 2023 CreateTO Budget.

DECISION HISTORY

On October 2, 2019, City Council adopted Item MM10.3 "Declaring a Climate Emergency and Accelerating Toronto's Climate Action Plan", which confirmed Council's declaration of a climate emergency for the purpose of naming, framing, and deepening our commitment to protecting our economy, our ecosystems and our community from climate change, and Council committed to, among other matters, accelerating the implementation of TransformTO climate actions at every opportunity.
http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2019.MM10.3

On July 23, 2020, the Board of Directors of CreateTO adopted item RA14.1 "Toronto Parking Authority Real Estate Program", and requested the Chief Executive Officer, CreateTO, to ensure that any redevelopment or disposition of TPA property and all future CreateTO initiated projects meet or exceed the Toronto Green Building Standard and that all future reports list opportunities to address climate change and city building.
http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2020.RA14.1

On July 14, 2021, City Council adopted Item PH25.17 "Toronto Green Standard Review and Update" which brought into effect the Toronto Green Standards Version 4 (2022) performance measures and requested CreateTO to require the application of the Toronto Green Standard Version 4, Tier 2 for all development agreements.
http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2021.PH25.17

On November 22, 2021, the Board of Directors of CreateTO adopted Item RA27.3 "Housing Now Progress Update" and requested a report to the Board to outline and confirm how all new buildings will achieve net-zero carbon emissions or Tier 3, Version 4 of the Toronto Green Standard.
http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2021.RA27.3

On December 15, 2021, City Council adopted Item IE26.16 "TransformTO - Critical Steps for Net Zero by 2040" which endorsed the targets and actions outlined in the report (December 2, 2021) from the Interim Director, Environment and Climate, titled "TransformTO Net Zero Strategy", and among other items, requested the Chief Planner to continue to ensure the Official Plan, Zoning By-laws, and planning policies and various Planning guidelines support the recommendations in the Net Zero Strategy, including to enhance building energy efficiency and reduce embedded carbon during construction.
http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2021.IE26.16

On May 11, 2022, City Council adopted Item PH33.7 "Delivering Affordable Rental Housing at 1113-1117 Dundas Street West", which authorized the Mass Timber Affordable Housing Pilot Program and funding requirements to assess the viability of mass timber as an approach to expeditiously deliver housing in a high-quality form that achieves near-zero Green House Gas emissions for City-owned site at 1113-1117 Dundas Street West (Car Park #204).
http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2022.PH33.7

On June 20, 2022, The Board of Directors of CreateTO adopted Item RA32.5 "Integrating a Climate Action Approach to City Real Estate Decisions - Mass Timber Pilot Program" which outlined the goals and objectives of the Mass Timber Pilot Program and requested CreateTO staff to report back with an update at the completion of the initial due diligence phase.
https://secure.toronto.ca/council/agenda-item.do?item=2022.RA32.5

COMMENTS

What is a Mass Timber Building?

A building is considered a mass timber building when the primary load-bearing structure is made of mass timber (including engineered wood) rather than steel or concrete. Mass timber buildings may incorporate various heavy timber components for its structure and envelope. These components are often manufactured off-site. The structure and envelope of a mass timber building may incorporate a variety of wood-based components, which are typically prefabricated off-site. The most prevalent mass timber components are glulam (glue-laminated) beams and columns, and cross laminated timber (CLT) floors and walls.

As of July 2022, the Ontario Building Code (OBC) allows encapsulated mass timber buildings up to 12-storeys and with 25% of ceilings to be exposed, consistent with the National Building Code.

Mass timber use has grown five-fold in Canada since 2007. As of 2019, over 400 projects were completed, and 72 were under construction or planned. Approximately 70% are commercial and institutional, with residential making up less than 10%. Overall, 85% are low-rise buildings, but many tall buildings are under construction or planned. Over 90% of activity is occurring in BC, Ontario, and Quebec.

Mass Timber Pilot Program (the "Pilot Program")

In June 2022, Management reported on a collaboration with the City's Environment and Climate Division to explore mass timber construction (such as cross laminated timber structural materials) to reduce embodied carbon emissions in the delivery of affordable housing and to explore and understand how to achieve TGS Tier 3, Version 4 (or near net-zero operational carbon emissions). CreateTO, in collaboration with the City's Environment and Climate Division, the Housing Secretariat, and City Planning, have advanced the Pilot Program opportunity to assess the feasibility of developing new housing with mass timber.

The Pilot Program strives to develop a scalable development model with a climate action approach that will add a new tool to the City's affordable housing toolkit, demonstrate the viability of this form of building to the real estate industry and help position the City to move quickly to optimize any future government funding opportunities that may become available.

The objectives of the Pilot Program are to assess and achieve future development opportunities on City-owned real estate assets that can deliver on the following pillars:

- New housing, both affordable and market;
- Development that is grounded in sustainability and climate action; and
- Development that is cost-effective and efficient to construct in the City.

The Pilot Program developed demonstration plans for two building typologies:
Typology 1

- Mid Rise residential mixed-use building with Encapsulated Mass Timber Construction (EMTC) consisting of:
  - A 10-storey building with laneway housing modelled on the 1113-1117 Dundas Street West site; and
  - A 12-storey hybrid building modelled on 1627 Danforth Avenue, Parcel A

Typology 2

- Tall Building, EMTC/Concrete (Hybrid) construction
- 18-storey building modelled on 150 Queens Wharf site.

The selection of the two typologies is based on:

- Advanced design concepts that support the efficient use of mass timber design while eliminating costly higher carbon materials such as steel and concrete;
- Opportunity to advance the use of mass timber for mid-rise construction along the City's many main streets and avenues;
- Mid-rise building typologies that comply with Ontario Building Code (the "OBC") requirements for mass timber construction (i.e., maximum of 12-storey mid-rise typologies);
- A tall building typology, up to 18-storeys, which will seek to comply with the OBC performance requirements for mass timber construction through the "alternative solutions" process, based on other tall tower mass timber precedents codified in other building codes (i.e., the International Building Code); and
- Building typologies (10 and 12- storeys) that are generally supported by City of Toronto Building and Fire Services, subject to further review with advanced design detail.

Further assumptions which informed the analysis include the following:

- The findings in this report will focus on Typology 1 buildings, as these projects are currently permissible as-of-right through the updated OBC, and therefore represent the best path for early adoption and implementation.

- The demonstration plans for Typology 1 are based on current mass timber production and construction procedures are likely to achieve approval by City of Toronto Building and Fire authorities based on in-effect code modifications.

As of July 1, 2022, the Ontario Building Code allows up to 12-storeys of encapsulated mass timber construction. This simplifies the future building permit review, but some alternative solutions may be required by City officials for the 10 and 12 storey typologies to allow for:

- Increased exposure of mass timber ceilings beyond 25%
  - The alternative solutions would depend on the amount of exposure which is a question of aesthetic value. This would of course add cost but would also require further analysis of the embodied carbon footprint given the need to increase ceiling CLT thickness where drywall is removed.
- CLT shear walls at zero lot line
  - Any CLT shear walls at the property line would require increased encapsulation to meet code requirements.
- Omissions of fire hose cabinets in floor areas
- Balloon framing in buildings greater than 30m

The Pilot Program examined each of the typologies using the following framework:

1. Design and capital costs of constructing mass timber buildings that strive to achieve:
   - Toronto Green Standards ("TGS") Version 4, Tier 1*;* and
   - TGS Version 4, Tier 3

2. Energy Performance for the building typologies targeting
   - TGS Version 4, Tier 1
   - TGS Version 4, Tier 3

3. Life Cycle Assessment
   - Life cycle carbon assessment (LCA) which provides a preliminary estimate of the embodied carbon footprint for each of the mass timber typologies*.*

4. Cost Analysis
   - Cost premium to go from TGS Version 4, Tier 1 to Version 4, Tier 3 performance standards
   - The cost premium to construct 10-storey and 12 storey concrete versus mass timber buildings.

A team of consultants, listed below, were retained in an exercise to demonstrate the approaches taken to deliver cost-effective, affordable housing that maximizes the use of mass timber to reduce embodied carbon and achieving near net-zero operational carbon emissions.

- Architectural
- Structural Engineer
- Mechanical, Electrical and Plumbing Engineer
- Fire and Code Consultant
- Energy Modelling Consultant
- Cost Consultant

Demonstration Plans

Typology 1- *10-Storey Demonstration Plan - modelled on 1113-1117 Dundas Street ("10-Storey Typology")*
The 10-Storey Typology is a midrise building and a separate row of 2-storey laneway suites. The mid-rise building is designed entirely of mass timber with concrete used only for construction of the foundation (slab on grade). The laneway suites will use a more conventional timber structure as well as prefabricated panels for enclosures. The key design elements are outlined below.

Development Statistics
- A 7,330 m^2 residential building
- A 10-storey building with non-residential space at grade fronting Dundas Street and a stand-alone row of 2-storey laneway suites
- 100 residential units
- No below grade parking

Structure
- CLT walls and floors and glulam beams; concrete will be used for the slab-on-grade foundation;
- A compact built form and high-performance envelope;
- Minimal façade articulation (i.e. no balconies; minimal step back only at fourth floor);
- a low ~35% window-to-wall ratio and triple glazed windows with fiberglass frames and 100 mm of insulation; and
- Use of a fiber cement rainscreen cladding, which is durable and non-combustible, but lower in embodied carbon compared to other options.

Mechanical Systems
- Heating and cooling provided by ground source heat pumps (i.e. geo-exchange field);
- Heating and cooling will be delivered to the suites via four-pipe fan coil units with integrated high efficiency ERV;
- Hot water provided by a separate air source heat pump with some geo-exchange preheat;
- Supplemental heating and hot water provided by an electric boiler; and
- The only natural gas use proposed is for the emergency generator, which will ensure resilience in the event of an area-wide power outage.

Renewable Energy

- Renewable energy on the site is proposed using Photovoltaic ("PV") panels on the roof;
- Note PV renewable energy is not sufficient to achieve net zero emissions, however it will help to ensure that the proposed building complies with the Greenhouse Gas Intensity requirements of TGS Version 4, Tier 3 and reduce the burden of the building on the grid during peak summer conditions.

Typology 1 - 12-Storey Building Demonstration Plan- modelled on Danforth Garage Site, Building A, 1627 Danforth Avenue ("12-Storey Typology")

The 12-Storey Typology is midrise hybrid building designed with mass timber and concrete. Concrete is used for the below grade parking structure and the first level above grade to accommodate long-span spaces and a higher percentage of glazing on the ground floor for non-residential uses. The key design elements are outlined below.

Development Statistics

- A 10,652 m^2 residential building
- 12-storeys with at grade non-residential space along Danforth Avenue
- 121 residential units
- One level of underground parking

Structure

- Danforth Building A is a hybrid mass timber building consisting of:
  - Concrete structure underground level up to the second floor;
  - Concrete structural core - Level P1- 1;
  - Mass Timber structural core Levels 2 and above;
  - Above-grade, the podium step back wraps around the entire building, and there are balconies on each façade; and
  - The enclosure includes more carbon intensive materials, including masonry veneer and aluminum composite cladding, as well as load-bearing steel studs.

Mechanical Systems

- The mechanical system uses a central air source heat pump plant to provide heating and cooling water to fan coils throughout the building; and
- Backup electric boilers are required to supplement the heating when temperatures drop below -5C.

Renewable Energy

- Renewable energy on the site is proposed using Photovoltaic ("PV") panels on the roof;
- A sizable portion of the roof top is utilized for indoor and outdoor amenity and a large area for outdoor mechanical space required for the air source heat pump equipment and potentially a generator for life safety and resilience; and
- Amenity and mechanical requirements therefore reduce the roof top area available for PV panels.

Typology 2 - 18-Storey Demonstration Plan
A residential high rise hybrid mass timber building with greater use of concrete relative to the 12-Storey Typology. Concrete is used for the below-grade structure (2 levels of parking) and mass timber for the floor assemblies, and structure above the first floor.

While the 18-Storey Typology exceeds Ontario Building Code ("OBC") and National Building Code ("NBC") limits, 18-Storey mass timber buildings are allowed in the International Building Code (US), which provides a basis from which to propose a reasonable alternative solution. The key design elements are outlined below.

Development Statistics
- A 15,463 m^2 residential building
- 18-storey with non-residential space at grade
- 177 residential units above grade
- Two levels of underground parking

Structure
- Hybrid mass timber building with concrete underground parking and building cores to the full height of the building;
- Encapsulated mass timber structure to the remaining areas above the second floor; and
- 25% window to wall ratio.

Mechanical Systems
- Mechanical system uses a central air source heat pump plant to provide heating and cooling water to fan coils throughout the building;
- Back up electric boilers are required to supplement the heating output when temperatures drop below -5C; and
- The only natural gas use proposed is for the emergency generator, which will ensure resilience in the event of an area-wide power outage.

Renewable Energy
- Renewable energy on the site is proposed using Photovoltaic ("PV") panels on the roof.

Energy Performance Energy Performance, (TGS Version 4, Tier 1 vs Tier 3) and Life Cycle Assessment of Embodied Carbon

Energy Performance
All building typologies in the Pilot Program were designed to target TGS V4, Tier 3 energy performance standards. All building Typologies are designed to further reduce greenhouse gas emissions as much as possible with the use of on-site renewable energy. A reasonable application of on-site photovoltaic (PV) panels on the building roof for the 10-Storey, 12-Storey and 18-Storey Typologies will assist to reduce Greenhouse Gas Intensity.

The key TGS, Version 4 Tier 3 energy performance metrics are:

- Energy Use Intensity ("EUI")
- Thermal Energy Demand Intensity ("TEDI")
- Greenhouse Gas Intensity ("GHGI")

The definition of the energy performance metrics is found in Attachment 2: Glossary of Terms. A summary of the energy performance is summarized in Table 1.

Table 1: Typology 1 Mass Timber Energy Performance TGS Tier 3 metrics

	TGS Tier 3, Target	**10-storey**	**12-storey**	**18-storey**	**Meet the TGS Tier 3 Target**
Energy Use Intensity (kWh/m2)	75	66.2	72.1	76.9	10-storey - Yes 12-storey - Yes 18-storey - No
Thermal Energy Demand Intensity (kWh/m2)	15	21.5	22.4	24.9	10-storey - No 12-storey - No 18-storey - No
Greenhouse Gas Intensity (kgCO2/m2)	5	3.4	3.6	**3.8**	10-storey - Yes 12-storey - Yes 18-storey - Yes

Both the 10 and 12-Storey Typologies meet the EUI and GHGI performance standards and operate as efficient low carbon buildings. The 10-Storey Typology outperforms the 12-Storey Typology due to the use of a geo-exchange field, which is more efficient than the air-source heat pumps used in the 12-Storey Typology.

The 18-storey typology does not meet the EUI or the TEDI targets. Further opportunities to examine sanitary heat recovery system for domestic hot water, and reduced energy consumption with the careful attention to lighting design and selection of Energy Star appliances in later stages of detailed design, should be considered.

The annual generation potential using PV panels as a source of renewable energy contributes to reducing the EUI and GHGI for all Typologies which are summarized in Table 2. However, the PV panels alone are not sufficient to achieve net zero emissions. Notwithstanding this, the renewable energy generated on each site does help to ensure that the proposed building complies with the GHGI target of TGS Version 4, Tier 3 and reduces the burden of the building on the grid during peak summer conditions.

Table 2: Greenhouse Gas Intensity and Energy Needs Off-Set by on-site PV Renewable Energy

	10-storey	12-storey	18-storey
Total Annual Energy Use (kWh/yr)	533,614	819,139	1,220031
PV Annual Energy Generation (kWh/yr	56,000	56,000	43,000
Percentage of Energy Needs Offset by PV Renewable Energy	10%	7%	3%

All building Typologies do not meet the TEDI target. To meet the TEDI target, a focused approach through design and construction would be required that pays high attention to envelope penetration to achieve the low levels of infiltration required for the high TEDI performance, which was not within the scope of conceptual design for each of the typologies. However, these factors should be considered through future detailed building design of a selected mass timber project. In the case of the 10-Storey Typology, further improvements to the envelope would be required, including exploring Passive House certification.

Life Cycle Assessment ("LCA") of Embodied Carbon
The LCA examines the whole-building lifecycle carbon emissions. The LCA calculates the sum of the emissions from all materials and construction activities over the lifespan of the building (assuming a 60-year lifespan). This includes the emissions associated with materials and construction processes including extraction of raw materials, processing, transport and on-site activities and currently includes structure, foundation and enclosure. The Embodied Carbon Intensity is the total embodied carbon divided by the gross floor area of the building.

The mid to high-rise residential buildings attempting to achieve TGS Version 4, Tier 3 are also required to demonstrate a minimum of 20% embodied carbon reduction compared to a base building which uses conventional materials.

The Toronto Green Building Council's Zero Carbon Building Design Standard Version 3, June 2022, sets a maximum intensity of **500 kgCO2e/m2** and awards points for a:

- 20% reduction or 350 kgCO2e/m^2) - 1 point; and
- 40% reduction or 240 kgCO2e/$m^{2)}$ - 2 points

Table 3 provides a summary of the preliminary lifecycle assessment for each of the typologies.

Table 3: Summary of Lifecycle Assessments by Building Typology

	10-Storey Typology	**12-Storey Typology**	**18-Storey Typology**
Whole Life Embodied Carbon (t CO2e)	1460	2,402	4,153
Canada Green Building Council's Zero Carbon Building Standard (kgCO2e/m$^{2)}$	**500**	**500**	**500**
Embodied Carbon Intensity (kg CO2e/m$^{2)}$	218	249	279
Percentage Reduction Compared to Baseline	56%	50%	44%

Each of the Typologies are on track to achieve low embodied carbon values to the mass timber structure. They are below the maximum requirements of TGS Tier 3 and they would meet the most aggressive ZCB Standard target. The 10-Storey typology outperforms the 12-storey and 18-storey typologies due to the entirely mass timber construction and a relatively simple footprint which generally optimizes material and energy usage.

Both the 12 and 18-Storey Typologies are hybrid buildings using varying degrees of concrete both in below grade structures and building cores. In particular, the reinforced concrete required for the 18-Storey Typology makes up a significant portion of the overall materials and Global Warming Potential. Investigation can be undertaken in detail design to optimize grid spacing, slab thickness and shear wall construction to minimize concrete quantities while maintaining structural integrity. Removing concrete in favour of products that are less carbon intensive could have a significant impact on the overall embodied carbon.

Establishing environmental performance thresholds on individual products, such as locally sourced concrete manufacturers with low carbon options at minimal cost premiums may also aid in improving the buildings carbon footprint.

Mass Timber Version 4, Tier 1 versus Tier 3 Capital

A key component of the Pilot Program was to understand the capital cost premiums for all three building typologies that target Version 4, Tier 3.

A cost consultant was retained to develop a Class D cost estimate based on the three building typologies targeting Version 4, Tier 3. The Tier 3 cost estimates were adjusted to reference Version 4, Tier 1 system changes. These included the following:

Envelope

- Window-to-Wall ratio
- Glazing Performance
- Wall Performance

Mechanical
- Domestic hot water
- Heating & Cooling Plant
- Gas

Electrical
- PV Panels - roofs shall be solar ready.

Table 4 summarizes the Tier 1 and Tier 3 construction costs premiums

Table 4: Tier 1 vs Tier 3 Mass Timber Construction Cost Premiums[1]

	Tier 1 ($/sf)	**Tier 3 ($/sf)**	**Percentage Premium**
10-Storey	$459	$472	2.8%
12-Storey	$436	$450	3.2%
18 Storey	$470	$484	3.0%

1. Square foot costs include: Design Contingency (12%); hard cost estimates are in Q3, 2022 dollars and includes Escalation Allowance (8.5%) to Q2, 2023; and General Requirements (9%) and Contractor fees (3%)

On average the premium to target TGS Version 4, Tier 3 over Tier 1 performance standards for mass timber construction is 3%. The key capital cost drivers for the Tier 3 premium across the 10-Storey and 12-Storey Typologies are:

- A high-performance enclosure (e.g. triple glazed windows instead of double)
- Mechanical systems that use electrically-driven heat pumps instead of conventional chillers and gas boilers
- Rooftop PV panels installed as opposed to being PV-ready only.

Mass Timber Versus Concrete Building - Cost Comparison

The final component of the analysis was understanding a cost comparison of a Tier 3 mass timber building versus a conventional concrete building. This analysis was undertaken for the 10-Storey and 12-Storey Typologies. Each were designed as mass timber and concrete buildings following which a cost estimate was completed. A comparison of the 18-Storey Typology was not undertaken given the hybrid nature of this mass timber building. A summary of the concrete cost premium is shown in Table 5.

Table 5: Tier 3 Mass Timber vs Concrete Cost Comparisons

	Tier 3 Mass Timber Building ($/sf)	**Tier 3 Concrete Building ($/sf)**	**Percentage Difference**
10-Storey	$472	$518	9.75%
12-Storey	$450	$447	0.67%

The 10-Storey Typology comparison results in a 9.75% premium to construct a concrete building as compared to the mass timber building. The cost drivers for the concrete building are the substructure, structure and exterior enclosure. The 10-Storey Typology demonstrated a significant increase in the substructure cost element with a slab on grade structure in the mass timber building and a raft slab with the concrete building. The 12-Storey Typology, which is hybrid structure, shows the cost to construct the mass timber hybrid vs the concrete to be relatively comparable.

The concrete comparison findings reflect concept designs. Further design development could impact these cost estimates. In addition, the inflated cost of form work and rebar over the past several years is also a factor which has impacted the costs in favour of the mass timber building, while there has been a reduction in the costs of timber since the rapid inflation experienced in 2020 and 2021. These market supply issues impact the costing undertaken as this point in time. As we begin to see a stabilization in materials (concrete) and form work, it would be prudent to revisit these cost comparisons.

Conclusions
To further the analysis for Mass Timber as a new, innovative building typology, CreateTO proceeded through an exercise to examine

- A 10-Storey mass timber typology
- A 12-Storey hybrid typology; and
- An 18-Storey hybrid topology

Each of the typologies were evaluated by:
- Energy Performance, (TGS Version 4, Tier 1 vs Tier 3) and Life Cycle Assessment of Embodied Carbon
- Cost Analysis (TGS Version 4, Tier 1 vs Tier 3)
- Mass Timber vs Concrete construction

The analysis demonstrated the following key conclusions:
1. Energy Performance
    - TGS Tier 3 energy use is achieved with the 10-Storey and 12-Storey Typologies meeting the Energy Use Intensity and Green House Gas Intensity performance standards and operating as efficient low-carbon buildings.
    - Capital investments in geothermal, air source heat pumps, photovoltaics and enhanced building envelopes are key drivers contributing to successfully achieving the energy performance standards.
    - Geothermal should be pursued wherever possible as it:
      - Improves energy performance;
      - Generates greater utility savings and a shorter payback time; and
      - Enables potential partnership with energy providers.

2. Embodied Carbon
    - Each of the Typologies are on track to achieve low-embodied carbon values with a mass timber structure.
    - The findings for all three typologies are below the TGS Tier 3 requirement and would meet the most aggressive Toronto Green Building Council's Zero Carbon

Building Design Standard Version 3, June 2022 with a greater than 40% reduction in Embodied Carbon Intensity.

3. Tier 1 vs Tier 3 Cost Premium
   - On average, the analysis found a 3% premium to deliver a mass timber building that targets TGS Tier 3, Version 4 as compared to Tier 1.
   - The key capital cost drivers for the Tier 3 premium are:
     - A high-performance enclosure (e.g. triple glazed windows instead of double);
     - Mechanical systems that use electrically-driven heat pumps instead of conventional chillers and gas boilers; and
     - Rooftop PV panels installed as opposed to being PV-ready only.
   - Upfront investment to achieve Tier 3 performance standards will minimize the risk associated with future required retrofit and bring on stream energy efficient buildings to support climate action initiatives.

4. Concrete versus Mass Timber Construction
   - Given the current state of the market with inflated costs particularly in form work, rebar and concrete, mass timber construction costs are less than conventional concrete construction.
   - As there is a stabilization of materials (concrete) and form work, it is anticipated that mass timber construction will be price competitively with conventional construction in concrete and steel.

5. Construction Schedules
   - Discussions with industry leaders and suppliers indicate that mass timber allows for a significantly reduced construction timing which, can result in financing and capital cost savings that could add to the cost effectiveness of mass timber construction and become a material of choice for mid-rise developments.
   - While construction schedules are reduced with mass timber construction, it should be noted that successful delivery of mass timber buildings requires an upfront integrated approach to design that requires architects, engineers, contractors and manufactures to work closely together starting on day one.
   - The impact of reduced construction schedules can be assessed in the future as a mass timber project is advanced through design, business case analysis and market offering phases.

Next Steps

The Mass Timber Housing Pilot Program, undertaken in collaboration with Environment and Climate and City Planning, demonstrates that mass timber buildings, particularly those designed as outlined in the 10-Storey Typology provides an excellent opportunity to positively impact the building/housing stock in the City.

Therefore, subject to the CreateTO Board of Directors, endorsing and supporting this report, CreateTO Management recommends, collaborating with City Planning, to advance the rezoning for a 10-storey mass timber building on the City lands at 1113-1117 Dundas Street West and report back to the CreateTO Board on the business case in Q1, 2024 with an opportunity to advance a market offering for a 10-storey storey mass timber residential building.

CreateTO Management will continue to examine opportunities to scale up the mass timber construction and examine other opportunities to deliver mass timber on City lands that provides a more sustainable building construction approach. CreateTO Management will report back to the Board of Directors in Q1, 2024 with opportunities to deliver mass timber buildings on other City sites.

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SIGNATURE

Vic Gupta

Chief Executive Officer
CreateTO

ATTACHMENTS

Attachment 1: Glossary of Terms

ATTACHMENT 1: GLOSSARY OF TERMS

Carbon Sequestration
- The process of capturing and storing carbon from the atmosphere through natural or anthropogenic methods

Energy Use Intensity (EUI)
- Refers to the sum of all site (not source) energy consumed on the project site (e.g. electricity, natural gas, district heat) including all process energy, divided by the building modelled floor area.

Embodied Carbon
- Embodied Carbon is the carbon dioxide (CO2) emissions associated with materials and construction processes throughout the whole lifecycle of a building or infrastructure.
- It includes any CO2 created during the manufacturing of building materials (material extraction, transport to manufacturer, manufacturing), the transport of those materials to the job site and the construction practices used.

Geo-exchange
- A system that exchanges heat with the earth or a body of water, usually with the goal of providing efficient heating and cooling using heat pumps.

Global warming potential (GWP)
- A measure of how much heat is trapped by a greenhouse gas over a specified timeframe, relative to carbon dioxide.

Greenhouse Gas Intensity ("GHGI")
- Is the annualized metric for reporting operating carbon performance in kilograms of carbon dioxide emissions per square meter, (kg CO2/m2) per year

Life cycle assessment (LCA)
LCA is a systematic set of procedures for compiling and examining the inputs and outputs of materials and energy, and the associated environmental impacts directly attributable to a building, infrastructure, product, or material throughout its life cycle.

Operational Carbon
- Carbon that comes from energy, heat, lighting etc. in the operation of a building post construction.

Passive House Institute
- The Passive House Institute ("PHI") is an independent research institute that has played a role in the development of the Passive House Concept - the only internationally recognised, performance-based energy standard in construction.

Passive House Design
- Passive is a construction concept that focuses on minimal energy consumption and great air quality;

- The five principles of Passive House Design are:
  - No thermal bridging
  - Superior windows
  - Mechanical ventilation with heat recovery
  - Quality insulation
  - Airtight building envelope construction

Photovoltaic ("PV") Panels
- Photovoltaic (PV) panels are used to produce electricity directly from sunlight. PV panels consist of a number of individual cells connected together to produce electricity of a desired voltage.

Renewable Energy
- A source of energy that is replenished through natural process or using sustainable management policies such that it is not depleted at current levels of consumption.
- Examples include solar and wind energy used for power generation and solar energy used for heating. Air-source and ground-source (geo-exchange) heat pump systems do not constitute renewable energy systems.

Thermal Energy Demand Intensity ("TEDI")
- The annual heating delivered to the building for space conditioning and conditioning of ventilation air.
- Measured with modelling software, this is the amount of heating energy delivered to the project that is outputted from any and all types of heating equipment, per unit of Modelled Floor Area.
- Heating equipment includes electric, gas, hot water, or DX heating coils of central air systems (e.g. make-up air units, air handling units, etc.), terminal equipment (e.g. baseboards, fan coils, heat pumps, reheat coils, etc.) or any other equipment used for the purposes of space conditioning and ventilation. Heating output of any heating equipment whose source of heat is not directly provided by a utility (electricity, gas or district) must still be counted towards the TEDI.
- For example, hot water or heat pump heating sources that are derived from a waste heat source or a renewable energy source do not contribute to a reduction in TEDI, as per the above definition.

Total Energy Use Intensity ("TEUI")
- TEUI is a measure of the total energy required by a building. It includes all energy uses that are required to operate a building; these include space heating, lighting, air conditioning, heating hot water, and many other end uses.

Whole life carbon:
- Emissions from all life cycle stages, encompassing both embodied carbon and operational carbon together (stages A1 to C4).

Acronyms
KWh
- Kilowatt hour

CO2e

- Carbon dioxide equivalents
- A single unit of measurement that allows for the impact of releasing different greenhouse gases into the atmosphere to be evaluated on a common basis. Carbon dioxide equivalents are calculated using Global Warming Potential factors that represent the impact of each greenhouse gas type (such as methane (CH4) and nitrous oxide (N2O)) relative to that of carbon dioxide

Sources:

1. Canada Green Building Council. *Zero Carbon Building: Design Standard Version 3*. June 2022.

2. City of Toronto. *TransformTO Net Zero Strategy: A Climate Action Pathway to 2030 and Beyond*. November 2021.