SUSTAINABLE BUILDING DESIGN STANDARDS

Comprehensive Study

December 2018

Prepared for

Campus & Facilities Planning, UTSG

By

Christopher Ford
Etiosa Igbinakenzua
Junior Osei Wireko
Mbonella Phiri-Nkomo

UNIVERSITY OF TORONTO

Table of Contents

Executive Summary

The University of Toronto Campus & Facilities Planning division is interested in finding opportunities for leadership in designing and building more sustainable buildings at the downtown St. George campus. An update was drafted in 2011 to its institutional design standards mandating buildings be designed to and certified to Leadership in Energy and Environmental Design for New Construction (LEED-NC) Silver at minimum, based on a benchmarking exercise identifying LEED point opportunities from compliance with the Toronto Green Development Standards, or Toronto Green Standards (TGS). Since this update, both LEED-NC and TGS have undergone content updates, and thus the draft update requires re-examination.

The study first examines the University of Toronto St. George Campus' (UTSG) performance in sustainable building design and construction by an exploration of institutional design standards at peer universities in Canada. LEED certification is found to be the common measure of sustainable building performance across peer universities, with all peer universities already having a mandate of designing to at least LEED silver at a minimum, and some LEED Gold at a minimum. However, the largest proportion of the sustainable building stock among peers currently consists of LEED Gold certified buildings. UTSG is not among the leading universities for sustainable building performance.

The study also performs a comparison of five sustainable building assessment systems available in the market, identifying that LEED and TGS are largely focused on enabling environmental impacts, versus social and economic impacts, and that sustainable building assessment systems have largely focused on relative performance, i.e. performing better than the average building, instead of absolute performance. In other words, they have largely focused on outcomes which simply mitigate negative impacts versus regenerative or net-positive outcomes. Several common and unique indicators were identified to highlight areas of potential leadership.

Based on the above and on a repetition of the benchmarking exercise performed in 2011, the study argues (1) that UTSG should commit to LEED Gold certification at a minimum for new construction and major renovations, (2) that compliance with Tier 3 or 4 can provide an opportunity for achieving many of the LEED points required for Gold certification, and can yield a number of benefits including reducing future policy risk and financial incentives, and (3) indicators with social or economic impacts should be prioritized for further leadership in sustainable building design.

Project Background

Introduction

As part of the requirements for ENV461/1103, "University of Toronto as a living lab of sustainability," the authors were paired with a client who is internal to the University of Toronto to complete a pre-identified project. The client, Campus and Facilities Planning (CFP) at the University of Toronto, is interested in finding ways to design more sustainable buildings.

With the growing understanding of the impacts of mainstream building design for human and environmental health and wellbeing, the concept of sustainable building design has arisen as "a conscious reaction to the consequences of unsustainable practices" (McLennan, 2004). Design standards which incorporate a wide range of sustainability considerations can contribute positively to human and environmental health & wellbeing, including habitat, in addition to a wide array of positive economic impacts. CFP has thus identified a need to complete a comprehensive review of its existing design standards to identify outdated compliance with established municipal policy on sustainable design and opportunities for leadership in sustainable design. Specifically, these standards will apply to planning, design, construction and performance of new buildings, or major renovations, at the University of Toronto St. George campus (UTSG).

The University of Toronto

The University of Toronto (UofT) was founded in 1827 and is Canada's largest post-secondary institution by enrolment. According to statistics from the 2017-2018 academic year, UofT hosts 90,077 students and 21,556 faculty and staff members across its three campuses in Mississauga (UTM), Scarborough (UTSC), and downtown Toronto (UTSG). 61,339 of these students - 43,820 undergraduate and 17,519 graduate - are enrolled at the UTSG campus (University of Toronto, n.d.-a). According to its mission statement, UofT is "is committed to being an internationally significant research university, with undergraduate, graduate and professional programs of excellent quality" (University of Toronto, n.d.-d). Its motto is *velut arbor ævo*, or "as a tree through the ages."

According to the University Ranking by Academic Performance, UofT is ranked the second best research university in the world behind Harvard University, and has held this ranking since 2012 (University Ranking by Academic Performance, 2018). The 2019 Times Higher Education World University Ranking places UofT as the top university in Canada, 16th in North America, and 21st in the world overall (Times Higher Education, 2018).

UofT has made several formal commitments to sustainability as an institution. UofT's Environmental Protection Policy was first approved in March 1994, and describes their commitment to:

- *Meet and, where reasonably possible, exceed compliance with applicable federal, provincial and local environmental regulations and other requirements to which the University subscribes*

- *Operate so as to minimize negative impacts on the environment*
- *Adopt practices that reflect the conservation and wise use of natural resources*
- *Respect biodiversity* (University of Toronto, 2010).

In November 2009, then-UofT President Dr. David Naylor was signatory to a pledge from the Council of Ontario Universities, stating the university community's recognition of global challenges arising from climate change and environmental degradation, and committing to working together towards a greener world. Related specifically to buildings, the pledge called for cooperation to "build new facilities in accordance with principles of sustainability and energy efficiency" and to "renovate existing facilities to improve energy efficiency and reduce waste" (Council of Ontario Universities, 2009).

In 2017, UofT President Professor Meric Gertler established the Presidential Advisory Committee on the Environment, Climate Change and Sustainability, which is mandated to find ways for the university to "advance…[its] contribution to meeting the challenge of climate change and sustainability" (Gertler, 2017). University operations and innovation were two particular areas of focus in this regard.

UofT is also a member of the University Climate Change Coalition, or UC3, which is a coalition of 18 leading North American universities formed in February 2018 with the stated mission of "leveraging their [coalition members] institutional strengths as leading research institutions to foster a robust exchange of best practices and lessons learned in pursuit of accelerating local climate solutions that reduce greenhouse emissions and build community resilience" (Second Nature, 2018).

University of Toronto Design Standards

UofT has incorporated criteria related to environmental sustainability into its design standards. The UofT Design Standards consist of two parts, with Part One dealing with "safety requirements, accessibility concerns and general design issues" (University of Toronto, n.d.-b) and Part Two dealing with "products and methodologies used in construction" (University of Toronto, n.d.-c). As our analysis is concerned with more general design requirements for sustainability, it will focus specifically on Part One of the Design Standards, specifically section 5 of Part One.

Section 5, "Environment," was identified by the client as the area of focus for this analysis. This section outlines specific requirements related to energy and water use, materials, emissions & pollution, outdoor environment, and waste. A draft revision to this section was performed in 2011, which recommended that new construction be designed to meet the Toronto Green Standards, Tier 1, Version 1, and the Leadership in Energy and Environmental Design Standards for New Construction (LEED-NC) Silver rating, Version 1, at a minimum, with specific requirements for achieving LEED-NC credits. The draft revision is available in Appendix A. This update however is still in its draft form and has not been approved through the University of Toronto governance process.

Since drafting this update, both LEED and the Toronto Green Standards (TGS), have released newer versions. The most current versions of LEED-NC and TGS as of October 2018 are versions 4 and 3 respectively, and thus this draft is no longer timely.

Objectives

The core objectives of the project are as follows: (1) to ensure compliance with the Toronto Green Standards (TGS) Tier 1, that UTSG is required to adhere to; (2) identify 'low-hanging fruit,' or items which can quickly and easily be incorporated into the environmental design standards; and (3) identify long-term opportunities for UTSG to become a leader in sustainable building design and construction. To explore these goals, our team developed three key questions to guide our research process:

1. How is 'sustainable building design' defined in the literature?
2. How do peer universities define sustainable building performance, and how does UTSG perform in comparison with its peers?
3. What are some key opportunities for leadership in sustainable building design for UofT?

Sustainability & Buildings: A Literature Review

The term sustainability arose out of the World Commission on the Environment and Development Report published in 1987, known commonly as the Brundtland Report after Commission Chair and former Norwegian Prime Minister Gro Harlem Brundtland. The Report published its definition of sustainable development in 1987 as "development that meets the needs of today without compromising the needs of future generations" (WCED, 1987, p. 46). This report, which describes the immense challenges facing the world due to poverty and environmental degradation, describes sustainable development as the path forward. The concept evolved from growing public discourse and concern on biophysical limits and environmental degradation, including Carson's 1962 *Silent Spring* (R. C. Hill & Bowen, 1997).

Since the Brundtland Report, buildings have been a prominent feature of the discussion on sustainability. Buildings are, on the one hand, centres for human activity, centres for culture, and important contributors to economic prosperity, both as places of business and as the key output of the construction industry (Spence & Mulligan, 1995). However, on the other, buildings are also significant users of energy, water, renewable and non-renewable resources, and can result in permanent destruction of ecosystems (Spence & Mulligan, 1995). This dual nature of buildings has led to the concept of sustainable building, which is both a recognition of the important role buildings play in human prosperity and a call to action to build buildings better, as "it does not need to be assumed that future construction will inevitably continue present patterns" (Spence & Mulligan, 1995, p. 281).

The first use of the concept of sustainable buildings was shared at the First International Conference of CIB TG 16 on Sustainable Construction in November 1994, in Tampa, Florida, by Dr. C. J. Kibert as 'sustainable construction.' Kibert stated the object of sustainable construction as being "the creation and responsible management of a healthy built environment based on resource efficient and ecological principles" (Kibert, 1994). Indeed, much of the literature on sustainable construction and sustainable building has since focused on resource efficiency and primarily environmental impacts, with the terms 'green building' and 'high-performance building' often being used synonymously with sustainable building (Zuo, Jin, & Flynn, 2012; Zuo & Zhao, 2014). Life cycle thinking has additionally become an integral part of the conversation on sustainable buildings, which facilitates building professionals to consider their impacts beyond the construction phase. For example, instead of looking simply at energy use in the operation phase of a building, life cycle thinking would encourage considering energy use in the planning, construction, operation, and demolition phases, in addition to transporting materials to and from the building site (Adalberth, 1997).

Sustainable building assessment systems (SBAS) have arisen as tools developed by and for industry to assist in both applying these concepts in the design and planning phases as well as measuring building performance. Their ability to consolidate and simplify a broad range of research as well as bring project teams and stakeholders together in conversation about how to make buildings better makes them significant in their implications for furthering sustainable building practice (Raymond J. Cole, 1999; Zuo et al., 2012; Zuo & Zhao, 2014; Awadh, 2017).

As a result, SBAS generally reflect the literature on sustainable buildings, and have also largely focused on environmental impacts of buildings. This is evidenced by the synonymous use of 'green building assessment systems' with SBAS. Social and economic impacts have received more attention over the past decade, with emerging approaches attempting to incorporate the use of quantitative measures of happiness or productivity, for example, in addition to qualitative measures to measure social and economic impacts (Zuo & Zhao, 2014; Stender & Walter, 2018).

These market-based solutions often have an accompanying certification, which allows developers or building occupants to showcase their commitment to sustainability. Aside from brand impacts, this can often allow developers or owners to obtain premiums on building sale prices or rent prices (Eichholtz, Kok, & Quigley, 2013).

SBAS have received a number of critiques, including for adding additional costs to projects, which may already have some additional upfront costs, and for the demanding nature of the documentation requirements (Rasekh & McCarthy, 2016). In addition, major critiques of SBAS surrounds their intended outcomes, or intent (Raymond J. Cole, 1999), and their focus on single buildings. Regarding the former, as Conte (2018) describes, sustainable building has been reduced simply to 'greening' – that is, in addition to being focused on environmental impacts, sustainable building has largely focused on simply creating buildings that perform better than the existing standard building, rather than absolute terms (Conte, 2018). Emergent regenerative or net-positive approaches have sought to raise the bar on sustainable building performance – for example, rather than buildings which simply use less energy than their peers, buildings can produce and store energy enough onsite to cover its needs, and supplement the grid in times of peak demand (R. J. Cole & Kashkooli, 2013). The Living Future Institute's Living Building Challenge, which will be explored in this study, is one example of a new SBAS which attempts to incorporate regenerative design into its requirements. For the latter, LEED has attempted to combat this through their neighborhood development certification. Research performed through the University of British Columbia Regenerative Neighborhoods Project examines the incorporation of both concepts into designing net-positive or regenerative neighborhoods (Waldron & Miller, 2013).

In addition, Robinson and Cole (2015) describe the difference between regenerative development and design and regenerative sustainability, the former which views net-positive outcomes in absolute terms and achievable through prescribed processes, and the later which is a procedural approach "rooted in an understanding of reality…as contested and socially constructed" (Robinson & Cole, 2015).

Methodology

To meet our objectives, the project was undertaken in two core phases: Phase I - Market Research, and Phase II - Benchmarking.

Market Research

Peer Universities

In the first part of Phase I, we will compare the University of Toronto's sustainable building performance against peer universities. In order to define 'peer' universities and develop a sample to compare to, the authors identified two core dimensions: (1) sustainability performance and reputation, and (2) overall reputation and global ranking. In short, since UofT aspires to be (and has been recognized as) the leading Canadian university, we assumed that our sample should focus on those universities who are highest ranked in terms of both sustainability and overall reputation. Due to the limited project time frame, we limited our selection to Canadian universities only.

To identify our sample population, we used the Sustainability Tracking, Assessment & Rating System™ (STARS) to identify the top-ranking universities in Canada for sustainability and the 2019 Times Higher Education (THE) Rankings to identify top-ranking universities overall. We then cross referenced the two lists to identify the highest-ranking universities in both lists.

Through this process, we identified the University of Western Ontario (London, ON), McGill University (Montreal, QC), the University of British Columbia (Vancouver, BC), Dalhousie University (Halifax, NS), the University of Victoria (Victoria, BC), the University of Calgary (Calgary, AB), and the University of Alberta (Edmonton, AB) as both leaders in sustainability and highly regarded Canadian institutions. We collected qualitative data on institutional design standards, focusing on answering the question, *Does your campus have green building standards for new builds or major renovations?,* and quantitative data on the number of sustainable buildings built to date on each university campus, as denoted by a third-party certification for sustainability such as LEED. We also performed informal interviews with representatives from the selected universities to verify and comment on the data collected from STARS.

Sustainable Building Assessment Systems

Secondly for Phase I, we perform research on available sustainable building assessment systems (SBAS) in the Canadian marketplace and perform a high-level qualitative comparison in order to identify core areas of leadership for UofT in sustainable building design. Based on our literature review, SBAS are not only commonly-used industry tools to guide building design and measure performance using sustainability criteria, but they are also generally representative of the literature on sustainable buildings (Zuo & Zhao, 2014). Their requirements also have the added benefit of facilitating stakeholder consultation and collaboration at the design and planning stage (Zuo, Jin, & Flynn, 2012).

Our high-level comparison will be performed along three dimensions: (1) impacts, (2) indicators, and (3) intent. The first of these entails assigning individual SBAS requirements or credit areas to one or more of the three pillars of sustainability - the economy, the environment, and society - based on their potential impacts. This methodology is established in Awadh (2017), however we will be adapting it by allowing requirements or credit areas to be assigned to more than one pillar of sustainability. The second, comparison by indicators, will examine whether specific indicators of sustainable buildings are present in each SBAS. This comparison replicates in part a method used in Castro et al. (2015), which generated a set of indicators based on the examined SBAS from the study in addition to using pre-established indicators for sustainable construction and sustainable buildings from the International Organization for Standardization (ISO) and the European Commission for Standardization (CEN). We are limiting the scope of our comparison solely to ISO indicators. Lastly, comparison by intent examines the goal of each SBAS, or in other words how it defines sustainable buildings performance. Both Cole (1999) and Conte (2018) discuss the significance of intent in terms of long-term impacts - for example, aiming to mitigate impacts or to simply perform better than peers is likely to have limited impacts, setting the bar much lower than, perhaps, an aspiration towards positive or regenerative outcomes (Raymond J. Cole, 1999; Conte, 2018).

Leadership in Energy and Environmental Design (LEED) and the Toronto Green Standards (TGS) were identified as areas of focus due to the high market penetration of LEED and the obligation to abide by TGS Tier 1. In addition, we identified Active House, the WELL Building Standard, and the Living Building Challenge to use in our comparison. We would like to thank our client for their guidance in selecting SBAS to compare. The number of SBAS examined were limited due to time constraints.

Benchmarking

In Phase II, we perform a benchmarking exercise to provide specific recommendations for improving the existing UofT design standards. We provide a more in-depth comparison of TGS and LEED in order to identify compatible requirements - in other words, areas of compliance within TGS which can also result in LEED points. The client conducted this benchmarking exercise in 2010 which culminated in the 2011 draft update to the Environment section of the UofT design standards. As discussed above, TGS and LEED have both been updated since this exercise, and thus it is significant for us to identify compatible requirements among the new iterations of the two SBAS.

Findings & Discussion

Peer Universities

Profiles of Peer Universities

University of Western Ontario (London, ON). The University of Western Ontario has a student population of 34,055 and is ranked eighth on the THE ranking, and rated Gold on STARS. Western has established guidelines based on LEED, but other types of measures are used. As a baseline at Western University, all buildings must meet LEED Silver at minimum. Western currently has 13 LEED certified buildings, 1 platinum, 8 gold, and 4 silver (Association for the Advancement of Sustainability in Higher Education (AASHE), n.d.; Cano, 2018).

McGill University (Montreal, QC).[1] McGill University has a student population of 36,381 and is ranked 3rd on the THE ranking, and Gold on STARS. Its green building standards incorporate LEED and aim to achieve at least LEED Silver. McGill currently has 1 LEED Gold certified building (Association for the Advancement of Sustainability in Higher Education (AASHE), n.d.).

University of British Columbia (Vancouver, BC). The University of British Columbia (UBC) has a population of 43,509 and is ranked 2nd according to the THE ranking, and Gold on STARS. UBC aspires to LEED gold, and in 2013 designed an internal LEED Implementation Guide. This guide is used primarily for non-residential buildings while its Residential Environmental Assessment Program (REAP) is used for residential buildings. UBC currently has 19 LEED certified buildings, 2 platinum, 16 gold, and 1 silver (Association for the Advancement of Sustainability in Higher Education (AASHE), n.d.; Montgomery, 2018).

Dalhousie University (Halifax, NS). Dalhousie University has a population of 18,824 and is ranked 11th on the THE, and Gold on STARS. Dalhousie's standards commit to building new facilities to LEED gold or higher. Dalhousie University currently has 5 certified buildings 3 silver 2 gold and 4 in the process of certification to gold or platinum (Association for the Advancement of Sustainability in Higher Education (AASHE), n.d.; Owen, 2018).

University of Victoria (Victoria, BC). University of Victoria has a population of 21,696 and is ranked 15th on times higher education ranking. Victoria has a gold rating on STARS and is required to "achieve the standard of LEED Gold or equivalent certification" and "utilize sustainable green building practices for all projects that are below the threshold for mandatory LEED Gold or equivalent certification." Victoria currently has 6 LEED certified buildings which are all gold (Association for the Advancement of Sustainability in Higher Education (AASHE), n.d.).[2]

University of Calgary (Calgary, AB). University of Calgary has a population of 30,004 and is ranked 9th on times higher education ranking. Calgary has a gold rating on STARS and builds

[1] A representative could not be reached for an interview to verify that this information is updated and correct.
[2] ""

to a Calgary High Performance Green Building Standard and has 11 LEED certified projects at the University of Calgary, 2 platinum, 6 gold, and 3 silver, with another 5 major projects currently pursuing LEED certification (Association for the Advancement of Sustainability in Higher Education (AASHE), n.d.; Stoker, 2018),

University of Alberta (Edmonton, AB). University of Alberta has a population of 36,846 and is ranked 6th on times higher education ranking. Alberta had a gold rating on STARS and it does not have a set design standard for the school but is required to build to LEED silver if the building is government funded. Otherwise, the University of Alberta designs using green globes standards. University of Alberta currently has 7 LEED certified buildings 3 silver and 4 gold (Association for the Advancement of Sustainability in Higher Education (AASHE), n.d.; Hall, 2018).

Sustainable Design Standards Comparison

Based on information available on STARS and interviews with representatives from peer universities, each of the examined universities possess institutional standards for new builds and major renovations, except for the University of Alberta whose standards are currently in development. In addition, it became clear that LEED is widely used both as a common measure of sustainable building performance and as incorporated into many institutional design standards at peer universities in Canada. Each of the existing standards incorporated LEED in some way, with the standards at Western, McGill, and Calgary including a commitment to designing to LEED Silver at a minimum. Institutional standards at UBC, Victoria, and Dalhousie mandate designing to LEED Gold at a minimum. By comparison, UTSG's draft standards, which are used currently as a guideline, mandate LEED Silver certification at a minimum.[3]

[3] This study was unable to conclusively answer the question of how many universities require certification and how many do not, and thus this discussion is not included in this section.

Figure 1. LEED as a common measure of sustainability

	MCGILL	UTSG	DALHOUSIE	VICTORIA	ALBERTA	CALGARY	WESTERN	UBC
Standards for New Builds / Major Renovations?	Yes	Yes	Yes	Yes	No - In Progress	Yes	Yes	Yes
Incorporation of LEED in Standards?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Minimum Requirements	Silver	Silver	Gold	Gold	Silver (Alberta Government Standard)	Silver	Silver	Gold

Sustainable Buildings Performance Comparison

Understanding LEED as a commonly used building assessment system and measure of sustainable building performance among Canadian universities, we can use the quantity and level of certified buildings to benchmark UTSG's sustainable buildings performance against its peers. In general, in comparison to peer universities in our sample, UTSG is not currently the leader for sustainable buildings.

Quantity of LEED certified buildings. In Figure 2, we show the total number of LEED buildings at each university, along with the level of LEED certification attained. UBC has the highest number of LEED certified buildings with 19. Inversely, UTSG currently is home to 4 certified buildings, having only more buildings than McGill University. Including UofT's other two campuses in the comparison, UTSG is the largest campus by both population and surface area yet has fewer LEED certified buildings than UTM. UTSC has two fewer LEED certified buildings than UTSG.

Students per LEED building. Assuming student population to be a proxy for both revenue and appetite for new buildings, one might assume that larger universities may have the ability and the need to build more sustainable buildings. Controlling for size in comparing the quantity of LEED certified buildings is thus important. In this comparison, which can be seen in Figure 3, UBC is again the leader, with a students per LEED building ratio of 2,290. UTSG by comparison has a students per LEED building ratio of 15,335, beating out only McGill University.

Level of LEED Certification. To show a better representation of the certification level of each building we created a points system using the maximum amount of points attainable for each level of LEED certification over the total number of possible attainable points for LEED. That is, silver is 59/110 which 0.54 of a point, gold is 79/110 which is 0.72 of a point, and platinum is 110/110 which is 1 point.

Figure 2. Quantity and Level of LEED Certified Buildings

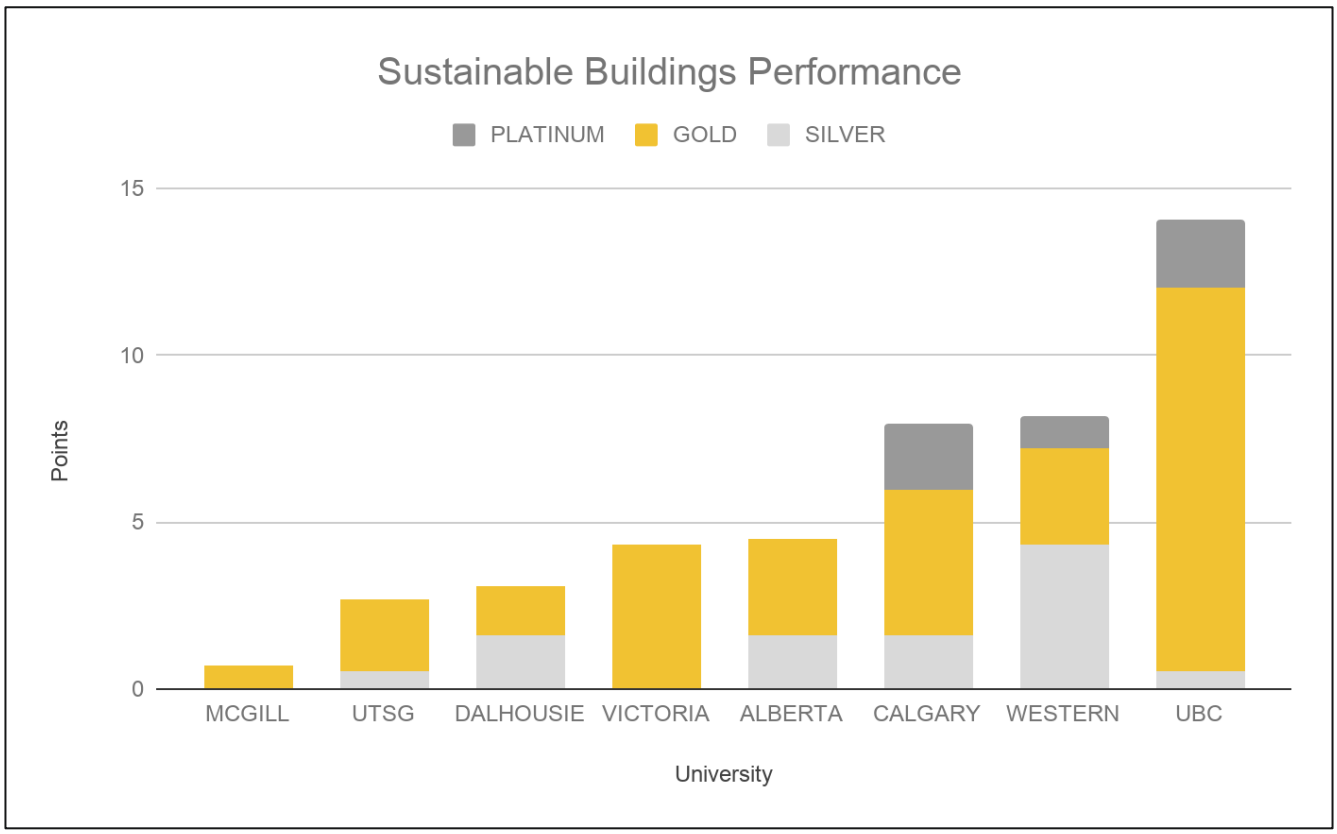
	MCGILL	UTSC	UTSG	DALHOUSIE	UTM	VICTORIA	ALBERTA	CALGARY	WESTERN	UBC
PLATINUM								2	1	2
GOLD	1	2	3	2	2	6	4	6	4	16
SILVER			1	3	3		3	3	8	1
TOTAL	1	2	4	5	5	6	7	11	13	19

Figure 3. Quantity of Students Per LEED Certified Building

	MCGILL	UTSC	UTSG	DALHOUSIE	UTM	VICTORIA	ALBERTA	CALGARY	WESTERN	UBC
Total LEED Buildings	1	2	4	5	5	6	7	11	13	19
Population	36,381	13,853	61,339	18,824	14,885	21,696	36,846	30,004	34,055	43,509
Students per LEED Building	36,381	6,927	15,335	3,765	2,977	3,616	5,264	2,728	2,620	2,290

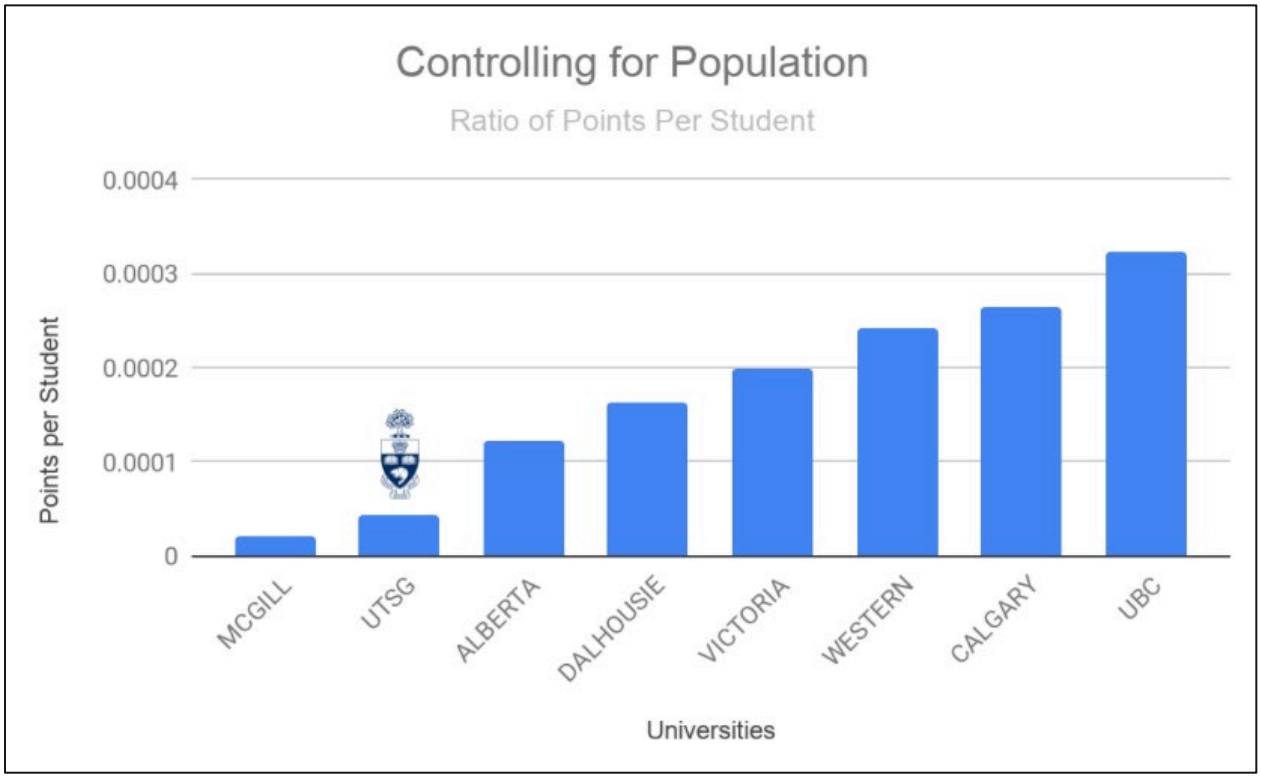
Our points system shows that UTSG has 2.7 points and UBC the leading school in sustainable building performance has 14.06 points. This shows that UofT is 11.36 points behind UBC. Our initial analysis shows Dalhousie and McGill as the only two schools ranked close to UofT with Dalhousie having 3.06 points and McGill at the bottom of the pack with 0.72 of a point.

Figure 4. Sustainable Buildings Performance Points



Controlling for University Size. To again control for university size, our second analysis divided each university's score by its student population to attain a ratio of points per student. In this case population acts as a proxy for size, with greater student population brings a higher demand for spaces to study, eat and live. Our second analysis saw UofT move to the second least performing university, with six of the eight universities ranking higher. Dalhousie the school that was ranked right ahead of UofT moves a spot higher and Alberta the school that replaces Dalhousie is almost double that of UofT in this performance analysis. McGill University remains the lowest ranked University and UBC remained atop performing nearly ten-times better than UofT. Calgary, Victoria and Western are all nearly equal and are all performing more than three-times better than UofT. (Figure 5) It should be noted that Calgary does surpass Western once population is considered.

Figure 5. Sustainable Buildings Performance Points Per Student



Discussion

In general, LEED is a commonly used measure of sustainable building performance among peer universities, and based on this measure, UTSG is not currently among the top performers in Canada for sustainable building design. Most universities already require building to LEED Silver at a minimum, however in practice most sustainable buildings among peer universities are built to LEED Gold. Committing to build to LEED Gold at a minimum is a key leadership opportunity for UTSG.

Benchmarking

As stated in the methodology section of this report, the University of Toronto is required to comply with TGS tier 1 at a minimum. Based on work performed by our client to prepare the 2011 draft update to the existing design standards, we know that there is compatibility between the requirements of the TGS and requirements of LEED – in other words, TGS compliance provides opportunities for LEED credits

Features of TGS Compatible with LEED. Figure 6 below highlights the specific LEED credits that, based on our analysis, are compatible with the related TGS requirements, as well as the estimated points from compliance at each Tier. TGS is a cumulative standard, meaning that each Tier requires compliance with its own requirements as well as the requirements of the Tier(s) before it. Therefore, any possible points obtained from compliance in a lower Tier will also be applicable for higher Tiers.

Figure 6. LEED Points available from TGS Compliance

LEED-NC (V4)			TGS (V3)				
Category	**Credit**		**TIER 1**	**TIER 2**	**TIER 3**	**TIER 4**	***Related TGDS Requirement***
Minimum Program Requirements (MPR)		**R**					
Prereq	Must be in a permanent location on existing land	R					*Exclusive to LEED*
Prereq	Must comply with project size requirements	R					*Exclusive to LEED*
Prereq	Must use reasonable LEED boundaries	R					*Exclusive to LEED*
Integrative Process Credit		**1**					
Credit	Integrative Process Credit	1					*Exclusive to LEED*
Location & Transportation (LT)		**16**					
Credit	LEED Neighbourhood Development location (Up to 16 pts)	16					*Exclusive to LEED*
OR							
Credit	Access to quality transit	5					*Exclusive to LEED*
Credit	Bicycle facilities	1	1	1	1	1	Tier 1 Requirements: AQ 2.2 Long-term Bicycle Parking Location, AQ 2.2 Long-term Bicycle Parking Location, AQ 2.3 Short-term Bicycle Parking Location, and AQ 2.4 Shower and Change Facilities Tier 2 Requirements: AQ 2.5 Bicycle Parking Rates (Optional); AQ 2.6 Publicly Accessible Bicycle Parking (Optional); AQ 2.7 Bicycle Shelter (Optional)
Credit	Green Vehicles	1	1	1	1	1	Tier 1 Requirements: AQ 1.3 Electric Vehicle Infrastructure Tier 2 Requirements: AQ 1.5 Electric Vehicle Infrastructure (Optional)
Credit	High Priority sites	2					*Exclusive to LEED*

Figure 6. LEED Points available from TGS Compliance

LEED-NC (V4)			TGS (V3)				
Category	**Credit**		**TIER 1**	**TIER 2**	**TIER 3**	**TIER 4**	***Related TGDS Requirement***
Credit	Reduced parking footprint	1	1	1	1	1	Tier 1 Requirements: AQ 1.1, 1.2 Tier 2 Requirements: AQ 1.4
Credit	Sensitive Land Protection	1					*Exclusive to LEED*
Credit	Surrounding density and diverse uses	5					*Exclusive to LEED*
Sustainable Sites (SS)		**10**					
Prereq	Construction activity pollution prevention (Required)	R	R	R	R	R	Tier 1: WQ 1.1 Erosion & Sediment Control
Credit	Heat island reduction	2	2	2	2	2	Tier 1 Requirements: AQ 4.1 UHI Non-roof Hardscape AND AQ 4.2 Green and Cool Roofs Tier 2 Requirements: AQ 4.3 UHI Non-roof Hardscape (Core)
Credit	Light pollution reduction	1	1	1	1	1	Tier 1 Requirements: EC 5.1 Exterior Lighting Tier 2 Requirements: EC 5.2 Exterior Lighting (Core); EC 5.3 Lighting Controls (Core)
Credit	Open space	1					*Exclusive to LEED*
Credit	Rainwater management	3			2	2	Tier 1 Requirements: WQ 2.1 Stormwater Retention and Reuse Tier 2 Requirements: WQ 2.2 Stormwater Retention and Reuse (Core)
Credit	Site assessment	1					*Exclusive to LEED*
Credit	Site development - protect or restore habitat	2		2	2	2	Tier 2 Requirements: EC 3.3 Restoration of Biodiversity and Pollinator Habitat
Water Efficiency (WE)		**11**					
Prereq	Building-level water metering	R		R	R	R	Implied through WQ 4.2 Water Efficient Fixtures (Core) and WQ 4.4 Water Efficient Fixtures (Core)
Prereq	Indoor water use reduction	R		R	R	R	Tier 2: WQ 4.2 Water Efficient Fixtures (Core) Tier 3: WQ 4.4 Water Efficient Fixtures (Core)
Prereq	Outdoor water use reduction	R		R	R	R	Tier 2: WQ 4.3 Efficient Irrigation (Core)

Figure 6. LEED Points available from TGS Compliance

LEED-NC (V4)			TGS (V3)				
Category	**Credit**		**TIER 1**	**TIER 2**	**TIER 3**	**TIER 4**	***Related TGDS Requirement***
Credit	Cooling tower water use	2					*Exclusive to LEED*
Credit	Indoor water use reduction	6		4	5	5	Tier 2: WQ 4.2 Water Efficient Fixtures (Core) Tier 3: WQ 4.4 Water Efficient Fixtures (Core)
Credit	Outdoor water use reduction	2		2	2	2	Tier 1: WQ 4.1 Drought-Tolerant Landscapes Tier 2: WQ 4.3 Efficient Irrigation (Core)
Credit	Water metering	1					*Exclusive to LEED*
Energy & Atmosphere (EA)		**33**					
Prereq	Fundamental commissioning and verification (Required)	R		R	R	R	Tier 2: Best Practice Commissioning (Core)
Prereq	Minimum energy performance (Required)	R	R	R	R	R	GHG 1.1 Buildings Energy Performance
Prereq	Building-level energy metering (Required)	R	R	R	R	R	Implied through GHG 1.1
Prereq	Fundamental refrigerant management (Required)	R					*Exclusive to LEED*
Credit	Enhanced commissioning	6		4	4	4	Tier 2: GHG 4.2 Best Practice Commissioning (Core)
Credit	Optimize energy performance	18	5	10	17	18	Tier 1 Requirements: GHG 1.1 Buildings Energy Performance Tier 2 Requirements: GHG 1.2 Buildings Energy Performance (Core); GHG 4.1 Benchmarking and Reporting (Core); GHG 5.1 Resilience Planning (Core); GHG 5.2 Refuge Area and Back-Up Power Generation (Optional) Tier 3 Requirements: GHG 1.3 High Performance, Low Carbon Pathway Tier 4 Requirements: GHG 1.3 High Performance, Low Carbon Pathway
Credit	Advanced energy metering	1		1	1	1	Tier 2 Requirements: GHG 4.4 Submetering

Figure 6. LEED Points available from TGS Compliance

LEED-NC (V4)			TGS (V3)				
Category	**Credit**		**TIER 1**	**TIER 2**	**TIER 3**	**TIER 4**	***Related TGDS Requirement***
Credit	Demand response	2					*Exclusive to LEED*
Credit	Renewable energy production	3		2	2	2	Tier 2: GHG 2.1 Solar Readiness (Core); GHG 2.2 On-Site Renewable Energy (Optional)
Credit	Enhanced refrigerant management	1					*Exclusive to LEED*
Credit	Green Power and Carbon Offsets	2					*Exclusive to LEED*
Materials & Resources (MR)		**13**					
Prereq	Storage and collection of recyclables	R	R	R	R	R	Tier 1 Requirements: SW 1.1. Waste Collection and Sorting; SW 1.2 Waste Storage Space; SW 1.3 Bulky Waste; SW 1.4 Compaction; Tier 2 Requirements: SW 1.5. In-suite Waste Storage Space (Optional)
Prereq	Construction and demolition waste management planning	R	R	R	R	R	Tier 1 Requirements: SW 3.1 Construction Waste Management Tier 2 Requirements: SW 3.2 Construction Waste (Core) Tier 3 Requirements: SW 3.3 Construction Waste (Core)
Credit	Building life-cycle impact reduction	5		3	3	3	SW 2.1 Building Lifecycle Impact Reduction (Optional)
Credit	Building product disclosure and optimization - environmental product declarations	2					*Exclusive to LEED*
Credit	Building product disclosure and optimization - sourcing of raw materials	2		1	1	1	Tier 2: SW 4.1 Sustainable Building Materials (Optional)
Credit	Building product disclosure and optimization - material ingredients	2					*Exclusive to LEED*
Credit	Construction and demolition waste management	2		2	2	2	Tier 1 (Required): SW 3.1 Construction Waste Management; Tier 2 (Required): SW 3.2 Construction Waste (Core) - Satisfies option 1 path 2; Tier 3 (Required): SW 3.3 Construction Waste (Core)
Indoor Environmental Quality		**16**					

Figure 6. LEED Points available from TGS Compliance

LEED-NC (V4)			TGS (V3)				
Category	**Credit**		**TIER 1**	**TIER 2**	**TIER 3**	**TIER 4**	***Related TGDS Requirement***
Prereq	Minimum indoor air quality performance	R					*Exclusive to LEED*
Prereq	Environmental tobacco smoke control	R	R	R	R	R	*Provincially legislated, & municipal bylaws*
Prereq	Enhanced indoor air quality strategies	2					*Exclusive to LEED*
Prereq	Low-emitting materials	3					*Exclusive to LEED*
Credit	Construction indoor air quality management plan	1					*Exclusive to LEED*
Credit	Indoor air quality assessment	2					*Exclusive to LEED*
Credit	Thermal comfort	1					*Exclusive to LEED*
Credit	Interior lighting	2					*Exclusive to LEED*
Credit	Daylight	3					*Exclusive to LEED*
Credit	Quality views	1					*Exclusive to LEED*
Credit	Acoustic performance	1					*Exclusive to LEED*
Innovation (IN)		**6**					
Credit	Innovation	5					*Exclusive to LEED*
Credit	LEED Accredited Professional	1					*Exclusive to LEED*
Regional Priority (RP)		**4**					
Credit	Regional Priority Specific Credit	4		2	3	3	Regional priority credits are available in Toronto for: • Minimum 10 points in the Optimize energy performance credit • Minimum 2 points in the Rainwater Management credit • Minimimum 4 points in the Indoor Water Use Reduction credit
	Total	**110**	**11**	**39**	**50**	**51**	**LEED Gold: Minimum 60 Points**

Based on this exercise, we anticipate 11 points from Tier 1 compliance, namely in credits under the Location & Transportation (LT), Sustainable Sites (SS), and Energy & Atmosphere (EA) categories. Tier 2 compliance however could result in approximately 39 LEED points, with points obtained in credits under Water Efficiency (WE) and Materials & Resources (MR). Further points are obtained in the SS and EA categories.

Tiers 3 & 4 have significantly fewer requirements under TGS than Tiers 1 & 2, however we estimate that there are significant further potential LEED points available from compliance at these levels, specifically in the WE and EA categories. Alternate compliance paths for the related TGS requirements include Zero Carbon Initiative or Passive House Certification.

LEED Credits compatible with UTSG context. In addition, we also examined whether existing features at UTSG, such as other internal standards, features consistent with existing development, or factors related to UTSG's location in downtown Toronto, could yield further opportunities for LEED points. Figure 7 highlights these potential additional points. We approximate an additional 8-14 points.

Figure 7. LEED Points Compatible with UTSG Context

Category	Credit	Possible Points	Estimated Points	Rationale
Location & Transportation	Access to Quality Transit	5	3-5	UTSG is in a central location within the City of Toronto, and within walking distance of many transit stops & subway stations. Based on the TTC's minimum service standards, proximity to the rapid rail transit network provides a minimum 3 points. If the location of the construction intersects with other transit routes, such as bus and streetcars, more points are likely. (Toronto Transit Commission (TTC), n.d.)
Location & Transportation	Sensitive Land Protection	1	1	Location on previously developed sites or infill locations is consistent with UTSG's current location in downtown Toronto.
Location & Transportation	Surrounding Density & Diverse Uses	5	3-5	High density development consistent with UTSG location.
Location & Transportation	High Priority Sites	2	0-1	A significant portion of UTSG's existing building stock and the neighbourhood it sits in is designated heritage. As a result, locating on an infill location in a historic district is consistent with some sites at UTSG.
Innovation	LEED-AP	1	1	This credit is simple to achieve, since it only requires training / professional development for staff, which is consistent with existing university HR practices, or seeking this common designation through hiring
Regional Priority	Regional Priority - High Priority Site	1	0-1	Achieving a minimum of 1 point in the High Priority Sites credit can yield an additional Regional Priority credit

Discussion

Combining possible LEED points from TGS compliance and the existing context at UTSG, we identify opportunities for between 19-24 points for Tier 1 compliance, 47-52 points for Tier 2 compliance, and 58-65 points for Tier 3 and 4 compliance. We argue TGS Tier 4 voluntary compliance to be preferred, since it presents the most significant opportunity for obtaining LEED points, bringing UTSG close to or above the threshold for LEED Gold certification.

Notably, TGS does not provide any opportunities for LEED points in the Innovation, Indoor Environmental Quality, or Integrative Process Credit categories.

Aside from LEED point opportunities, there are several other reasons for UTSG to obtain TGS Tier 4 voluntary compliance. To begin, high-level compliance helps UTSG to plan for future local policy changes. The City of Toronto plans to launch a new version of TGS every four years, with plans to launch new, more stringent voluntary compliance levels. However, in addition, Tier 1 targets will become increasingly more stringent, with the current Tier 4 to become Tier 1 by 2030 (Barker, 2018).

Secondly, aiming for voluntary levels of compliance versus the mandatory compliance level provides the opportunity for monetary and non-monetary incentives. The City of Toronto has established a Development Charge Refund program for compliance beyond TGS Tier 1 (City of Toronto, 2018a). Other non-financial incentives such as expedited development review and approvals are currently being explored by the City of Toronto (City of Toronto, 2018b).

Lastly, voluntary compliance provides a key opportunity for local leadership. In total since 2010, only 22 development projects have been certified as Tier 2 or above (City of Toronto, 2018b). UTSG can play a role in highlighting the TGS program and supporting its municipal partners through high-level compliance on any new buildings or major renovations at UTSG.

Sustainable Building Assessment Systems (SBAS) Comparison

In this study, we compared five SBAS available in the marketplace in Toronto, where the University of Toronto St. George campus is located. These SBAS are LEED, TGS, Active House (AH), the WELL Building Standard (WELL), and the Living Building Challenge (LBC).

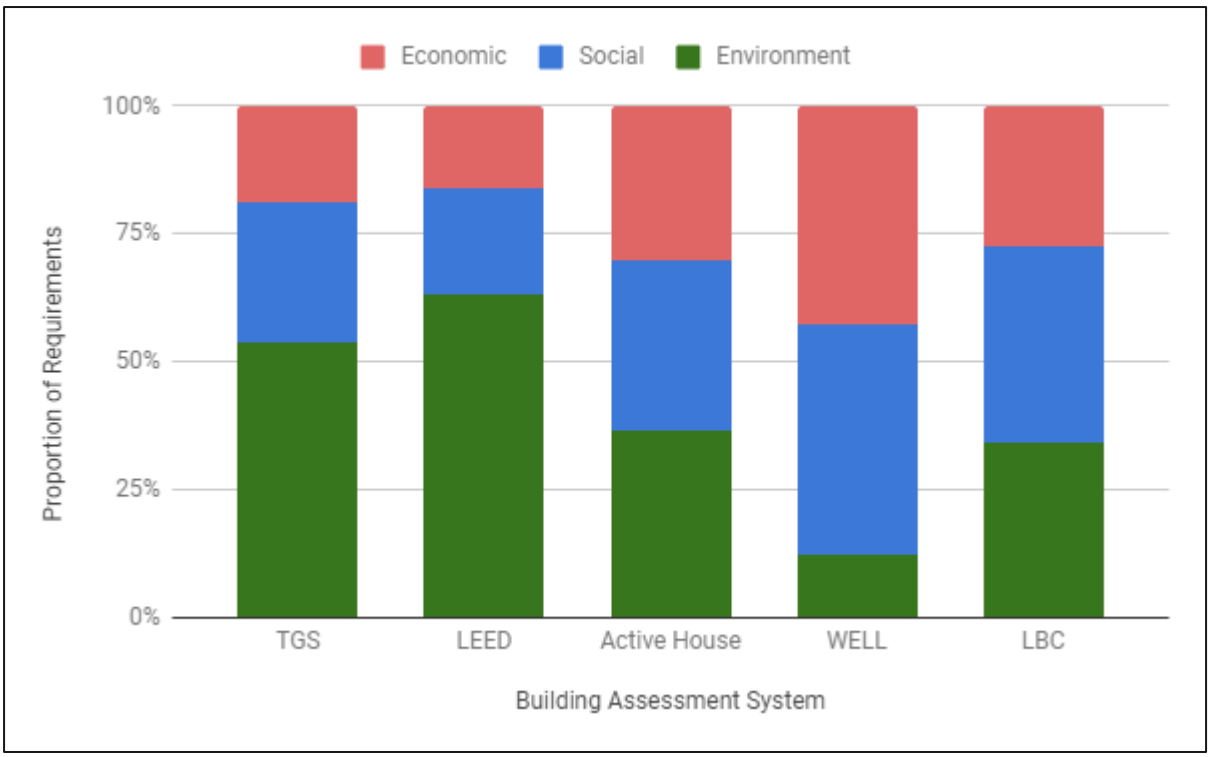
Leadership in Energy and Environmental Design.

Comparison by Impacts

In the first stage of our analysis comparing building assessment systems, we examined the extent to which each building assessment system contributes to each pillar of sustainability. We reviewed the requirements of each building assessment system and assigned each to one or more pillars of sustainability based on their potential impacts. This method is established in Castro et al. (2015) and used in Awadh (2017), however in Awadh, each requirement or credit is assigned to only one pillar of sustainability (Awadh, 2017; Castro, Mateus, & Bragança, 2015). In our analysis, some requirements were assigned to more than one pillar. For example, requirements related to pollution such as those related to eutrophication potential would fall under the environmental pillar, whereas transportation requirements such as requiring bicycle parking would fall under all three pillars, resulting in a cleaner environment, more active building occupants, and faster goods movement from reducing the number of single-occupant vehicles. To simplify this analysis, if a requirement or credit were found to have impacts in more than one pillar of sustainability, their values were split evenly between the applicable pillars. The results were then normalized for comparability.

The results of this analysis can be found below in figure 6. LEED and TGS were found to be limited in their approaches in that they have a largely environmental focus: each were found to have a significant proportion of their requirements focused on environmental impacts, with social and environmental impacts garnering much less attention.

Figure 6. Comparison by Impacts



Inversely, WELL has a largely social and economic focus, with most of its requirements focus on building occupant health, wellbeing, and productivity. Active House and the Living Building Challenge take a more balanced approach, with several requirements attempting to encompass all three pillars at one time.

Comparison by Indicators

We again use a method adapted from Castro et al (2015), which compares SBAS by their indicators. The comparison is conducted based on indicators and categories of indicators:

- Found within the examined SBAS; and
- Of Construction works according to ISO/TC 59/SC 17 (ISO TS 2011).

These comparisons are found in Figures 7 and 8, respectively.

Figure 7. Main Indicators of the Examined SBAS

Indicators	LEED	TGS	AH	WELL	LBC
Economy					
Sustainable local economy					X
Supplier disclosure & transparency	X			X	X
Professional Designation / Training for Sustainability	X		X		
Innovation	X			X	
One-Time Charitable Donation					X
Ongoing Charitable Donation				X	

Figure 7. Main Indicators of the Examined SBAS

Indicators		LEED	TGS	AH	WELL	LBC
	Knowledge-Sharing					X
Energy						
	Energy Measurement/ Metering	X	X	X		X
	Commissioning & Verficiation	X	X	X		X
	On-site Generation	X	X	X		X
	On-site Storage		X			X
	Energy Supply	X	X	X		X
	Energy Demand / Efficiency	X	X	X		X
Indoor Environmental Quality / Well-being						
	Indoor Air Quality	X		X	X	X
	Thermal Comfort	X		X	X	
	Thermal Controls	X		X	X	
	Visual Comfort	X		X	X	
	Olfactory Comfort / Ventilation	X		X	X	X
	Acoustic Performance	X		X	X	
	Daylight	X		X	X	X
	Operable windows			X	X	X
	External Views	X		X	X	X
	Urban Agriculture / Access to Quality Food	X			X	X
	Health Education				X	
	Promotion of Physical Activity		X		X	
	Access to nature / biophilia	X			X	X
Management						
	Stakeholder participation				X	X
	Sustainable Procurement				X	X
	Construction Site Impacts	X	X			X
Materials						
	Material content declaration & labelling	X		X	X	X
	Third-Party certification sustainable extraction certification			X		X
	Building / material reuse	X	X	X		X
	Embodied Carbon					X
	Avoiding the use of materials with pollutant content					X
	Furniture and furnishings				X	
	Design for disassembly			X		X
	Life Cycle Impacts	X				X
	Recycled content of materials			X		X
	Responsible sourcing of materials	X		X		X
	Low-emitting materials	X		X	X	X
Pollution						
	Emissions	X	X	X		X

Figure 7. Main Indicators of the Examined SBAS

Indicators		LEED	TGS	AH	WELL	LBC
	Noise Pollution					X
	Impact of refrigerants / Stratospheric Ozone Depletion	X		X		X
	Light Pollution Reduction	X	X			X
	Construction activity pollution	X	X		X	X
Sustainable Sites						
	Density & diverse uses	X			X	
	Neighbourhood sustainability	X				
	Site selection	X				X
	Mitigating ecological impact	X	X	X		X
	Long-term impact on biodiversity	X	X	X		X
	Ecological Value of site/ protection of ecological features	X	X			X
	Enhancing site ecology	X	X			X
	Heat island reduction	X	X			X
	Townscape and landscape	X		X		X
	Outdoor amenities	X		X	X	X
	Land trust endowment					X
Transportation						
	Proximity to Transit	X		X		
	Reduced Parking Footprint	X	X			X
	Pedestrian Infrastructure	X	X	X	X	X
	Cycling Infrastructure	X	X	X	X	X
	EV Infrastructure	X	X			X
	Active modes promotion & Advocacy		X		X	X
	Low-Emission mode promotion & advocacy		X		X	X
Waste						
	Construction waste reduction & management	X	X	X		X
	Waste collection and sorting facilities	X	X			X
	On-site waste management					X
	Waste Upcycling / Circular Economy					X
	Building End-of-Life	X		X		X
Water						
	Water Measurement/ Metering	X	X	X		X
	Indoor Water Use & Efficiency	X	X	X		X
	Outdoor Water Use & Efficiency	X	X			X
	Stormwater / Rainwater Management	X				X
	Stormwater / Rainwater retention / reuse		X	X		X
	Fundamental Water Quality & Treatment		X		X	X
	Access to Water				X	X
	Drinking Water Promotion				X	
Culture						

Figure 7. Main Indicators of the Examined SBAS

Indicators		LEED	TGS	AH	WELL	LBC
	Public Art & Culture				X	X
	Educating for Sustainability					X

Figure 8. Sustainability indicators of construction works according to ISO/TC 59/SC 17 (ISO TS 2011) mandate; ISO 21929-1: 2011

Indicators		LEED	TGS	AH	WELL	LBC
Access to services						
	Public transportation	X		X	X	X
	Personal modes of transportation	X	X	X	X	X
	Green and open spaces	X	X	X	X	X
	User relevant basic services					
Aesthetic quality						
	Integration with the surrounding	X		X		X
	Impact of building in site	X		X	X	X
	Local concerns			X		X
Land						
	Site selection	X			X	X
Accessibility						
	Building site		X		X	X
	Building			X	X	X
Harmful emissions						
	Potential impact on climate	X	X	X	X	X
	Potential impact on the depletion of stratospheric ozone layer	X		X	X	X
Non-renewable resources						
	Use of resources	X	X	X		X
Fresh water						
	Use/consumption	X	X	X		X
Waste						
	Production	X	X	X		X
Indoor environmental						
	Indoor conditions	X		X	X	X
	Indoor air quality	X		X	X	X
Safety						
	Stability					
	Resistance					
	Fire safety					
Serviceability						
	Planning/ measurement			X		
Adaptability						

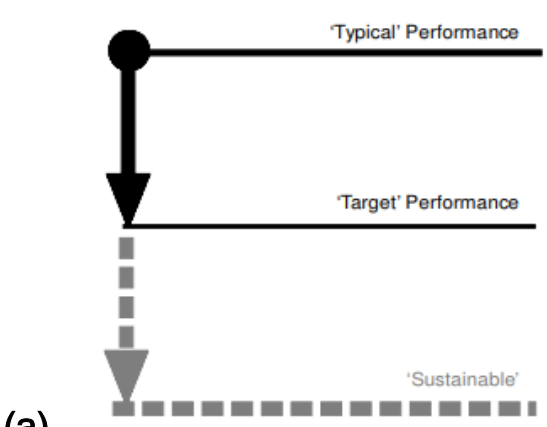
Figure 8. Sustainability indicators of construction works according to ISO/TC 59/SC 17 (ISO TS 2011) mandate; ISO 21929-1: 2011

	Indicators	LEED	TGS	AH	WELL	LBC
	Adaptability for changed use purpose				X	
	Adaptability for climate change		X	X		X
Costs						
	Planning/ measurement					
Maintainability						
	Planning/ assessment				X	

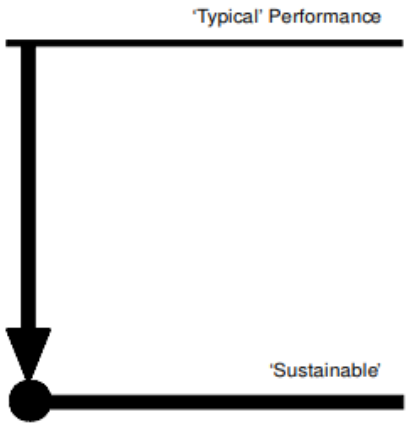
Comparison by Intent

Lastly, we explored the overall intent of each SBAS, examining whether each takes a 'do-less-harm approach,' which is based on comparing performance against a typical building and determining sustainable by the degree to which a building performs better than the typical building, or a regenerative or net-positive approach, which focuses instead on achieving more objective measures of sustainability that go beyond even doing no harm (i.e. net-zero) to net-positive outcomes (Cole, 1999). Figure 10 from Cole (1999) highlights this difference.

Figure 10. (a) 'do-less-harm' approach versus (b) sustainability or regenerative approach (from Cole, 1999)



(a)



(b)

Though both Active House and The Living Building Challenge commit to a broader vision of positive outcomes – for example, the stated vision of Active House is "buildings that give more than they take" (Active House, n.d.) – the Living Building Challenge is the only SBAS examined with an explicit commitment to net-positive or regenerative outcomes. For example, its net positive energy requirement mandates that "one hundred and five percent of the project's energy needs must be supplied by on-site renewable energy on a net annual basis". On the other hand, the stated intent of LEED's Optimize Energy Performance credit is "…to reduce environmental and economic harms associated with excessive energy use". The latter is not only much less compelling, but is less stringent, and likely not to lead to the same impacts as an explicit commitment to net positive outcomes.

In our interviews with representatives from peer universities, we asked whether each university has or is planning to have any net positive buildings. Four of the universities discussed that they were exploring the concept or actively planning to build a net-positive or net-zero building. UBC was the only university which has previously built a building which was committed to achieving net-positive outcomes: this building is the Centre for Interactive Research on Sustainability, or CIRS, building, which features innovative design features that enable it to achieve net-positive energy performance, zero emissions, and zero waste, among other positive outcomes (Clean50, 2013).

Discussion

In comparing the SBAS it becomes clear that our benchmarking exercise is limited in its approach. Focusing solely on LEED points, and opportunities for LEED points from TGS, limits any potential UTSG standard not only to having a largely environmental focus but additionally to outcomes which are only intended to outperform the standard building.

We can look to our comparison by indicators for some potential solutions. In general, many of the common indicators are already covered in our benchmarking exercise, such as indicators for energy and water use and efficiency, limiting pollution, and enabling low-emission and active transportation through infrastructure and proximity to public transit. However, many other common indicators fall under the category of Wellbeing or Indoor Environmental Quality, such as indoor air quality, daylight, ventilation, external views, thermal comfort and controls, acoustic performance, and urban agriculture/access to food. As is noted in our benchmarking section, TGS does not provide any opportunities for LEED points in the Indoor Environmental Quality category. This section in particular can have significant implications for the student learning environment, as a number of studies have found that features of classrooms and university buildings which support wellbeing and indoor environmental quality can improve student satisfaction (M. C. Hill & Epps, 2010), student health and work performance (Fisk & Seppanen, 2007), reduced employee absenteeism and improved productivity (Singh, Syal, Grady, & Korkmaz, 2010), and more.

There are additionally several indicators which are common to most SBAS *except LEED*. Some of these include ensuring accessibility of the building and building site, promoting active and low emission modes of transportation to building occupants, such as through providing free transit vouchers or TDM programming or services onsite,[4] operable windows to ensure individual control and access to fresh air, and providing onsite energy storage to improve adaptability and resilience for climate change.

Lastly, there are also unique indicators, or indicators which are only present in one of the examined SBAS. Figure 10 highlights these unique indicators.

[4] This indicator in particular already aligns with existing practice at UTSG, as the campus is a participant in the Smart Commute program. Continuing participation in this program

Figure 10. Unique Indicators of Examined SBAS

Economy	Society	Envrionment
• Sustainable Local Economy • Knowledge Sharing • Charitable Donation (one-time, ongoing)	• Neighbourhood sustainability • Health & Wellness Education • Drinking water promotion • Education for sustainability • Access to water, food	• Land trust endowment • Waste management: on-site management, upcycling, circularity

There are a few of these in particular which align well with research and innovation at UofT. Knowledge sharing and education for sustainability speak to both the core of the university's commitment to being a leading provider of research and education, as well as existing commitments such as UC3. In fact, many sites across the university already seek to do this – for example, the Exam Centre and Rotman School of Management both contain educational posters which highlight sustainability features of the buildings and/or work on campus. The Exam Centre also provides a terminal with real-time monitoring of energy and water use, as well as savings from building features such as collecting of rainwater.

Photos taken at the Exam Centre, Building #155, 255 McCaul Street, Toronto, on December 6, 2018

Health and wellness education and drinking water promotion align with existing practice at UofT, which already has a number of student clubs and on-campus job opportunities which

aim to educate and provide programming on health and wellness. Lastly, neighborhood sustainability is a key opportunity – universities are unique in their roles as single landowners and property managers for large swaths of land, making them essentially responsible for the planning and management of neighbourhoods. Seeking opportunities for neighbourhood sustainability can help UofT find ways to further sustainability on campus that go beyond single buildings. In addition, this is also further opportunities for both recognition and LEED points, as LEED's Neighbourhood Development certification can provide points in lieu of individual credits in the Location and Transportation category.

Conclusion

In summary, we recommend the following for UTSG:

- Commit to designing new buildings and major renovations to achieve LEED Gold certification at a minimum;
- Seek voluntary levels of compliance with the Toronto Green Standards, as these provide opportunities to achieve LEED Gold as well as provide incentives and reduce future policy risk;
- Seek to incorporate additional social and economic criteria into standards for new buildings and major renovations at UTSG, such as
    - Indoor environmental quality features, such as thermal comfort and controls, air quality and ventilation, external views, acoustic performance, operable windows;
    - Wellbeing features such as urban agriculture/access to quality food, promoting active and low emission transportation modes, and health and wellbeing wellness and education;
    - Full accessibility of the building and building site;
    - Onsite energy storage to improve climate change resilience and adaptability; and
    - Knowledge sharing and educating for sustainability.
- Explore the concept of net-positive or regenerative sustainability in future building design.

References

Active House. (n.d.). Active House - the specifications for residential buildings (2nd Edition). Active House. Retrieved from http://www.activehouse.info/wp-content/uploads/2016/05/activehouse_specifications_2nd_edition.pdf

Adalberth, K. (1997). Energy use during the Life Cycle of Buildings: A Method. *Building and Environment*, *32*(4), 317–320. Retrieved from http://resolver.scholarsportal.info.myaccess.library.utoronto.ca/resolve/03601323/v32i0004/317_eudtlcobam.xml

Association for the Advancement of Sustainability in Higher Education (AASHE). (n.d.). Participants & Reports - STARS. Retrieved October 2, 2018, from https://stars.aashe.org/institutions/participants-and-reports/

Awadh, O. (2017). Sustainability and green building rating systems: LEED, BREEAM, GSAS and Estidama critical analysis. *Journal of Building Engineering*, *11*, 25–29. https://doi.org/10.1016/j.jobe.2017.03.010

Barker, A. (2018). *TGS V3: How does the typical MURB stack up?* (p. 6). EQ Building Performance. Retrieved from http://www.eqbuilding.com/wp-content/uploads/2018/03/18.03.27_TGSv3__MURBS_AB_SM_AB_AE_rev6.pdf

Cano, D. (2018, November 14). Peer University Research Interview - University of Western Ontario [Phone].

Castro, M. de F., Mateus, R., & Bragança, L. (2015). A critical analysis of building sustainability assessment methods for healthcare buildings. *Environment, Development and Sustainability*, *17*(6), 1381–1412. https://doi.org/10.1007/s10668-014-9611-0

City of Toronto. To Amend City of Toronto Municipal Code Chapter 415, Development of Land, by Re-enacting Article I, Development Charges, Pub. L. No. BY-LAW 515-2018 (2018). Retrieved from https://www.toronto.ca/legdocs/bylaws/2018/law0515.pdf

City of Toronto. (2018b). *Toronto Green Standard Version 3 - Review of Potential Incentives and Results of Additional Consultation* (No. PG.30.9) (p. 7). City of Toronto.

City of Toronto. (2018c, April 11). Toronto Green Standard - Mid to High-Rise Residential & all Non-Residential Version 3. Retrieved from https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/toronto-green-standard-version-3/mid-to-high-rise-residential-all-non-residential-version-3/

Clean50. (2013). CIRS. Retrieved from https://clean50.com/top-15-projects/projects-2013/cirs/

Cole, R. J., & Kashkooli, A. M. (2013). Clarifying Net Positive Energy. In *Stream 5 - Pushing the Boundaries: Net Positive Buildings (SB13)*. Vancouver, BC. Retrieved from https://www.researchgate.net/publication/259216706_Clarifying_Net_Positive_Energy

Cole, Raymond J. (1999). Building environmental assessment methods: clarifying intentions. *Building Research & Information*, *27*(4–5), 230–246. https://doi.org/10.1080/096132199369354

Conte, E. (2018). The Era of Sustainability: Promises, Pitfalls and Prospects for Sustainable Buildings and the Built Environment. *Sustainability*, *10*(6), 2092. https://doi.org/10.3390/su10062092

Council of Ontario Universities. (2009, November). Ontario Universities Committed To A Greener World. Council of Ontario Universities. Retrieved from http://cou.on.ca/wp-content/uploads/2015/06/COU-Exec-Heads-Green-Pledge.pdf

Eichholtz, P., Kok, N., & Quigley, J. M. (2013). The Economics of Green Building. *Review of Economics and Statistics*, *95*(1), 50–63. https://doi.org/10.1162/REST_a_00291

Fisk, W., & Seppanen, O. (2007). Providing better indoor environmental quality brings economic benefits, 18.

Gertler, M. (2017, February 1). Announcing the Committee on the Environment, Climate Change, and Sustainability (PDAD&C #58). Retrieved from https://memos.provost.utoronto.ca/announcing-the-committee-on-the-environment-climate-change-and-sustainability-pdadc-58/

Hall, L. (2018, November 15). Peer University Research Interview - University of Alberta [Email].

Hill, M. C., & Epps, K. K. (2010). The Impact of Physical Classroom Environment on Student Satisfaction and Student Evaluation of Teaching in the University Environment, *14*(4), 16.

Hill, R. C., & Bowen, P. A. (1997). Sustainable construction: principles and a framework for attainment. *Construction Management and Economics*, *15*(3), 223–239. https://doi.org/10.1080/014461997372971

International Living Future Institute. (n.d.). Living Building Challenge 3.1 Standard. Retrieved from https://living-future.org/product/lbc-3-1-standard/

International WELL Building Institute. (2018). The WELL Performance Verification Guidebook (V2). International WELL Building Institute. Retrieved from https://www.wellcertified.com/sites/default/files/resources/2018%20Q3%20WELL%20Performance%20Verification%20Guidebook.pdf

Kibert, C. J. (1994). Establishing Principles and a Model for Sustainable Construction. In *Proceedings of the First International Conference of the First International Conference of CIB TG 16*. Tampa, FL.

McLennan, J. F. (2004). *The Philosophy of Sustainable Design: The Future of Architecture* (1st ed.). Kansas City, Missouri: Ecotone LLC.

Montgomery, N. (2018, November 15). Peer University Research Interview - University of British Columbia [Phone].

Owen, R. (2018, November 14). Peer University Research Interview - Dalhousie University [Phone].

Rasekh, H., & McCarthy, T. J. (2016). DELIVERING SUSTAINABLE BUILDING PROJECTS – CHALLENGES, REALITY AND SUCCESS. *Journal of Green Building*, *11*(3), 143–161. https://doi.org/10.3992/jgb.11.3.143.1

Robinson, J., & Cole, R. J. (2015). Theoretical underpinnings of regenerative sustainability. *Building Research & Information*, *43*(2), 133–143. https://doi.org/10.1080/09613218.2014.979082

Second Nature. (2018). *UC3 2018 Progress Report: Research For Solutions - Convening Stakeholders to Galvanize Local Climate Action*. University Climate Change Coalition (UC3). Retrieved from https://secondnature.org/wp-content/uploads/SecondNature_UC3_2018ProgressReport-Final.pdf

Singh, A., Syal, M., Grady, S. C., & Korkmaz, S. (2010). Effects of Green Buildings on Employee Health and Productivity. *American Journal of Public Health*, *100*(9), 1665–1668. https://doi.org/10.2105/AJPH.2009.180687

Spence, R., & Mulligan, H. (1995). Sustainable development and the construction industry. *Habitat International*, *19*(3), 279–292. https://doi.org/10.1016/0197-3975(94)00071-9

Stender, M., & Walter, A. (2018). The role of social sustainability in building assessment. *Building Research & Information*, *1*(13). https://doi.org/10.1080/09613218.2018.1468057

Stoker, A. (2018, November 15). Peer University Research Interview - University of Calgary [Email].

Times Higher Education. (2018). 2019 World University Rankings. Retrieved November 17, 2018, from https://www.timeshighereducation.com/world-university-rankings/2019/world-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/stats

Toronto Transit Commission (TTC). (n.d.). Service Standards and Decision Rules for Planning Transit Service. Toronto Transit Commission. Retrieved from https://www.ttc.ca/PDF/Transit_Planning/TTC_Service_Standards.pdf

University of Toronto. (2010, April 26). University Environment Protection Policy. Retrieved from http://www.governingcouncil.utoronto.ca/Assets/Governing+Council+Digital+Assets/Policies/PDF/ppmar071994iii.pdf

University of Toronto. (n.d.-a). About U of T. Retrieved from https://www.utoronto.ca/about-u-of-t

University of Toronto. (n.d.-b). Facilities & Services: Design Standards Part One. Retrieved September 19, 2018, from http://www.fs.utoronto.ca/DesignStandards/PartOne

University of Toronto. (n.d.-c). Facilities & Services: Design Standards Part Two. Retrieved September 19, 2018, from http://www.fs.utoronto.ca/DesignStandards/PartTwo

University of Toronto. (n.d.-d). Mission. Retrieved from https://www.utoronto.ca/about-u-of-t/mission

University Ranking by Academic Performance. (2018). 2018 University Ranking by Academic Performance. Retrieved November 2, 2018, from http://www.urapcenter.org/2018/world.php?q=MS0yNTAw

U.S. Green Building Council. (n.d.). LEED V4 credit library. Retrieved from http://www.usgbc.org/credits

Waldron, D., & Miller, D. (2013). *Regenerative Sustainability at the Neighbourhood Scale* (p. 71). University of British Columbia. Retrieved from http://rnp-sustain.sites.olt.ubc.ca/files/2013/02/Regenerative-Sustainability-at-the-Neighbourhood-Scale-Potential-and-Practicalities.pdf

WCED. (1987). *Report of the World Commission on Environment and Development: Our Common Future*. World Commission on Environment and Development. Retrieved from http://www.un-documents.net/wced-ocf.htm

Zuo, J., Jin, X.-H., & Flynn, L. (2012). Social Sustainability in Construction – An Explorative Study. *International Journal of Construction Management*, *12*(2), 51–63. https://doi.org/10.1080/15623599.2012.10773190

Zuo, J., & Zhao, Z.-Y. (2014). Green building research–current status and future agenda: A review. *Renewable and Sustainable Energy Reviews*, *30*, 271–281. https://doi.org/10.1016/j.rser.2013.10.021

Appendix A

Environmental Design Standards

DRAFT
(Revised December 14, 2011)

This Design Standard has not yet received approval through University governance. It is included here as a reference for planning new facilities to be built in the near future.

1. **New Construction**
   a. At a minimum, all new buildings* shall be designed to meet the Toronto Green Development Standard, Tier 1 and LEED Canada – NC Silver rating with at least 10 points achieved for "Optimizing Energy Performance", 2 points achieved for "Enhanced Commissioning" and 4 points achieved for "Water Use Reduction". This will significantly reduce the building's operating costs over its lifetime. The attached chart indicates the University's minimum point expectation in all categories.
   b. It is recommended that the building undergo full LEED Canada – NC Silver certification, not just be designed to be equivalent to LEED without certification. This will ensure that features planned at the beginning of the project to enhance the environmental sustainability of the building will still exist at the end of the construction, will be properly commissioned and will be monitored for performance after the construction is complete.
   c. It is recommended that glazing be limited to no more than 40% of the exterior wall area.
   d. Equipment and systems must be put in place so that the long term energy and water efficiency can be monitored and verified.

2. **Major Renovations**
   a. For major renovations requiring governance approval affecting 100% of the mechanical and electrical systems and 50% of the interiors, the re-constructed area shall be treated as "New Construction" above.

3. **Related Relevant Documents**
   a. Other University of Toronto Design Standards can be found at http://www.fs.utoronto.ca/aboutus/design.htm. Of particular relevance are the Mechanical and Electrical Design Standards.
   b. *A Pledge from the Executive Heads*, Council of Ontario Universities, November 2009 http://www.cou.on.ca/issues-resources/key-issues/more/pdfs/committed-to-a-greener-world---a-pledge-from-execu.aspx

* = Wet labs and data centre buildings will be considered on an individual basis.

UofT Environmental Design Standard for New Construction
based on LEED Canada 2009

Sustainable Sites

Min. point expectation			Possible LEED points
R	Prereq 1	Construction Activity Prevention	R
1	Credit 1	Site Selection	1
5	Credit 2	Development Density and Community Connectivity	3,5
0	Credit 3	Brownfield Redevelopment	1
6	Credit 4.1	Alternative Transportation - Public Transport Access	3,6
0	Credit 4.2	Alternative Transportation - Bicycle Storage & Changing Rooms	1
0	Credit 4.3	Alternative Transportation - Low-Emitting and Fuel Eff. Vehicles	3
1	Credit 4.4	Alternative Transportation - Parking Capacity	2
1	Credit 5.1	Reduced Site Disturbance - Protect/Restore Habitat	1
0	Credit 5.2	Reduced Site Disturbance - Maximize Open Space	1
1	Credit 6.1	Stormwater Management - Quantity Control	1
0	Credit 6.2	Stormwater Management - Quality Control	1
1	Credit 7.1	Heat Island Effect - Non-Roof	1
1	Credit 7.2	Heat Island Effect - Roof	1
0	Credit 8	Light Pollution Reduction	1
17		points	26

Water Efficiency

R	Prereq 1	Water Use Reduction	R
2	Credit 1	Water Efficient Landscaping	2,4
0	Credit 2	Innovative Wastewater Technologies	2
4	Credit 3	Water Use Reduction	2to4
6		points	10

Energy & Atmosphere

R	Prereq 1	Fundamental Commissioning of Building Energy Systems	R
R	Prereq 2	Minimum Energy Performance	R
R	Prereq 3	Fundamental Refrigerant Management	R
10	Credit 1	Optimize Energy Performance	3to19
0	Credit 2	On-site Renewable Energy	1to7
2	Credit 3	Enhanced Commissioning	2
1	Credit 4	Enhanced Refrigerant Management	2
1	Credit 5	Measurement and Verification	3
0	Credit 6	Green Power	2
14		points	35

Materials & Resources

R	Prereq 1	Storage & Collection of Recyclables	R
0	Credit 1.1	Building Reuse: Maintain Existing Walls, Floors, Roof	1to3
0	Credit 1.1	Building Reuse: Maintain Interior Non-Structural Elements	1
2	Credit 2	Construction Waste Management	1to2
0	Credit 3.1	Materials Reuse	1to2
2	Credit 4.1	Recycled Content	1to2
1	Credit 5.1	Regional Materials	1to2
0	Credit 6	Rapidly Renewable Materials	1
0	Credit 7	Certified Wood	1
5		points	14

Indoor Environmental Quality

R	Prereq 1	Minimum IAQ Performance	R
R	Prereq 2	Environmental tobacco Smoke (ETS) Control	R
0	Credit 1	Outdoor Air Delivery Monitored	1
0	Credit 2	Increased Ventilation	1
1	Credit 3.1	Construction IAQ Management Plan, During Construction	1
0	Credit 3.2	Construction IAQ Management Plan, Testing before Occupancy	1
1	Credit 4.1	Low-Emitting Materials: Adhesives & Sealants	1
1	Credit 4.2	Low-Emitting Materials: Paints & Coatings	1
1	Credit 4.3	Low-Emitting Materials: Flooring Systems	1
1	Credit 4.4	Low-Emitting Materials: Composite Wood & Agrifibre Products	1
1	Credit 5	Indoor Chemical & Pollutant Source Control	1
0	Credit 6.1	Controllability of Systems: Lighting	1
0	Credit 6.2	Controllability of Systems: Thermal Comfort	1
1	Credit 7.1	Thermal Comfort: Design	1
0	Credit 7.2	Thermal Comfort: Verification	1
0	Credit 8.1	Daylight & Views: Daylight	1
0	Credit 8.2	Daylight & Views: Views	1
7		points	15

Innovation & Design Process

4	Credit 1	Innovation in Design	1to5
1	Credit 2	LEED Accredited Professional	1
5		points	5

Regional Priority

1	Credit 1	Durable Building	1
1	Credit 2	Regional Priority Credit	1to3
2		points	4

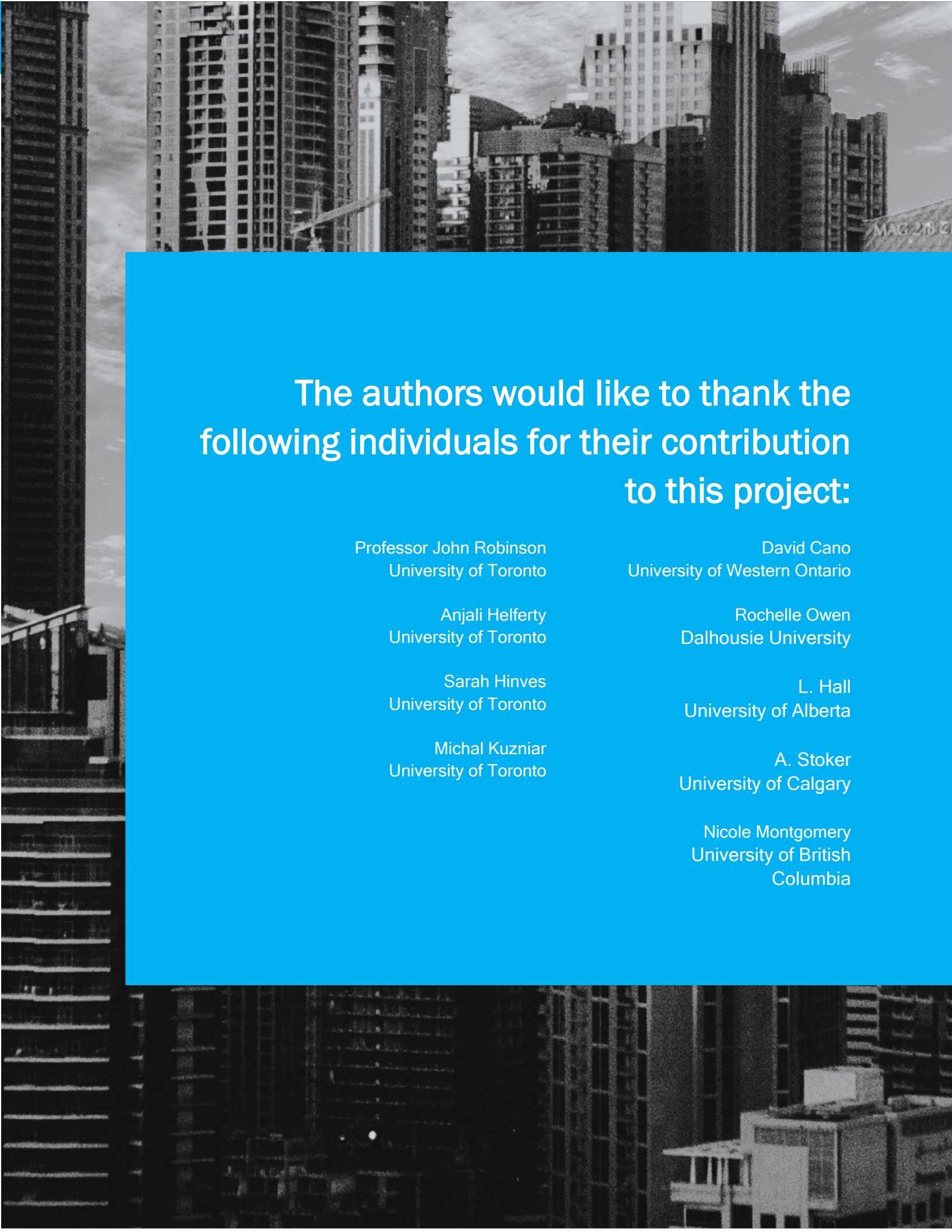
LEED CANADA 2009 NC minimum:

LEED Certified 40-49

56 **LEED Silver 50-59** 110

LEED Gold 60-79

LEED Platinum 80-110



The authors would like to thank the following individuals for their contribution to this project:

Professor John Robinson
University of Toronto

Anjali Helferty
University of Toronto

Sarah Hinves
University of Toronto

Michal Kuzniar
University of Toronto

David Cano
University of Western Ontario

Rochelle Owen
Dalhousie University

L. Hall
University of Alberta

A. Stoker
University of Calgary

Nicole Montgomery
University of British Columbia