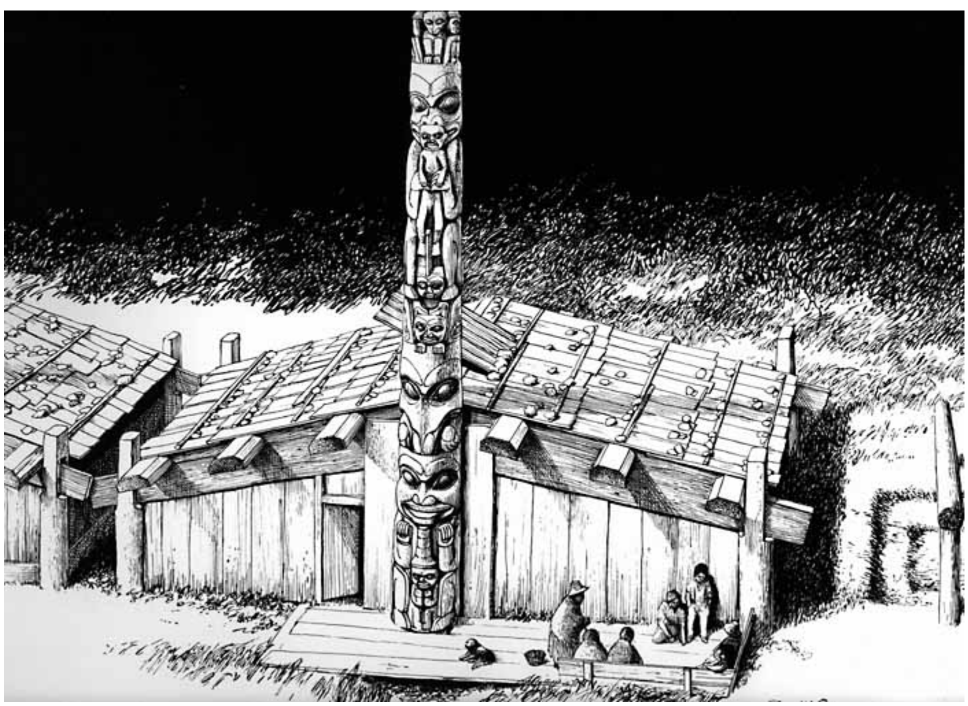
Sustainability and Resilience Review

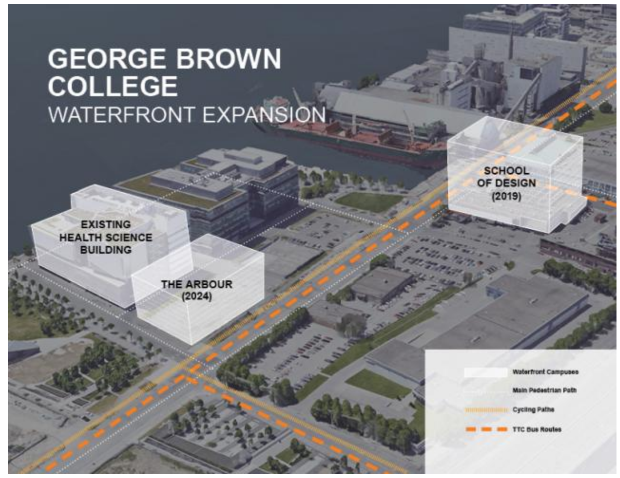
The Arbour Competition

George Brown College

March 20, 2018

Tomorrow's mass timber buildings – not original ideas, but adaptations of proven precedents to ever changing contexts.





With an aim to create a carbon-neutral facility, George Brown College has launched this international design competition, asking architects to submit concepts for a 12-storey timber-framed building—the first institutional building of this type in Ontario. To be known as "The Arbour", the building will be designed to function as a "living laboratory" for climate-friendly building design, serving as the home of a new Tall Wood Building Research Institute, George Brown's Centre for Information and Computer Technology, a new child care facility, and additional research facilities. A number of smart building systems will be integrated into the project with an aim towards attaining carbon-neutral status. The Arbour's status as the first tall wood institutional building in Ontario means that the project will serve as a demonstration facility and testbed for new technologies in sustainable building design.

Sustainability and Resilience Review: The Arbour Design Competition

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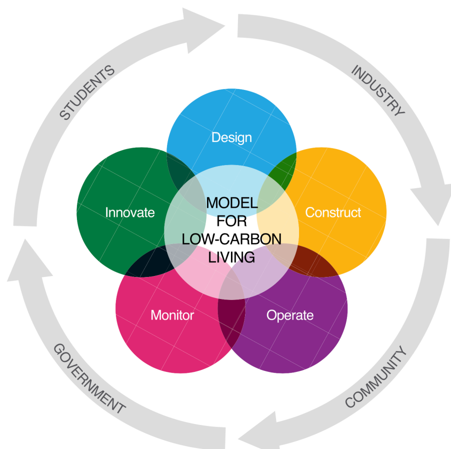
ACKNOWLEDGEMENTS
The author wishes to acknowledge the collegial assistance of George Brown College, DTAH Architects, and the various consultants retained to inform the competition jury deliberations - their insights and feedback proved invaluable.

DISCLAIMER
All of the assessments presented herein were conducted independently by the author in accordance with the terms of reference governing the competition and do not necessarily represent the views of George Brown College, DTAH Architects (Professional Advisor), or any of the consultants retained to inform the competition jury deliberations.

Overview

This resilience and sustainability review represents but one part of a broader process undertaken within The Arbour Design Competition. In preparing this report, the consultant examined the terms of reference within the request for proposal and all of the supporting documentation and addenda provided to the competitors. This formed the basis for development of a resilience and sustainability assessment framework that was deployed in evaluating each of the design submissions.



Low Carbon Living. Implicit in The Arbour is George Brown College's larger vision for low carbon living and how to educate and train its students, faculty and staff, and to engage its societal stakeholders in order to advance this agenda.

Overall, the submissions requirements were structured to deliver sufficient technical and environmental design information to enable a comprehensive assessment of resilience and sustainability. Competitors were also given an opportunity to provide clarification where key information was missing, incoherent or possibly incorrectly entered in the documentation packages. Every attempt was made to give each of the competitors the opportunity to clearly and completely convey the design intent underlying their submissions.

There is deliberately no ranking of the resilience and sustainability of the design proposals because this review represents one among a number of assessment processes that are intended to inform the adjudication process in a manner to be interpreted and distilled at the discretion of the jury.

All of the remarkable design proposals that have been submitted should be considered as a work in progress that can normally be expected to be revisited and revised as the design development process goes forward. The jury is urged to take into consideration:

- Potential for leading edge innovation in site and facilities design, operation and maintenance;
- Flexible/adaptable pathways to enhanced environmental performance to enable continuous improvement;
- Robust and adaptive design DNA capable of integrating innovative technologies that emerge throughout the design development process; and
- Exemplary and extensible design precedents for parts and the whole that help guide future planning and development by George Brown College and its stakeholder community.

Sustainability remains a complex consideration in architecture, landscape and urban design that is best achieved by accommodating a diversity of perspectives and looseness of fit, while recognizing that ultimately it is a symbiotic relationship between the built environment and those who inhabit it over the life cycle of the facilities.

The Difference Between Resilience and Sustainability

Resilience is not the new sustainability and while the two concepts are related they should not be confused.

Resilience, like sustainability, will not go out of style. These two performance objectives are related to one another, with sustainability being a broader and longer-term process that periodically hinges on our ability to be resilient and bounce back from adversity so that the sustainability agenda is not set back and further compromised.

Resilience is a complex attribute that is comprised of numerous aspects - some physical, some technical and some social and cultural. We become aware of resilience when it is absent or insufficient and we are unable to persevere and overcome challenges such as extreme weather events.

re·sil·ience

1. the act of rebounding or springing back;
2. the capacity to adapt to changing conditions and to maintain or regain functionality and vitality in the face of stress or disturbance.

Sustainability is not possible without resilience, but to phrase it in the vernacular of science, resilience is a necessary but insufficient condition for sustainability.

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Our Common Future (Brundtland Report), United Nations World Commission on Environment and Development, 1987.

Limits of growth and the ever-expanding ecological footprint of human civilization have caused humankind to reject conventional ideas about growth and progress that have led to waste generation, resource depletion, environmental degradation, social stratification and reductions in biodiversity. The new mantra of social, economic and environmental sustainability recognizes that at its root lies the very survival of the human species, and all of our diverse cultures.

Resilience is like a shock absorber that allows for a safe, smooth ride while sustainability is the road taken – one that hopefully does lead to a precipice or dead end.

The Arbour project is an opportunity to integrate resilience measures within a broader framework of sustainability so that George Brown College is not merely an educational service provider but an organism engaged in a symbiosis between itself, it’s immediate academic community, and the larger web of societal stakeholders. The challenges of sustainable development will require us all to re-think our built environment as a means to an end, not an end in itself. Most importantly, we must be careful to ensure that today’s decisions do not compromise the ability of future generations to meet their own needs.

Competition Entries

Four design proposals as depicted below are reviewed in this report. The review was conducted and presented in alphabetical order based on the surname of the lead architecture proponent.

Shigeru Ban Architects + Brook McIlroy Architects

Moriyama & Teshima Architects + Acton Ostry Architects

Patkau Architects + MJMA

Provencher Roy | Turner Fleischer | Arup

Resilience and Sustainability Assessment Framework

The evaluation framework guiding this technical review is derived in part from The Arbour Brief, and subsequently augmented by commonly used metrics for social, environmental and economic sustainability.

According to George Brown's overarching vision, at the most basic level of technical resolution, The Arbour will:

- Utilize mass timber construction (tall wood building);
- Use low carbon building materials;
- Achieve net positive energy performance;
- Utilize smart building systems and technologies;
- Meet LEED™ Gold Certification;
- Be resilient in design, including the integration of a high degree of flexibility and adaptability in interior design and layout to ensure future building resiliency and operation; and
- Comply with City of Toronto Green Building Standard Version 3, Tier 4.

GBC is committed to sustainability and is ambitious in providing leadership in the reduction of greenhouse gases (GHG). Therefore, a net-positive energy approach is a major design element in The Arbour which will be designed to potentially plug into low carbon District Energy systems. Mechanical space to support connections to the District Energy systems are therefore a mandatory requirement. The Arbour should also integrate with the Daphne Cockwell Centre as required to work symbiotically with the existing building to achieve net positive results and positively impact the existing LEED Gold Health Sciences buildings. More details on sustainability requirements follow in the next section, *The Arbour Approach*.

THE ARBOUR APPROACH

In developing this next building as part of GBC's Waterfront Campus, and seeking solutions that align with a low carbon future, GBC intends to create a landmark building that incorporates four strategic areas of focus. These four areas will ensure that the project is a leader in intelligent sustainable building practices and will be a global demonstration of what can be achieved in advancing low carbon, net positive, intelligent and resilient buildings.

Low Carbon

Reduce the building's life cycle carbon footprint through the use of Mass Timber construction leveraging the associated assembly and construction efficiencies. This may include, but is not limited to:

- *Utilization of sustainable, locally sourced materials that act as a carbon sink;*
- *Efficient design strategies that reduce construction material use and support prefabrication and ease of assembly;*
- *Reduction of traditional energy intensive construction methods using prefabricated building components, renewable powered machinery and innovative project governance to support sustainability and performance targets;*
- *Setting performance targets for operation at LEED™ Gold Level minimum required by Waterfront Toronto;*
- *Minimizing operating carbon and GHG emissions; and*
- *Compliance with Tier 4 of Version 3 of the City of Toronto's Green Building Standard (TGS), and City of Toronto's Green Roof Policy*

Future Proofing & Building Resilience

Develop strategies to ensure long term success of the building in terms of potential change in use as well as long term effects of climate change and supporting the development of related practices and technologies within the building sector. This may include, but is not limited to:

- *Elevation of academic spaces in the building one storey above ground level and eliminating below-grade useable spaces to ensure the Arbour will be ready to weather any climate change driven extreme weather events (e.g. high-water conditions) without undue damage to the inhabited portion of the building, its contents and users;*
- *Resilient locations for mechanical systems to enable operation during emergency situations;*
- *No occupancy below grade except for storage and building connections to Health Sciences Complex;*
- *Provide areas of refuge during emergency situations;*
- *Focus on flexibility and modularity in the design for all classrooms, labs, lecture halls and meeting spaces;*
- *Design all aspects of The Arbour with flexibility for adaptation and reuse;*
- *Incorporation of GBC Master Planning design and planning principles;*
- *Intuitive wayfinding strategies including exposed vertical circulation;*
- *Community and stakeholder engagement in design development stages; and*
- *Aligning with City of Toronto resilience policies.*

Net-Positive

Develop net-positive energy performance. This may include, but is not limited to:

- *Improving energy efficiency and reducing and eliminating unnecessary energy loads by incorporating passive design features and optimizing mechanical systems;*
- *Utilizing renewal energy sources to achieve highest possible on- site energy supply, e.g. geothermal, solar thermal, kinetic energy capture, waste heat recovery, district energy sources etc.;*
- *Designing with the highest level of conservation and passive design best practices;*
- *Incorporating sustainable on-site and district energy generation and thermal energy supply;*
- *Recovery and storage of waste energy and heat;*
- *Active monitoring to improve efficiencies using intelligent building systems;*
- *Using energy from occupants and engaging occupants in energy sharing initiatives; and*
- *Proposing unique and leading edge on-site energy generation systems that may also provide emergency combined heat and power to enhance resilience.*

Smart

Incorporate smart systems to improve utilization and operation of the building. These systems should automate mechanical, life safety, user comfort, communication and facility management to improve asset reliability and performance. This may include, but is not limited to:

- *Adaptive and responsive controls with failsafe (manual override) modes;*
- *Occupant engagement systems;*
- *Reactive building envelopes;*
- *Automated facility management;*
- *Real-time data collection and display;*
- *Accessibility and security;*
- *Research, testing and monitoring systems; and*
- *Transit strategies integrated with walkability and cycling best practices.*

Sustainability Submission Requirements

The Arbour approach to sustainability is open to interpretation and innovation by the design teams provided submissions address, at a minimum, the four primary objectives of low carbon, future proofing & resilience, net-positive and smart.

In addition to the various submission requirements outlined in this competition brief, each design team's submission shall include the following:

1. A sustainability narrative for the design concept that explains the approach taken to meeting and/or exceeding sustainability requirements outlined in this brief. Competitors are not required to achieve a particular level of achievement associated with the WELL Building Standard®, but may wish to consider how their design responds to the concepts of Air, Water, Nourishment, Light, Fitness, Comfort and Mind through features related to nudging occupant behavior, architectural/landscape design and facility management/operations.
2. An infographic panel that conveys the key sustainability strategies and features of the proposed design including, but not limited to, deep life cycle sustainability approaches to flexibility/adaptability, access to building services for maintenance, repair and replacement, building envelope refurbishment/renewal, and passive survivability. The sustainability narrative may be incorporated into this infographic panel.
3. A technical report describing the passive and active systems, materials, components and equipment comprising the proposed design, including the various energy systems, municipal and site infrastructure serving the proposed design. This should include stormwater management, low impact development measures and landscape features that improve pedestrian comfort while enhancing biodiversity.
4. An appendix is to be included in the above report that provides a summary of key performance metrics as outlined in the table below. This appendix shall include a description of the methods (software) and modelling assumptions deployed to estimate the performance metrics, as applicable, for measures related to energy, durability (hygrothermal), life cycle analysis (materials), daylighting/views, thermal comfort, pedestrian comfort, and stormwater management. In all cases, future projected weather that accounts for anticipated climate change influences will guide modelling efforts.

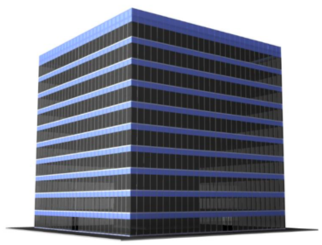
Table of Required Performance Metrics

Performance Assessment Metrics	**Proposed Design**
Total Project GFA (above and below grade - m^2)	
Total Project Energy Demand (kWh/year)	
Renewable Energy Generation (kWh/year)	
Total Project Carbon Emissions (kg eCO_2/year)	
Total Project Sequestered Carbon (kg eCO_2)	
Total Project EUI (Target - 65 kWh/m^2.year)	
Total Project TEDI (Target - 15 kWh/m^2.year)	
Total Project GHGI (Target - 4 kg eCO_2/m^2.year)	
Overall Effective U-value of the Above-Grade Enclosure (W/m^2.K)	
Thermal Autonomy (% of Year Passive Heating/Cooling – No Active Systems)	

Mandatory and Recommended Considerations

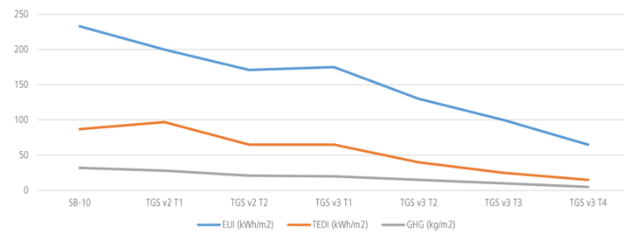
The Arbour is committed to supporting City of Toronto initiatives and GBC has mandated the facility conform to requirements for commercial office buildings according to City of Toronto Green Building Standard Version 3, Tier 4. In doing so it is recognized the associated targets have not been calibrated to available/achievable technologies. It is also recommended that design teams consider using the WELL Building Standard, as a framework to guide occupant health and wellbeing.

COMMERCIAL OFFICE BUILDINGS



FLOOR AREA: 196,000 ft^2 (18,200m^2)
FLOORS: 10 X 12ft (3.66m)
OCCUPANTS: 790 people

Figure 19: Target Progression for Commercial Office



BACKGROUND. An average Tier 1-compliant solution for Commercial Office buildings today includes a standard curtain wall assembly with a 50% window-to-wall ratio, an effective R-value in the range of R5 to R7, and the use of double glazed windows. Building mechanical systems typically use a standard Variable Air Volume system (VAV) with mid- to high-efficiency heating, and OBC-compliant air or water-cooled chillers, depending on building size. Lighting savings over code are also common for Tier 1 compliant buildings. Buildings complying with current Tier 2 requirements are designing higher performing envelopes with R-values between R8 and R10, less than 50% window to wall ratio), better delivery of ventilation and higher performance cooling solutions.

Tier	New TGS Targets		
	EUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)
SB-10	233	84	27
TGS v2 T1	200	82	23
TGS v2 T2	171	68	19
T1	175	70	20
T2	130	30	15
T3	100	22	8
T4	65	15	4

TIER 1
- 40% WWR
- Wall R-10
- Roof R-20
- Window U-0.4
- 25% lighting savings
- 0% plug savings

TIER 2
- 40% WWR
- Wall R-10
- Roof R-20
- Window U-0.3
- 25% lighting savings
- 0% plug savings

TIER 3
- 40% WWR
- Wall R-10
- Roof R-20
- Window U-0.2
- 50% lighting savings
- 25% plug savings

TIER 4
- 40% WWR
- Wall R-20
- Roof R-30
- Window U-0.14
- 70% lighting savings
- 25% plug savings

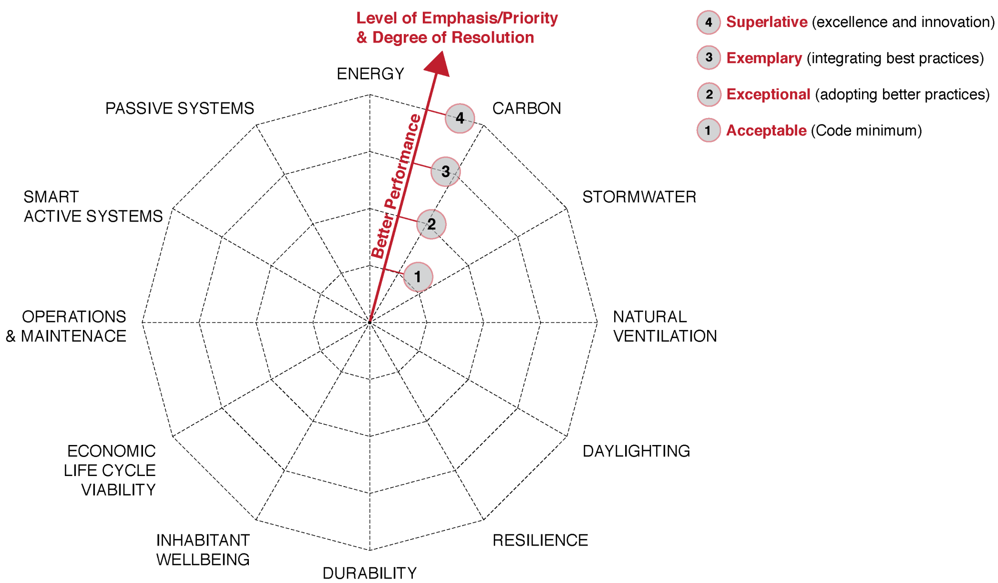
Toronto Green Standard Version 3. Performance Targets for Commercial Office Buildings. T2 represents the minimum requirement and T4 is the near net-zero energy (low carbon) ambition for future buildings in Toronto.

STANDARD VERSION	LEVEL OF ACHIEVEMENT	PRECONDITIONS THAT MUST BE ACHIEVED	OPTIMIZATIONS THAT MUST BE ACHIEVED
WELL Building Standard®	Silver Certification	All applicable	None
	Gold Certification	All applicable	40% of applicable
	Platinum Certification	All applicable	80% of applicable
WELL Pilot Standards	Silver Certification	All applicable	20% of applicable
	Gold Certification	All applicable	40% of applicable
	Platinum Certification	All applicable	80% of applicable

WELL Building Standard® requires all preconditions and no optimizations to be achieved in order to obtain a minimum Silver Certification. No preconditions or optimizations are mandatory for The Arbour but may be used as a guiding framework when evaluating the design proposals.

Performance Assessment Mapping Protocol

In order to visualize the holistic performance of the proposed design, a mapping protocol for each of the critical attributes has been developed, as depicted below.



Critical Performance Attributes. The mapping protocol developed in this report is intended to aid in the visualization of the proposed designs to enable meaningful comparisons.

Energy – Energy efficiency, renewable energy generation, potential integration with low carbon district energy systems, compatibility of HVAC system with low temperature district energy systems.

Carbon – net-positive or low life cycle carbon, greenhouse gas emissions, low carbon materials.

Stormwater – management of stormwater to maintain water quality, integration with waterfront stormwater management features.

Natural Ventilation – provision of inhabitant controlled natural ventilation serving occupied areas.

Daylighting – adequate daylighting to support program uses, to promote occupant wellbeing (light and views), and control of glare/overheating.

Resilience – thermal autonomy, flooding protection, failsafe smart systems, vulnerability to glass damage by wind-born projectiles (debris), protection of emergency backup systems, persistence of landscape plantings, place of refuge and safe evacuation.

Durability – useful service life, differential durability, functional obsolescence.

Inhabitant Wellbeing – health and safety, thermal comfort, indoor air quality, daylighting, fitness, mind.

Economic Life Cycle Viability – optimal life cycle costs balanced between capital costs and operating and maintenance costs, flexibility/adaptability to accommodate churn rates.

Operations and Maintenance – materials, systems and technology that are easy to monitor and accessible for cleaning, maintenance and replacement, all within the capability of facility staff.

Smart Active Systems – responsive environmental control systems and building services, distributed/unitized versus centralized control strategies, migratory path for upgrading components.

Passive Systems – robustness of building enclosure, control of heat, moisture, light and air, inhabitant-friendly failsafe/manual operation of windows, lights, temperature controls, etc.

The sections that follow present performance summaries for each of the four design proposals and conclude with a comparative discussion and synopsis.

SB + BM Performance Summary

Shigeru Ban Architects + Brook McIlroy Architects

Compulsory Elements		
Net-Positive, TGS Tier 4 Version 3, Green Roof Policy, LEED™ Gold Certification * Only if the enhanced energy generation option is deployed.	**Yes***	No

Renewable Energy	
Total Project Energy Demand (kWh/year)	784,657
Renewable Energy Generation – Building Only (kWh/year)	372,682
Renewable Energy Generation – Enhanced (kWh/year)	826,169

Energy and Carbon	Target	Proposed/Enhanced
Total Project Site Energy Use Intensity (EUI)	65 kWh/m^2.year	47 kWh/m^2.year
Total Project Thermal Energy Demand Intensity (TEDI)	15 kWh/m^2.year	37 kWh/m^2.year
Total Project Greenhouse Gas Intensity (GHGI)	4 kg eCO_2 /m^2.year	4 / 2.1 kg eCO_2 /m^2.year
Passive Systems (Building Enclosure)	**Recommended**	**Proposed**
Overall Effective U-value (W/m^2.K)	0.75	0.824
Thermal Autonomy (% Passive <18^{o}C Heating/Cooling >25^{o}C)	> 35%	39%

Commentary:

- *Enhanced renewable energy system (optional) delivers a carbon negative life cycle performance.*
- *Method used for calculating TEDI yields value exceeding target which is met when mechanical ventilation excluded.*
- *Overall effective U-value and thermal autonomy will provide a reasonable level of thermal resilience.*

Resilience & Sustainability	Acceptable → Exceptional → Exemplary → Superlative
Durability	■■■■■■■■■■■■■■■■□□
Future Proof & Resilience	■■■■■■■■■■■■■■■□□□
Passive Systems	■■■■■■■■■■■■■■■■□□
Smart Active Systems	■■■■■■■■■■■■■■■□□□
Economic Life Cycle Viability	■■■■■■■■■■■■■■□□□□

Commentary:

- *Major innovation - breathing building without ducts, hybrid demand-controlled and occupant-controlled ventilation.*
- *Double-skin facade provides reasonable protection against glass breakage during extreme weather events.*
- *Highly sophisticated and innovative passive enclosure design integrated with smart active systems.*
- *High level of durability for structure enclosed within double-skin facade, robust fixtures and finishes.*
- *Flexible and adaptable spaces with accessible services provide good futureproofing.*
- *Ground-source heat pumps and run-around loop compatible with high efficiency, low carbon district energy system.*
- *HVAC is compatible with low temperature district energy system. Lighting is efficient but not exemplary.*
- *Decentralized ventilation units may require extensive cleaning and maintenance program, and building skin geometry will require special considerations for glass cleaning.*
- *A well considered balance between initial costs and ongoing operations, maintenance and refurbishment costs provides sustainable economic viability.*

Inhabitant Wellbeing	Acceptable → Exceptional → Exemplary → Superlative
Air, Light, Fitness, Comfort, Mind*	■■■■■■■■■■■■■■■■□□

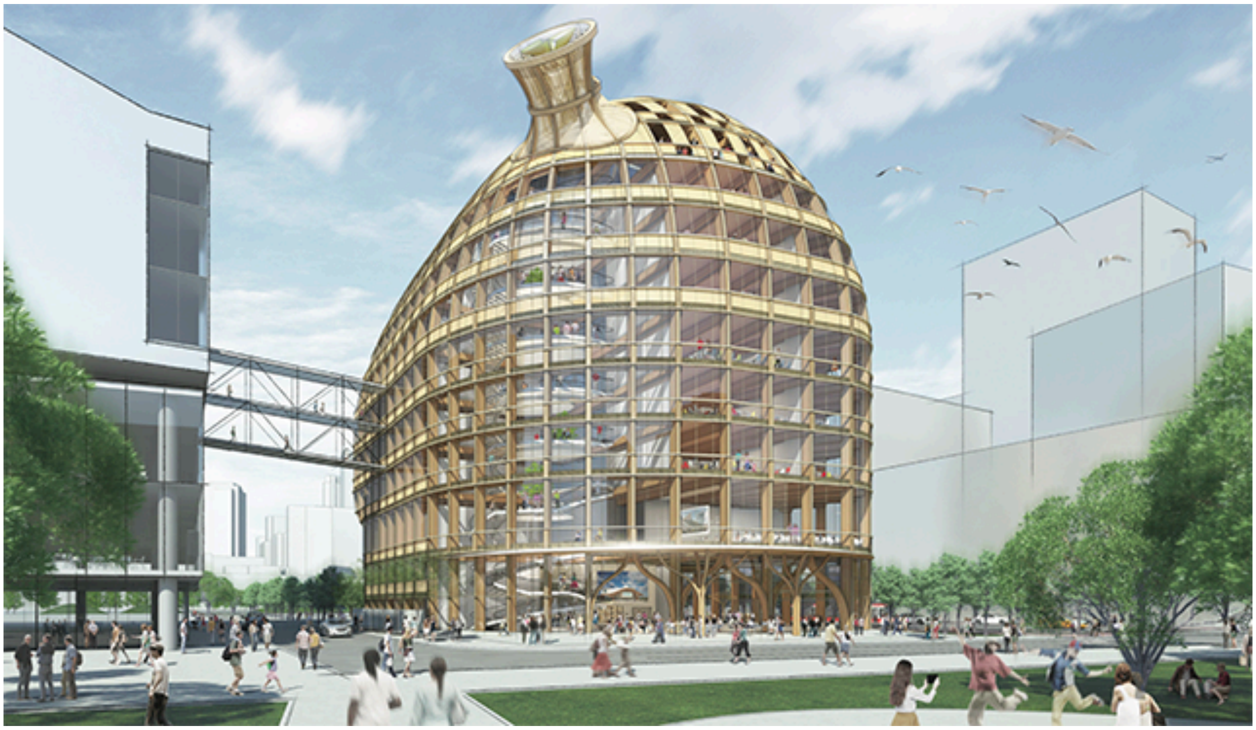
* Water and nourishment as positioned in the WELL Building Standard® are related to operational policy, not design.

Commentary:

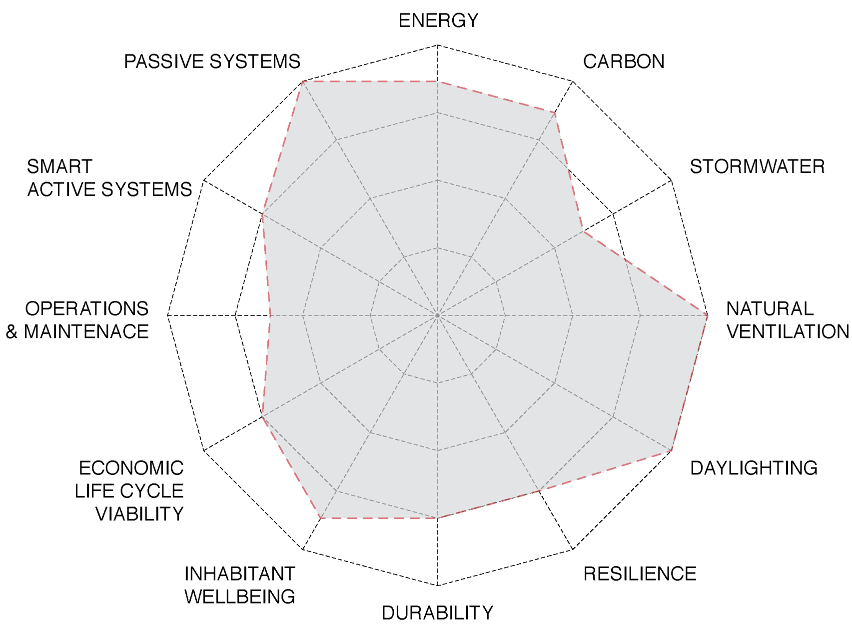
- *Design respects inhabitant access to daylight and air, and ability to control comfort conditions.*
- *Learning landscape, stairwell and generous views to the outdoors promote fitness and enhance mindful qualities.*

Summary

- ***Significant strengths*** *of this submission are: 1) a breathing building without ducts featuring demand-controlled and occupant-controlled hybrid ventilation strategy, coupled to low energy heating and cooling; 2) Durable, flexible and adaptable building armature that addresses futureproofing effectively; 3) massing, form, fabric and siting that are distinctive, environmentally performative and resilient; and 4) concrete core provides places of refuge during fires and/or extreme weather events coinciding with extended power outages.*
- ***Significant weaknesses*** *of this submission are: 1) decentralized ventilation units will require continuous cleaning, maintenance and periodic retrofitting; 2) special consideration required for exterior glass cleaning; 3) undifferentiated facade does not reinforce principles of bioclimatic design; and 4) site immediately surrounding the building does not provide pedestrian comfort and landscape amenity.*



Shigeru Ban Architects + Brook McIlroy Architects



SB + BM

M&T + AO Performance Summary

Moriyama & Teshima Architects + Acton Ostry Architects

Compulsory Elements		
Net-Positive, TGS Tier 4 Version 3, Green Roof Policy, LEED™ Gold Certification	Yes	**No**

Renewable Energy	
Total Project Energy Demand (kWh/year)	760,000
Renewable Energy Generation – Building Only (kWh/year)	420,000
Renewable Energy Generation – Enhanced (kWh/year)	N/A

Energy and Carbon	Target	Proposed/Enhanced
Total Project Site Energy Use Intensity (EUI)	65 kWh/m^2.year	49 kWh/m^2.year
Total Project Thermal Energy Demand Intensity (TEDI)	15 kWh/m^2.year	20 kWh/m^2.year
Total Project Greenhouse Gas Intensity (GHGI)	4 kg eCO_2/m^2.year	3.7 kg eCO_2/m^2.year
Passive Systems (Building Enclosure)	**Recommended**	**Proposed**
Overall Effective U-value (W/m^2.K)	0.75	0.775
Thermal Autonomy (% Passive <18^{o}C Heating/Cooling >25^{o}C)	> 35%	50%*

* Proponent's energy modelling methods and assumptions yield unrealistically high thermal autonomy rating (~ 40% max).

Commentary:

- *Building integrated photovoltaics cannot generate total energy demand. System designed to be net-zero positive ready.*
- *Method used for calculating TEDI yields value exceeding target which is met when mechanical ventilation excluded.*
- *Proposed design delivers thermal resilience, energy efficiency and reduced carbon footprint.*

Resilience & Sustainability	Acceptable → Exceptional → Exemplary → Superlative
Durability	■■■■■■■■■■■■■□□□□□
Future Proof & Resilience	■■■■■■■■■■■■■■■■□□
Passive Systems	■■■■■■■■■■■■■■■■□□
Smart Active Systems	■■■■■■■■■■■■■■□□□□
Economic Life Cycle Viability	■■■■■■■■■■■■■■■□□□

Commentary:

- *Major innovation – "Breathing Rooms" with hybrid ventilation systems + use of "wallumns" structural system.*
- *High performance facade reflects bioclimatic design principles and provides exceptional passive systems.*
- *Indicator lights nudge users to engage passive systems and also signal operation of smart active systems.*
- *Exposed structure and wood finishes will demand routine/ongoing inspection, cleaning, maintenance and refinishing.*
- *Tartan grid floor plan provides flexible and adaptable perimeter spaces but services accessibility is somewhat more restrictive than demising walls.*
- *Ground-source heat pumps are compatible with low carbon district energy system.*
- *HVAC is compatible with low temperature district energy system. Lighting is efficient but not exemplary.*
- *Solar chimneys rely on hallways as plenums for natural ventilation and will require special engineering design.*
- *Proven material, assembly and component strategies help manage risk of project cost overruns (value engineering) to ensure manageable operations, maintenance and refurbishment costs over the facility life cycle.*

Inhabitant Wellbeing	Acceptable → Exceptional → Exemplary → Superlative
Air, Light, Fitness, Comfort, Mind*	■■■■■■■■■■■■■□□□□□

* Water and nourishment as positioned in the WELL Building Standard® are related to operational policy, not design.

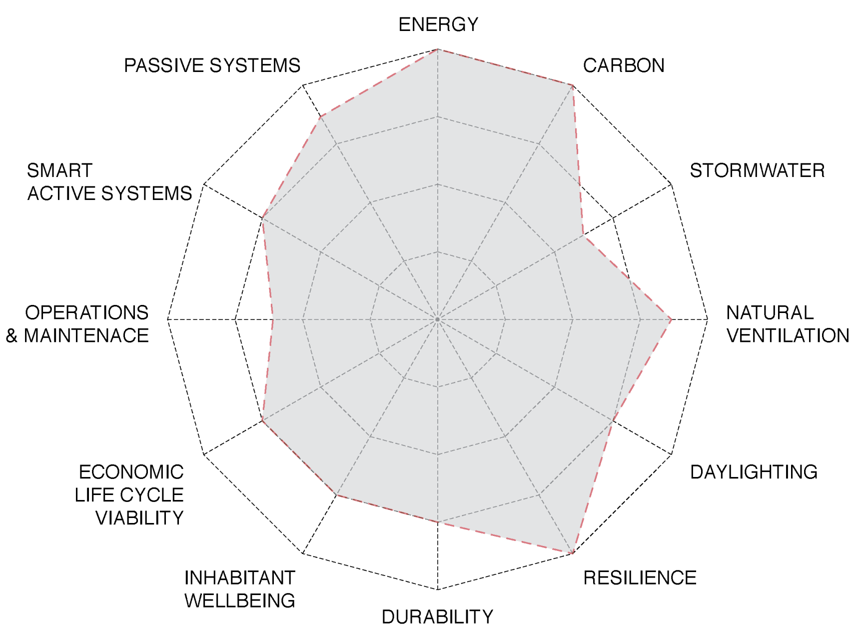
Commentary:

- *Perimeter zones are more privileged than core for inhabitant access to daylight and air, and ability to control comfort conditions.*
- *Daylighting and views throughout the learning landscape and Breathing Rooms contribute to mindful qualities, stairwell circulation encourages fitness.*

Summary

- ***Significant strengths** of this submission are: 1) "Breathing Rooms" provide healthful and mindful environments for recreation and respite; 2) Proven structural system and off-the-shelf enclosure technology increase economic feasibility and buildability of the project; 3) Dedicated outdoor air system with heat recovery enhances indoor air quality and energy efficiency; and 4) Expression of wood and different bioclimatic responses evidenced in facades are didactic.*
- ***Significant weaknesses** of this submission are: 1) exposed exterior wood finishes will require significant life cycle devotion; 2) occupied core areas do not privileged with the same environmental quality as perimeter zones; and 3) site immediately surrounding the building does not provide pedestrian comfort and landscape amenity.*

Moriyama & Teshima Architects + Acton Ostry Architects



M&T + AO

PA + MJMA Performance Summary

Patkau Architects + MJMA

Compulsory Elements		
Net-Positive, TGS Tier 4 Version 3, Green Roof Policy, LEED™ Gold Certification * Only if enhanced energy generation option is deployed.	**Yes***	No

Renewable Energy	
Total Project Energy Demand (kWh/year)	893,000
Renewable Energy Generation – Building Only (kWh/year)	427,000
Renewable Energy Generation – Enhanced (kWh/year)	908,000

Energy and Carbon	Target	Proposed/Enhanced
Total Project Site Energy Use Intensity (EUI)	65 kWh/m2.year	55 kWh/m2.year
Total Project Thermal Energy Demand Intensity (TEDI)	15 kWh/m2.year	53 kWh/m2.year
Total Project Greenhouse Gas Intensity (GHGI)	4 kg eCO_2 /m2.year	2.57 kg eCO_2 /m2.year
Passive Systems (Building Enclosure)	**Recommended**	**Proposed**
Overall Effective U-value (W/m2.K)	0.75	0.51
Thermal Autonomy (% Passive <18oC Heating/Cooling >25oC)	> 35%	35.7%

Commentary:

- *High performance opaque enclosure plus BIPV double-skin facade fulfill energy and carbon ambitions.*
- *Method used for calculating TEDI yields value exceeding target which is met when mechanical ventilation excluded.*
- *Overall effective U-value and thermal autonomy will provide an exceptional level of thermal resilience.*

Resilience & Sustainability	Acceptable → Exceptional → Exemplary → Superlative
Durability	■■■■■■■■■■■■■■■■■■
Future Proof & Resilience	■■■■■■■■■■■■■■■■□□
Passive Systems	■■■■■■■■■■■■■■■■■□
Smart Active Systems	■■■■■■■■■■■■■■■■□□
Economic Life Cycle Viability	■■■■■■■■■■■■■■■□□□

Commentary:

- *Major innovations – Bubble laminated timber (BLT), BIPV double-skin facade, radiant+acoustic wood ceiling*
- *Double-skin facade preserves opaque high-performance wood enclosure and provides reasonable protection against inboard glass breakage during extreme weather events.*
- *Smart active systems support hybrid ventilation strategy and free cooling.*
- *High level of durability for structure and enclosure contained within double-skin facade.*
- *Clear span structural system maintains flexible and adaptable spaces.*
- *Raised access floor system enhances futureproofing.*
- *Ground-source heat pumps HVAC system are compatible with district energy systems.*
- *Integrated visualization system promotes occupant engagement for maintaining facility performance.*
- *Robust and durable fabric, components and materials deliver lower life cycle operations, maintenance and refurbishment costs.*

Inhabitant Wellbeing	Acceptable → Exceptional → Exemplary → Superlative
Air, Light, Fitness, Comfort, Mind*	■■■■■■■■■■■■■■■■■□

* Water and nourishment as positioned in the WELL Building Standard® are related to operational policy, not design.

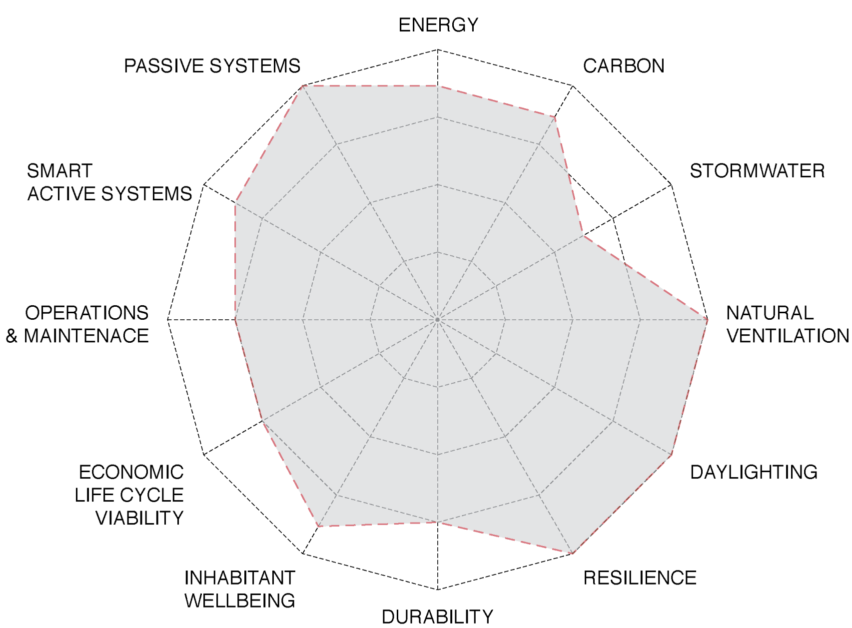
Commentary:

- *Winter garden and Children's garden provide year-round delight and respite during winter.*
- *Careful attention to material selection promotes superior indoor air quality.*
- *Dominant programming of perimeter zones enables majority of inhabitants to directly access daylight, views and air.*
- *Learning landscape is well integrated with vertical circulation, daylighting and natural ventilation.*

Summary

- ***Significant strengths** of this submission are: 1) exemplary energy and carbon performance; 2) highly visible demonstration of innovative mass timber technologies extensible to commercial and institutional building typologies; 3) robust and responsive high-performance enclosure with BIPV feature; 4) clear span structure renders a flexible and adaptable facility; 5) hybrid mass timber/concrete construction enhances resilience.*
- ***Significant weaknesses** of this submission are: 1) life cycle cost and performance of BIPV double-skin facade, including sloped roof glazing, is uncertain (cleaning, inspection/maintenance, repair and replacement); 2) stormwater management is not exemplary; and 3) landscaping of the site immediately surrounding the building does not address pedestrian comfort and social amenity.*

Patkau Architects + MJMA



PA + MJMA

PR + TF + A Performance Summary

Provencher Roy I Turner Fleischer I Arup

Compulsory Elements		
Net-Positive, TGS Tier 4 Version 3, Green Roof Policy, LEED™ Gold Certification	Yes	**No**

Renewable Energy	
Total Project Energy Demand (kWh/year)	987,200
Renewable Energy Generation – Building Only (kWh/year)	185,000
Renewable Energy Generation – Enhanced (kWh/year)	N/A

Energy and Carbon	Target	Proposed/Enhanced
Total Project Site Energy Use Intensity (EUI)	65 kWh/m².year	65 kWh/m².year
Total Project Thermal Energy Demand Intensity (TEDI)	15 kWh/m².year	15 kWh/m².year
Total Project Greenhouse Gas Intensity (GHGI)	4 kg eCO_2 /m².year	4 kg eCO_2 /m².year
Passive Systems (Building Enclosure)	**Recommended**	**Proposed**
Overall Effective U-value (W/m².K) * Double-skin facade U-value incorrect, actual U-value is higher.	0.75	0.30*
Thermal Autonomy (% Passive <18ºC Heating/Cooling >25ºC)	> 35%	20%

Commentary:

- *Renewable energy generation is lowest among all submissions, total energy demand is highest.*
- *Low TEDI value does not correlate with total project energy demand and should be checked.*
- *Thermal resilience of proposed design is not exemplary.*

Resilience & Sustainability

	Acceptable				→	Exceptional				→	Exemplary			→	Superlative			
Durability	■	■	■	■	■	■	■	■	■	■	■	■						
Future Proof & Resilience	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
Passive Systems	■	■	■	■	■	■	■	■	■	■	■	■	■					
Smart Active Systems	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Economic Life Cycle Viability	■	■	■	■	■	■	■	■	■	■	■	■	■					

Commentary:

- *Major innovation – Staggered truss structural strategy, atrium light shaft, microclimate landscape features, combined photovoltaic and thermal (PVT) panels.*
- *Passive operation of the double-skin facade is not clearly explained/depicted.*
- *Natural ventilation strategy and atrium aerodynamics not fully resolved.*
- *Smart building systems engage user participation to enable continuous performance improvement.*
- *Large staggered trusses provide flexible and adaptable spaces but the modular is correspondingly constrained.*
- *Ground-source heat pumps are compatible with low carbon district energy system.*
- *HVAC is conventional. Lighting is efficient but not exemplary.*
- *Long-term performance (reliability, maintenance, replacement) of building enclosure components (fluctuating facade, PVT panels, etc.) is not addressed.*
- *Energy, water and waste streams are well integrated.*

Inhabitant Wellbeing

	Acceptable				→	Exceptional				→	Exemplary			→	Superlative			
Air, Light, Fitness, Comfort, Mind*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

* Water and nourishment as positioned in the WELL Building Standard® are related to operational policy, not design.

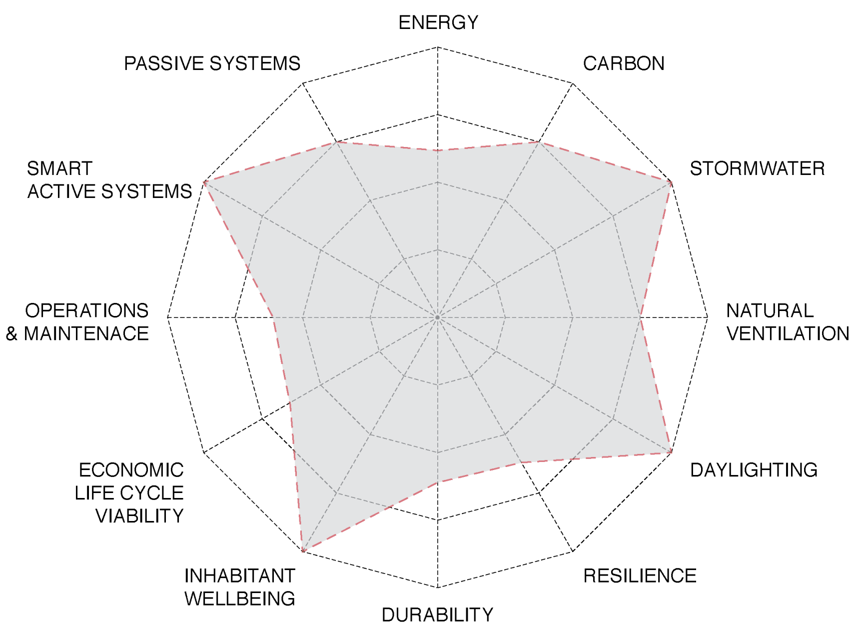
Commentary:

- *Atrium light shaft delivers daylighting to core spaces and is intended to serve as a natural ventilation plenum.*
- *Low carbon building materials contribute to improved indoor air quality.*
- *Microclimate landscape features and TWRI pods promote wellbeing, and provide year-round delight and respite during winter*

Summary

- ***Significant strengths*** *of this submission are: 1) Elegant integration of staggered truss structural system with atrium light shaft; 2) Responsive facade elements and innovative PVT panels; 3) smart active system strategy that engages occupants; and 4) microclimate landscape features and TWRI pods.*
- ***Significant weaknesses*** *of this submission are: 1) excessively glazed enclosure compromises thermal resilience; 2) incompletely resolved natural ventilation system integration with active systems; and 3) durability of innovative building enclosure components is largely unproven.*

Provencher Roy I Turner Fleischer I Arup



PR + TF + A

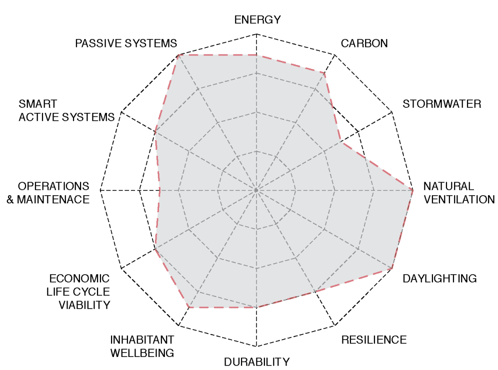
Sustainability Indicators Comparison

This section of the report provides two means of comparison for consideration by the competition jury when adjudicating the design proposals. The first is to compare the energy and carbon performance of the proposed designs. It should be noted that the building site and development envelope does not permit the installation of sufficient renewable energy generation technologies to achieve net-positive performance. Two of the design teams proposed enhanced renewable energy generation options that could easily be incorporated into any of the design proposals. The energy and carbon performance of the four design proposals may all be considered exceptional and it is anticipated that even further gains are achievable as the design development process proceeds.

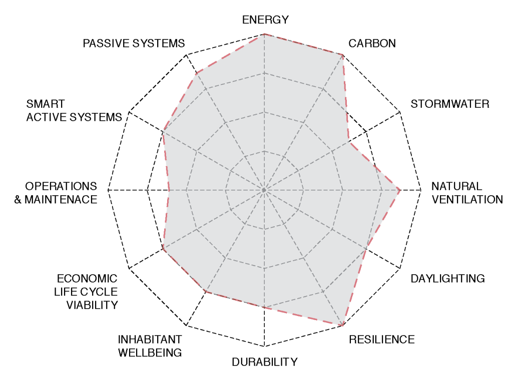
	Energy Use Intensity (ekWh/m^2.yr)	Thermal Energy Demand Intensity (ekWh/m^2.yr)	Greenhouse Gas Intensity (kg eCO_2/m^2.yr)	Sequestered Carbon (kg eCO_2)	Renewable Energy Generation (kWh/year)
SB + BM	47	37	2.1	4,179,164	372,682 / 826,169*
M&T + AO	49	20	3.7	8,005,000	420,000
PA + MJMA	55	53	2.6	5,699,000	427,000 / 908,000*
PR + TF + A	65	15**	4.0	4,810,000	185,000

* Only if the enhanced energy generation option is deployed.
*** Low TEDI value does not correlate with total project energy demand and should be checked.*

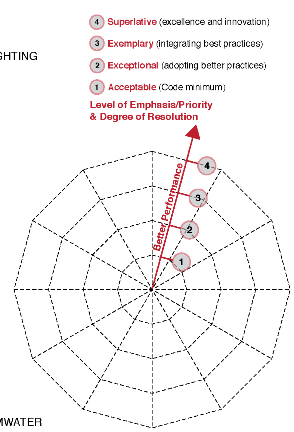
The second means of comparison between the four submissions was to visualize the emphases on key resilience and sustainability indicators inherent in each design. This was conducted by assigning a rank to each indicator as assessed by a review of the design drawings and narrative.

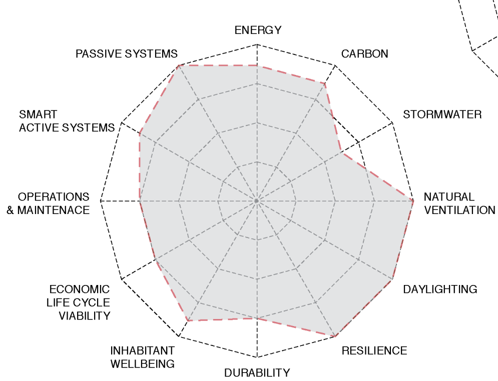


SB + BM

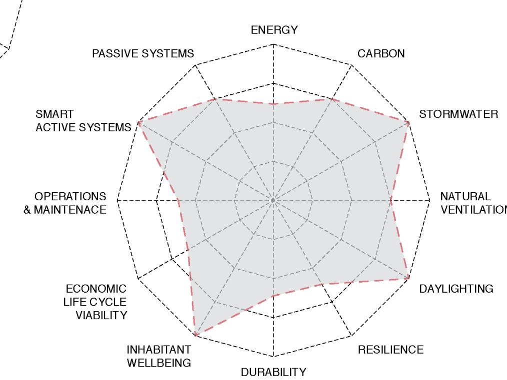


M&T + AO





PA + MJMA



PR + TF + A

Some of the larger and more complex issues associated with sustainability, as raised below, remain the purview of the design competition jury. This report is intended to serve as a reference document to inform a more holistic and overarching process of deliberation and adjudication.

Deja Vu? The future of the Toronto waterfront will likely be as unrecognizable as its past and The Arbour will soon be surrounded by evolving generations of buildings, infrastructure, digital technologies and new Canadians. Interestingly, heavy timber buildings dominated Toronto's mercantile and warehouse buildings during the 19th century. What have these historical buildings, many of which are still in service, taught us? Persistence through durability, flexibility and adaptability is key to resilient and sustainable architecture, and this is largely determined by the DNA of a building, and its ability to accommodate future, but unforeseeable, uses and modes of access/inhabitation.

City of Toronto Archives, Series 1465, File 364, Item 1

Leading Edge, Not Bleeding Edge. Canada's high carbon past could not imagine the Dockside technology and education hub that would follow during the early part of the 21st century. Will The Arbour project usher in a new era of net-positive energy and carbon neutral mass timber buildings? If the past is any indicator, the early precedents often establish the typologies that follow, proliferate and establish normative practices. A careful balance between technological innovation and constructor capability must be maintained so that the envisioned reach of The Arbour does not exceed the building industry's grasp.

Resilience and Sustainability Assessment Synopsis

This synopsis is not intended to compare the four design proposals, since as mentioned earlier there is no ranking possible when considering such a vast array of performance indicators with often incommensurable metrics (i.e., social, economic and environmental). Instead each major area of The Arbour Approach will be highlighted with a view to what can be learned from the submissions as a suite of ideas that are then synthesized from the perspective of innovation.

Low Carbon

The greatly reduced carbon footprint of the design proposals through renewable energy generation, energy efficiency measures, and material choices is remarkable, but the final design of The Arbour must ensure that inferior durability and functional obsolescence do not compromise life cycle performance through recurring embodied energy inputs. Robust finishes and looseness of fit as demonstrated in our most persistent Canadian buildings are key to a low carbon future.

Future Proofing and Building Resilience

Active systems come and go - the structure and building enclosure must endure the test of time. Future proofing is mostly about the ease and economy with which the retrofit of active system technologies can be woven back into the fabric of the building. Building resilience should focus on flood protection and natural disasters, as well as extended power outages during prolonged periods of extreme weather, hot or cold. The proposed designs offer exceptional future proofing and resilience measures and care must be exercised to ensure the building-as-a-system can be properly managed and operated to be fit for survival throughout its entire life cycle.

Net Positive

It has long been known that most commercial and institutional buildings taller than several storeys cannot generate sufficient renewable energy to meet their energy demands. Excellent strategies for net positive ready buildings, and for means of achieving net positive energy on site, have been advanced in the design proposals. Just as every building cannot come with its own hydroelectric dam, it may be more responsible and advantageous to harvest renewable energy distant from the building to feed the grid where it can offset carbon fuel generated electricity supply. A hybrid balance between energy autonomy and community energy systems may prove the best approach.

Smart

Can buildings be smarter than the people who endow them with their intelligence? It is possible than in the same way a lever was devised to provide a mechanical advantage by amplifying physical force, that smart sensors, controls and cybernetic algorithms may produce buildings more responsive than inhabitant demands. But it must be recognized that smart features can only achieve performance that is as good as what the building can deliver. Passive systems that operate manually in a failsafe mode should never be superseded by automatic systems that can malfunction or breakdown.

Innovation

Implicit in the notion of innovation is significantly improving on something that already works. Many innovations have been proposed in the submissions, but only those that have been tested and their performance measured should be given serious consideration. Laboratories and testing facilities, not construction sites, are the appropriate environments to develop innovation reliably.

Each submission holds the potential to be further developed and refined but they differ in their design emphases. Hence it is not only the evidence submitted, but also the promise embedded in each design proposition along with the past performance of the design team that need to be reconciled.

Appendix 1 – WELL Building Standard® Features Matrix

Pages 19 to 21 of the WELL Building Standard® have been excerpted below for convenient reference by the competition jury. The features listed as Preconditions under the New and Existing Buildings category all have to be achieved in order to obtain a Silver Certification. Note than many of the features are not associated with the design aspects and do not apply to this sustainability assessment.

WELL BUILDING STANDARD® FEATURES MATRIX

This table shows which features are Preconditions and Optimizations for the different project types of the standard for commercial and institutional offices. Refer to the tables in the beginning of each concept for details about the applicability of specific parts.

		Core and Shell	New and Existing Interiors	New and Existing Buildings
Air				
01	Air quality standards	P	P	P
02	Smoking ban	P	P	P
03	Ventilation effectiveness	P	P	P
04	VOC reduction	P	P	P
05	Air filtration	P	P	P
06	Microbe and mold control	P	P	P
07	Construction pollution management	P	P	P
08	Healthy entrance	P	O	P
09	Cleaning protocol		P	P
10	Pesticide management	P		P
11	Fundamental material safety	P	P	P
12	Moisture management	P		P
13	Air flush		O	O
14	Air infiltration management	O	O	O
15	Increased ventilation	O	O	O
16	Humidity control		O	O
17	Direct source ventilation	O	O	O
18	Air quality monitoring and feedback		O	O
19	Operable windows	O	O	O
20	Outdoor air systems	O	O	O
21	Displacement ventilation		O	O
22	Pest control		O	O
23	Advanced air purification	O	O	O
24	Combustion minimization	O	O	O
25	Toxic material reduction		O	O
26	Enhanced material safety		O	O
27	Antimicrobial activity for surfaces		O	O
28	Cleanable environment		O	O
29	Cleaning equipment		O	O
Water				
30	Fundamental water quality	P	P	P
31	Inorganic contaminants	P	P	P
32	Organic contaminants	P	P	P
33	Agricultural contaminants	P	P	P
34	Public water additives	P	P	P
35	Periodic water quality testing		O	O
36	Water treatment	O	O	O
37	Drinking water promotion	O	O	O

		Core and Shell	New and Existing Interiors	New and Existing Buildings
Nourishment				
38	Fruits and vegetables		P	P
39	Processed foods	P	P	P
40	Food allergies	P	P	P
41	Hand washing		P	P
42	Food contamination		P	P
43	Artificial ingredients	O	P	P
44	Nutritional information	O	P	P
45	Food advertising	O	P	P
46	Safe food preparation materials		O	O
47	Serving sizes		O	O
48	Special diets		O	O
49	Responsible food production		O	O
50	Food storage		O	O
51	Food production	O	O	O
52	Mindful eating	O	O	O
Light				
53	Visual lighting design		P	P
54	Circadian lighting design		P	P
55	Electric light glare control	P	P	P
56	Solar glare control	O	P	P
57	Low-glare workstation design		O	O
58	Color quality		O	O
59	Surface design		O	O
60	Automated shading and dimming controls		O	O
61	Right to light	O	O	O
62	Daylight modeling	O	O	O
63	Daylighting fenestration	O	O	O
Fitness				
64	Interior fitness circulation	P	O	P
65	Activity incentive programs		P	P
66	Structured fitness opportunities		O	O
67	Exterior active design	O	O	O
68	Physical activity spaces	O	O	O
69	Active transportation support	O	O	O
70	Fitness equipment	O	O	O
71	Active furnishings		O	O
Comfort				
72	Accessible design	P	P	P
73	Ergonomics: visual and physical		P	P
74	Exterior noise intrusion	P	O	P
75	Internally generated noise	O	P	P
76	Thermal comfort	P	P	P
77	Olfactory comfort		O	O
78	Reverberation time		O	O
79	Sound masking		O	O
80	Sound reducing surfaces		O	O
81	Sound barriers		O	O
82	Individual thermal control		O	O
83	Radiant thermal comfort	O	O	O

		Core and Shell	New and Existing Interiors	New and Existing Buildings
Mind				
84	Health and wellness awareness	P	P	P
85	Integrative design	P	P	P
86	Post-occupancy surveys		P	P
87	Beauty and design I	P	P	P
88	Biophilia I - qualitative	O	P	P
89	Adaptable spaces		O	O
90	Healthy sleep policy		O	O
91	Business travel		O	O
92	Building health policy		O	O
93	Workplace family support		O	O
94	Self-monitoring		O	O
95	Stress and addiction treatment		O	O
96	Altruism		O	O
97	Material transparency	O	O	O
98	Organizational transparency		O	O
99	Beauty and design II	O	O	O
100	Biophilia II - quantitative	O	O	O
Innovation				
101	Innovation I	O	O	O
102	Innovation II	O	O	O
103	Innovation III	O	O	O
104	Innovation IV	O	O	O
105	Innovation V	O	O	O

The Arbour. Ontario's ground zero for mass timber buildings will represent the first seed planted in Toronto's waterfront and hopefully the harbinger of a built environment based on the sustainable management of renewable resources.

Fallen Toronto. What people fear will happen if we fail to responsibly address the challenges of climate change and take the path towards sustainable development