UNIVERSITY OF TORONTO

UNIVERSITY OF TORONTO TRI-CAMPUS ENERGY MODELLING & UTILITY PERFORMANCE STANDARD

Reference Date: July 1, 2020
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1 EXECUTIVE SUMMARY

1.1 Scope

The University of Toronto is committed to reducing its scope 1 and 2 greenhouse gas (GHG) emissions to at least 37% below its 1990 level - a reduction of 43,275 tonnes eCO_2 from 116,959 tonnes eCO_2 by 2030 in absolute terms. Furthermore, U of T is targeting to be a net-zero GHG institution by 2050. To accomplish this, the University has retired the previous Energy Performance and Modelling Standard (April 1, 2019) and introduced this now-governing Tri-Campus Energy Modelling & Utility Performances Standard (July 1, 2020).

1.2 Application

This standard provides project-specific energy and water efficiency targets in new and renovation projects, calculates energy and GHG project budgets and introducing a streamlined modelling, benchmark comparison, documentation submission and approvals approach. All projects that develop a PPR or renovation project initialization process as of July 1, 2020 must adhere to these standards. Note that projects following the previous standards (April, 2019) must show still how they would meet the requirement to be "40% better than" ASHRAE in order for the U of T Implementation Committee to decide whether or not to pursue that option as specified in the 2019 standards.

1.3 Promote Innovation

This standard is meant to inspire innovative designs based on absolute energy and GHG targets that calculate energy and GHG performance budgets, according to the year the building is scheduled to be occupied along with archetypical program use (entered as NASMs and converted to GSM through an approved gross up factor). The targets ratchet down predictably over time as codes, cost-effective technologies, designs and delivery methods improve. The University is interested in innovative designs that promote resiliency, sustainability, well-being and low carbon and energy solutions.

1.4 Energy and GHG Performance Charter

The tool used to define the targets and budgets is called the "Charter". The Charter calculates the utility targets as energy and GHG utilization indices which are then used to estimate the annual performance budgets. The NASMs of the archetypical space use in each design is input to the Charter and completed by U of T staff during the PPR stage and before the call for design tenders is issued. The final GSMs are calculated using approved gross up factors applied to the NASMs. Final energy and GHG utilization indices are calculated using GSMs.

1.5 Scheduled Occupancy

The energy and GHG performance targets for all projects are defined for the year that occupancy is scheduled in the project planning reports. If the actual occupancy is delayed for any reason, the original scheduled occupancy date and targets will hold for the purposes of performance approvals.

1.6 Documentation Steps

The approved energy modelling procedures will be used to calculate the energy and GHG performance targets and budgets for the designs and compared to the Charter targets throughout the design stages described in Tables 1.14.1 and 1.14.2.

1.7 Targets and Budget Steps

The 2020 – 2022 targets (Table 1.12.1) form the basis for the subsequent targets. During the development of these standards, archetype buildings were used that represent the majority of structures/spaces within the university portfolio. These archetypes were used to prepare models and reductions calculations using existing technologies (at 2019). The targets for 2022-2026 (Table 1.12.2) are, on average, 8% lower than Table 1.12.1 in terms of absolute energy and GHG indices. The targets for the 2026-2030 (Table 1.12.3) are 20% below those in Table 1.12.2. As a comparison, these targets are in line with the Toronto Green Standards v3, between Tier 3 and Tier 4 at each step with adjustments to reflect campus archetype specifics. This will ensure U of T will maintain a leadership role and be ahead of the TGS steps every four years.

1.8 Modelling as Performance Estimates

These Standards and resulting models are not post-occupancy energy or GHG predictions. They are to be used to establish and track energy and GHG use indices compliance during the design process and as a comparative tool for building baseline and performance evaluation. The intention is to narrow the gap between predicted energy use and actual performance. The U of T will use the modelling results to assess post-occupancy performance. *If the actual energy performance, after 12 months of continuous operation, exceeds the predicted performance by more than 15%, the design team/modelers will be asked to comment and assist U of T to determine the possible reasons for the variation.*

1.9 Codes and Standards in effect at time of Scheduled Occupancy

Throughout, whenever Codes, Guidelines or Standards are referenced, they are to be those during the assigned Charter year of scheduled occupancy. For example, these standards, the Ontario Building Code, Toronto Green Standards and ASHRAE revise their criteria toward more stringent levels of performance regularly, usually every four years.

1.10 Anticipate Future Code/Standards

Realizing we will not know these changes until they are released, the design teams are to anticipate improved energy performance and low carbon metrics based on the targets described in these standards and the year of occupancy. Estimates of the impact of these future standards, codes and guidelines shall be presented to the U of T Implementation Committee for consideration. In all cases, higher performance targets shall be the default design mandate.

1.11 LEED™ and other High Performance Guidelines

LEED™ Silver is to be the minimum level for any projects that are using/referring this program. It is not a U of T requirement that projects are certified. For the purposes of these Standards, the points in the "Optimize Energy Performance" and "Enhanced Commissioning" within the "Energy & Atmosphere" category are to be maximized.

Any other high performance guidelines that are specified and complied to, e.g., WELL, PassivHaus, CaGBC Zero Carbon building standards will be announced in the PPR and indicated in any subsequent requests for proposals.

1.12 Greenhouse Gas Emissions and System Efficiency Factors

GHG emissions factors (EF) and distributed energy systems efficiencies are based on factors as of 2020. The EF's in Section 7.10 shall be used for GHG indices predictions in all target periods and will be adjusted to the actual factors when they become known at the time of the Charter configuration. EF's, district energy system efficiencies, equipment efficiencies and heat pump coefficients of efficiency shall be approved by U of T Implementation Committee before used in any modelling.

1.13 Calendar Years

Calendar years are used throughout these Standards (January 1 – December 31) when referencing target periods and scheduled occupancy dates. The year when the project is defined to be occupied (in the PPR, requests for tenders, project initialization) will define the performance targets and energy/GHG budgets.

1.13.1 New Construction: Targets for Scheduled Occupancy Dates between 2020 to 2022

Building Type	Thermal energy Source	TEUI	GHGI	TEDI - Heating	TEDI - Cooling
		ekWh/m²/yr	kg eCO_2/m²/yr	ekWh/m²/yr	ekWh/m²/yr
Academic	District Energy	105	16	40	25
	Non-District	80	6		
Office	District Energy	105	16	40	25
	Non-District	80	6		
Wet Labs	District Energy	510	50	100	100
	Non-District	430	30		
Dry Labs	District Energy	230	16	20	110
	Non-District	210	11		
Retail	District Energy	130	16	25	25
	Non-District	105	11		
Residence	District Energy	105	11	30	20
	Non-District	80	6		
Athletic	District Energy	112	16	40	35
	Non-District	85	6		
Library	District Energy	100	15	38	24
	Non-District	75	6		

1.14 District energy and non-district energy systems

"District Energy" refers to thermal energy, in particular steam or med/high temperature water (>60°C), delivered to the building from a central utility plant that uses natural gas as the primary fuel. Unless otherwise specified by U of T, the Central Plant heating annual efficiency is defined as 80%; Central cooling plants shall use a COP of 5.

For sites not connected to a central utility plant, Non-District targets are to be used. For sites connected to a central

heat pump network or heat recovery network (e.g., Sofame at St. George) use Non-District targets. In the case of ground source heat pumps and central chiller plants, proposed plant efficiencies/coefficient of performance shall be presented to and approved by U of T.

1.14.1 New Construction: Targets for Scheduled Occupancy Dates between 2022 to 2026

Building Type	Thermal energy Source	TEUI	GHGI	TEDI - Heating	TEDI - Cooling
		ekWh/m²/yr	kg eCO_2/m²/yr	ekWh/m²/yr	ekWh/m²/yr
Academic	District Energy	97	15	37	23
	Non-District	75	5		
Office	District Energy	97	15	37	37
	Non-District	75	5		
Wet Labs	District Energy	470	46	95	95
	Non-District	395	28		
Dry Labs	District Energy	212	15	20	104
	Non-District	195	10		
Retail	District Energy	120	15	24	24
	Non-District	195	10		
Residence	District Energy	97	10	28	19
	Non-District	74	5		
Athletic	District Energy	103	15	38	33
	Non-District	78	5		
Library	District Energy	92	14	24	19
	Non-District	69	6		

1.14.2 New Construction: Targets for Scheduled Occupancy Dates between 2026 to 2030

Building Type	Thermal energy Source	TEUI ekWh/m²/yr	GHGI kg $eCO_2/m^2/yr$	TEDI - Heating ekWh/m²/yr	TEDI - Cooling ekWh/m²/yr
Academic	District Energy	78	12	30	18
	Non-District	59	4		
Office	District Energy	78	12	30	18
	Non-District	59	4		
Wet Labs	District Energy	376	37	76	76
	Non-District	316	22		
Dry Labs	District Energy	170	12	16	83
	Non-District	156	8		
Retail	District Energy	96	12	19	19
	Non-District	78	8		
Residence	District Energy	78	8	22	15
	Non-District	59	4		
Athletic	District Energy	82	12	30	26
	Non-District	62	4		
Library	District Energy	75	10	19	15
	Non-District	57	3		

1.15 Renovations

The renovation of existing buildings plays a critical part in U of T's plan to achieve the established 2030 GHG emission reduction target. For example, in order to meet our 2030 goals on St. George Campus, the average GHG (2020) intensity ~69ekWh/m² must be reduced by ~50% to < 32 ekWh/m². This Standard identifies utility performance requirements and targets for renovation projects of varying scopes and complexities through a prescriptive pathway for minor renovations and performance pathway for major renovation projects.

1. As in new construction, the renovation targets calculate the project energy and GHG budgets.
2. Renovations are considered "minor" or "major". See section 3.7, 3.8 and 6.0.
3. All renovations shall target high performance energy and GHG performance designs.
4. Beyond energy, additional performance levels include:
    a. 50% reduction in indoor water use over the LEED™ version 4 baseline;
    b. 60% reduction in outdoor water use over the LEED™ version 4 baseline; and
    c. Complete whole-building air tightness testing following the US Army Corps of Engineers Air Leakage Test Protocol for Building Envelopes and submit air leakage testing report.
5. The above targets are combined with project-specific information to establish unique energy and water efficiency targets for every building based on floor area and different space use types.
6. The project-specific goals are established as part of the Project Planning Report (PPR) or Project Initialization stage document, using the separately enclosed Project Charter.
7. The Project Charter outlines key project information, performance targets, and serves as a reference point throughout the project to ensure the performance goals are clearly understood by all involved parties and ultimately achieved.

1.16 Documentation Requirements and Timelines

1. To further ensure projects are developed in accordance with these performance requirements, documentation must be completed by the Project Consultant Team and/or the U of T Implementation Committee at each project stage. For each documentation item, the expectations and responsible parties are outlined in this Standard.
2. The documentation requirements for **New Construction projects and Renovations** are listed in Table 1.16.1below:

1.16.1 New Construction: Documentation and Milestones

Documentation	Project Stage					
	PPR	Project Initialization	SD	DD	CD	Occupancy
Project Charter – PPR Form	●					
Project Charter – Design Form		●				
Project Charter – Project Submissions Checklist		●	●	●	●	●
Energy Simulation Files			●	●	●	●
Energy Performance Report			●	●	●	●
Water Efficiency Worksheets			●	●	●	●
Summary of Changes from Previous Submission				●	●	●
Equipment Cut Sheets						●
Air Leakage Test Report						●

3. Water efficiency worksheets apply when water use is required, e.g., kitchen addition or upgrades, washroom additions or upgrades, bottle refill stations, etc.
4. At each design milestone, these documents shall be prepared and reviewed by the Implementation Committee. These documents are to ensure designs are progressing in a way to meet the prepared performance targets and budgets.
5. The design process for renovations may or may not include a PPR Milestone. The scope, scale and targets may instead be defined at the Project Initialization milestone. U of T has an internal engineering and architectural team that may require outside consultants depending on the size and complexity of the renovation. If so, the RFP for these services will include the energy and GHG performance path based on targets prepared internally.
6. Not all renovations will require an energy performance model. When a comfort system is being modified or other renovation activity that affects energy use and a sizing exercise is required (e.g., Carrier HAP or equal), the energy performance report shall be prepared and presented at the SD stage (or equal) and updated at each of DD and CD stages.
7. The renovation may require reassigning the space as a different space than original (e.g., convert offices to labs). The design team shall target energy use indices for the new converted space to meet the new building targets unless otherwise approved by the Implementation Committee.
8. U of T Implementation Committee will prepare baseline energy and GHG performance indices based on existing building performance when there is an opportunity to impact the energy performance during a renovation. The design team shall target energy performance that is less than the existing energy use indices based on archetype classification on an area weighted average basis.

9. In all cases, renovations shall define the scope and scale of the project with energy and GHG performance taken into consideration, targeting high performance indices.
10. The documentation for **Renovation projects and Renovations** are listed in Table 1.16.2 below:

1.16.2 Renovation: Documentation and Milestones

Documentation	Project Stage					
	PPR	Project Initialization	SD	DD	CD	Occupancy
Project Charter – PPR Form	●					
Project Charter – Design Form		●				
Project Charter – Project Submissions Checklist		●	●	●	●	●
Utilities Performance Report			●	●	●	●
Water Efficiency Worksheets			●	●	●	●
Summary of Changes from Previous Submission				●	●	●
Equipment Cut Sheets						●

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2 ACRONYMS

- AHJ: Authority having Jurisdiction
- ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers
- CD: Construction documents project stage
- COP: Coefficient of Performance
- DD: Design development project stage
- F&S: Facilities and Services
- GHGI: Greenhouse Gas Emission Intensity
- GSM: Gross Square Meters
- HVAC: Heating Ventilation and Air Conditioning
- LEED™ v4: Leadership in Energy and Environmental Design, Version 4 (at Jan, 2020)
- MFA: Modelled Floor Area
- NASM: Net Assignable Square Meters
- OBC: Ontario Building Code
- PPR: Project Planning Report
- SB-10: Ontario Building Code Supplementary Standard SB-10: Energy Efficiency Requirements
- SD: Schematic design project stage
- TEDI-Heating: Thermal Energy Demand Intensity for Heating
- TEDI-Cooling: Thermal Energy Demand Intensity for Cooling
- TEUI: Total Energy Use Intensity
- TGS: Toronto Green Standards, (Version 3 2019 or as amended)

3 DEFINITIONS

3.1 **Archetypes**

The building use types, archetypes, are based on dominant uses found on the campuses. The Implementation Committee will typically determine the archetype for each space at the PPR stage for use in the Charter. Current performance target guidelines do not include all the occupancy types that exist or are being built at U of T. The following archetypes were developed based on current and typical building type and occupancies. These are as follows;

3.1.1 Academic:

Classrooms, study areas (not associated with Libraries), lecture halls, common rooms, multipurpose rooms, related academic purpose spaces. Student density specific, plug loads are low-medium density, lighting at desk top reading levels, occupancy levels fluctuate from low to high through the business hours of a day. Typically less than 18/7, weekend scheduling, special event scheduling, vacation time shut downs.

3.1.2 Offices:

Staff, faculty, grad offices and related areas. Plug loads are medium, lighting at desk top at reading levels, occupancy is low, potential for occupancy control. Typically less than 18/7/365, weekend scheduling, vacation time shut downs.

3.1.3 Wet Labs:

High ventilation spaces (fume hoods, dedicated general exhaust), high plug and process loads, high lighting levels, and occupancy fluctuates through the day, possible 24/7/365 operation.

3.1.4 Dry Labs:

High plug and process loads, low to medium ventilation loads, lighting at desk for reading to high level for drafting, occupancy fluctuates through the day, typically less than 24/7/365, weekend scheduling, vacation time shut downs.

3.1.5 Retail:

Sales areas, dining/seating and common spaces (usually associated with food related services), non-industrial scale kitchens (NB: Consider Wet Lab for large kitchen areas with high ventilation), medium plug loads, high lighting levels, occupancy fluctuates, tending to peak periods. Typically less than 18/7/365.

3.1.6 Residential:

Living quarters, amenity and common spaces, lobbies. Low to medium plug loads, low lighting levels, occupancy fluctuates through the day 24/7/365, high DHW loads, potential for occupancy control.

3.1.7 Athletic:

Exercise rooms, gyms, change rooms, locker rooms, multipurpose rooms, pools, lobbies. Medium plug loads, medium to high light levels, medium ventilation loads, high DHW loads, occupancy fluctuates through the day, possible 24/7/365, weekend scheduling, vacation time shut downs..

3.1.8 Libraries & Other:

Stacks, common and reading rooms, lobbies, study carrels. Low plug loads, medium to high light levels, occupancy fluctuates from low to medium through the day, potential for occupancy control in stacks, study spaces, possible 24/7/365, weekend scheduling, vacation time shut downs. Includes spaces not described by

the archetypes above such as F&S storage, staff rooms, low energy shops (no heavy tools, excess ventilation).

3.2 **Targets and Budgets**:

Targets are energy and GHG annual maximum indices in equivalent units/m^2/yr. These ratchet down every four (4) years. Budgets are calculated from the targets and GSM and define the maximum energy/GHG allowable budgets in equivalent units/year.

3.3 **Design Process Stage:**

Points at which the U of T Implementation Committee and Project Consultant Team design efforts require comprehensive modelling results and approvals. Note that "stage" and "milestone" are used interchangeably. A milestone usually referring to a deliverable action whereas a stage refers to a process.

3.4 **District Connected:**

A building that receives thermal energy (heating and/or cooling) from any of the U of T district energy systems. Buildings that receive some but not all thermal energy from a district energy system are considered district connected. The Charter requires that the district energy source be defined as from the steam plant (Steam District = Yes) or low temperature source such as recovered heat or heat pump (Steam District = No).

3.5 **Equivalent kW, ekWh:**

Equivalent kWh used to present different energy sources in a common unit based on accepted energy conversion factors from the Government of Canada. At site and includes delivery efficiencies. https://apps.cer-rec.gc.ca/Conversion/conversion-tables.aspx?GoCTemplateCulture=en-CA#1-7

3.6 **Greenhouse Gas Intensity (GHGI, kg $eCO_2/m^2/yr$):**

(As defined in the TGS Energy Modelling Guidelines) The total greenhouse gas emissions associated with the use of all energy utilities on site on a per area basis, using the emissions factors in Section 7.12 of this standard.

$$GHGI\ \left[\frac{kg\ eCO_2}{m^2 year}\right] = \frac{\Sigma\left(Site\ Energy\ Use\ \left[\frac{ekWh}{year}\right] \times Emissions\ Factor\ \left[\frac{kg\ eCO_2}{ekWh}\right]\right)}{Modelled\ Floor\ Area\ [m^2]}$$

3.7 **Major Renovation:**

Renovation projects that are anticipated to have a meaningful impact on the utility use of an existing building, which will be determined on a case-by-case basis by the U of T Implementation Committee.

Examples of major renovations could include cladding replacements or revitalization of the building, conversion of space use to a higher energy profile such as office to lab space.

3.8 Minor Renovation:

Renovation projects that are not anticipated to meaningfully impact the energy use of an existing building, as determined by the U of T Implementation Committee. Examples of minor renovations could include deferred maintenance replacement of HVAC, lighting upgrades, equipment or interior fit-out of tenant spaces.

3.9 Modelled Floor Area (MFA, m^2):

(As defined in the TGS) The total enclosed floor area of the building, as reported by the energy simulation software, excluding exterior areas and parking areas. All other spaces, including semi-heated (as defined under SB-10 2017) and unconditioned spaces are included in the MFA. The MFA must be within 5% of the gross floor area from the architectural drawings, unless justification is provided demonstrating where the discrepancy arises and why the MFA should differ from the gross floor area by greater than 5%.

3.10 Multiplier:

The multiplier is a gross-up factor used to convert NASM to GSM in building planning. The Gross-up accounts for all non-assignable areas as well as building structure and internal and externa wall assembly areas. The multiplier may differ between building space use types and is to be inputted by Campus and Facilities Planning in the PPR Form of the Charter.

3.11 New Construction Projects:

New building developments, including new additions to existing buildings, are considered new construction projects under this standard. Projects that require a Site Plan Approval are considered "New".

3.12 Non-District Connected:

A building that generates all of its thermal energy on site and does not receive thermal energy from any of the U of T district energy systems. Hybrid buildings (e.g., a building served by district heating and on site cooling equipment) are considered District Connected when calculating performance targets using the Project Charter.

3.13 Occupancy:

Calendar year when occupancy is scheduled to occur. Defines the targets in the Charter through the "Proposed Occupancy Date" cell.

3.14 Ontario Building Code (OBC):

The current Ontario Building Code at the time of the Project Implementation, as amended and required for building permit submission. Project Consultant and Implementation to take into consideration future upgrades for project occupancy beyond 2021.

3.15 Project Charter:

The Project Charter is a separately enclosed worksheet-style Excel document that outlines project-specific performance budgets/targets. The Charter establishes the required performance levels for each project and serves as a reference point during the design process. Prepared and presented with the PPR for architect and/or design team selection.

3.16 Project Consultant Team:

Typically consisting of: architectural, energy modelling, mechanical, electrical, plumbing consultants, etc., selected to complete the project. In the case of renovations, the Team may include internal engineering staff. U of T reserves the right to accept or reject any of the proposed consultants. The consultants carried in the RFP shall not be altered post-RFP submission without written acceptance by U of T.

3.17 Project Planning Report (PPR):

Specifies all desired building space program, functional requirements and/or special facilities consistent with the academic priorities and requirements. PPRs are prepared by U of T for all individual capital projects and Infrastructure Renewal Projects for which Project Committees are established.

3.18 Site Energy Use:

All energy used on site including all end-uses (e.g., heating, cooling, fans, pumps, elevators, parkade lighting and fans, and exterior lighting, etc.). It incorporates all site efficiencies, including the use of heat pumps or re-use of waste heat. Site Energy Use can be reduced using Site Renewable Energy Generation by applying the energy generation as a credit to the utility that is being avoided (e.g., electricity, natural gas, district energy). For design alternatives that include district energy connections, central utility plants, and/or thermal energy obtained from neighboring facilities, the generation energy (inclusive of thermal efficiency and associated losses) will be included as part of the Site Energy Use.

3.19 Site Renewable Energy Generation:

Energy generated on site from renewable sources, such as solar photovoltaics (PV), wind, or solar thermal. Where a site is not able to send energy off-site (e.g. connected to the electricity grid), only energy that can be consumed (or stored and then ultimately consumed) on site shall be counted as Site Renewable Energy Generation. Site Renewable Energy Generation can be used to reduce Site Energy Use before calculating TEUI and GHGI. The U of T is *not* considering the purchase of renewable energy or other carbon offset packages.

3.20 Total Energy Use Intensity (TEUI, ekWh/m²/year):

(As defined in the TGSv3 Energy Modelling Guidelines). The sum of all energy used on site (i.e., electricity, natural gas, and district heating and cooling), minus any Site Renewable Energy Generation, and divided by the Modelled Floor Area.

$$TEUI\ \left[\frac{ekWh}{m^2 year}\right] = \frac{Site\ Energy\ Use\ \left[\frac{ekWh}{year}\right]}{Modelled\ Floor\ Area\ [m^2]}$$

3.21 Thermal Energy Demand Intensity for Heating (TEDI-Heating, kWh/m²/year):

(As defined in the TGSv3 Energy Modelling Guidelines). The annual heating delivered to the building for space conditioning and conditioning of ventilation air. Measured with modelling software, this is the amount of heating energy delivered to the project that is outputted from any and all types of heating equipment, per unit of Modelled Floor Area. Heating equipment includes electric, gas, hot water, or direct expansion (DX) heating coils of central air systems (e.g., make-up air units, air handling units, etc.), terminal equipment (e.g., baseboards, fan coils, heat pumps, reheat coils, etc.) or any other equipment used for the purposes of space conditioning and ventilation. Heating output of any heating equipment where the source of heat is not directly provided by a utility (i.e., electricity, gas, or district energy) must still be counted towards the TEDI-heating. For example, hot water or heat pump heating sources that are derived from a waste heat source or a renewable energy source do not contribute to a reduction in TEDI-heating, as per the above definition. Specific examples of heating energy that are not for space conditioning and ventilation, which would not be included in the TEDI include: maintaining swimming pool water temperatures, outdoor comfort heating (e.g. patio heaters, exterior fireplaces), gas-fired appliances (e.g. stoves, dryers), heat tracing, etc.

$$TEDI\text{-}heating\ \left[\frac{kWh}{m^2 year}\right] = \frac{\sum Space\ and\ Ventilation\ Heating\ Output\ \left[\frac{kWh}{m^2 year}\right]}{Modelled\ Floor\ Area\ [m^2]}$$

3.22 Thermal Energy Demand Intensity for Cooling (TEDI-Cooling, kWh/m²/year):

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

$$TEDI\text{-}cooling\ \left[\frac{kWh}{m^2 year}\right] = \frac{\sum Space\ and\ Ventilation\ Cooling\ Output\ \left[\frac{kWh}{m^2 year}\right]}{Modelled\ Floor\ Area\ [m^2]}$$

3.23 Toronto Green Standard (TGS v3 in effect as of January, 2020):

The Toronto Green Standards version 3.0 (2017) is a tiered set of environmental performance measures that facilitate sustainable new developments in Toronto. The TGS version at scheduled Occupancy will be the defining version. https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/toronto-green-standard-version-3/

3.24 U of T Implementation Committee:

A project group made up of U of T staff and/or assigned personnel as required for the project with authority to develop and implement the project. The project manager assigned to the project by U of T shall be the main point of contact. The Implementation Committee must include a representative from Facilities & Services.

3.25 Ventilation loads:

Delivery of and removal of air is treated in different ways by the range of Standards and Guidelines. Ventilation is to be modelled as per design. Recognizing the impact ventilation has on the energy and GHG loads, the U of T requires that ventilation loads be broken out, when included in the models, and presented as indices on its own, ekWh/m, ² in order to assess the impact on the TEDI targets. The intention is to ensure the TEDI is representative of a superior envelope design without being lost in a high ventilation load such as large kitchens and laboratories. The ventilation index shall be prepared and presented separately for review and consideration by the Implementation Committee.

4 INTRODUCTION

4.1 Motivation and Intention

The University of Toronto (U of T) has committed to reducing its scope 1 and 2 GHG emissions across all three campuses to 37% below its 1990 level by 2030. This represents a reduction from 116,959 tonnes eCO_2/year in 1990 to 73,684 tonnes eCO_2/year by 2030 – eliminating 43,275 tonnes eCO_2/year across the University's portfolio – not including population and new building growth. This plan puts the university on the path to becoming a net-zero GHG institution by 2050. Achieving this goal calls for substantial reductions in energy consumption and resultant GHG emissions for both new construction, renovation projects and existing buildings. Accordingly, U of T has replaced the previously governing Energy Performance & Modelling Standard (April 1, 2019) with this new Tri-Campus Energy Modelling & Utility Performances Standard (July 1, 2020).

Energy and GHG reductions are more than cutting costs. U of T strives to provide high performance facilities as part of the core mission to provide world class research and higher education for its students, faculty and staff. These standards were developed to,

1. Target low carbon performance to achieve the 2030 goals and path to zero carbon 2050,
2. Anticipate and increase resiliency against future climate based changes,
3. Encourage long term high performance designs,
4. Reduce the performance gap between predicted energy/carbon performance and actual,
5. Engage planning and engineering staff with design teams,
6. Encourage the sound use of innovative designs and technologies,
7. Increase communication amongst stakeholders,
8. Right timing for optimum renovation impact,
9. Standardize the modelling inputs and compliance process and,
10. Increasing the recognition of the University as leaders in the transition to a low carbon, high performance organization.

This standard focuses on the energy modelling process that Project Consultant Teams must follow, in addition to the required levels of performance related to utilities (i.e., energy and water consumption) that all new construction and renovation projects must achieve. The performance targets have been formalized into this standard and a separately enclosed Project Charter to balance environmental stewardship with design efficacy.

Project Consultant Teams must meet the performance targets indicated in this standard and Charter and are encouraged to use creative and contextually-specific solutions based on the unique project characteristics of the design at hand.

The energy, comfort and carbon performance of the building, new or renovation, will vary. These Standards assist the design teams to be able to compare to other buildings with defined limits leading to a better prediction of performance after occupancy as well as on-going benchmark analyses.

These Standards are not meant to predict actual performance due to the range of variables – intensity, occupancy hours, occupancy behaviour, weather, as-built versus as-designed. The intention is to encourage

integration between the design teams and the University with a common goal of consistent, measurable high performance facilities.

4.2 Applicable Projects

U of T's ambitious GHG emission reduction target will require action and attention to optimizing the utility performance of all new and existing buildings. As such, this standard applies to all building projects on all three campuses of U of T. Wherever possible, this standard is intended to be performance-based, giving Project Consultant Teams the flexibility to implement creative, contextually appropriate solutions to meet the performance requirements outlined in this standard and the Project Charter.

New construction projects, including any new development or major addition(s) to an existing building, are expected to reach the performance thresholds outlined in Utility Performance Requirements for New Construction Projects.

Acknowledging the variety in scale of renovation initiatives, different requirements have been developed for "**minor renovations**" and "**major renovations**". Projects must meet the corresponding performance requirements outlined in the Utility Performance Requirements for Minor Renovation Projects and Utility Performance Requirements for Major Renovation Projects.

There are many nuances to the definitions of new construction, major and minor renovation. For this reason, the above is provided as a general guide, and projects will be categorized on an individual basis at the discretion of the U of T Implementation Committee. Baseline energy use will be determined by the U of T Implementation Committee.

4.3 Background on Standards Development

The performance metrics included in this standard were developed through an archetypal energy modelling process and a review of the current landscape of sustainability requirements in industry standards and guidelines, and in the sustainability standards of other leading post-secondary institutions.

A review of existing sustainability standards and guidelines was conducted to gather the performance metrics associated with energy and water efficiency. From this review, the leading performance metrics were selected for adoption into this standard, with the goal of including energy and water requirements that will help guide U of T towards achievement of their GHG emission reduction goals. These utility requirements have been formalized into this performance-based standard and the separately enclosed Project Charter.

The energy performance targets were developed using an energy modelling exercise that involved creating six archetype energy models based on the geometries and functional programming of representative U of T buildings (two additional are based on these basic six archetypes for a total of eight archetypes in the Tables).

These archetype energy models were iterated to explore the improvements in energy performance that could be achieved using technologies and systems that are available in the current market. Additionally, the opportunities for energy and GHG emission reduction in district-connected buildings were considered

separately from the opportunities in buildings with on-site thermal plant equipment. The archetype energy models are considered a proof of concept for the energy performance targets in this standard.

5 NEW CONSTRUCTION PROJECTS

5.1 Utility Performance Requirements for New Construction Projects

5.1.1 Energy

New construction projects must meet the project-specific energy performance targets and budgets established in the Project Charter. The requirements will be calculated using the archetype targets in tables 5.1.1, 5.1.2, and 5.1.3 and project information, including: planned building use, year of occupancy, presence of a connection to the U of T district steam or low temperature heating, and district chilled water energy systems. For buildings with mixed uses, the targets are area-weighted using the Project Charter to determine a set of performance targets that are representative of the building programming.

The Project Consultant Team must complete and submit an energy simulation, key performance indicators (TEUI, TEDI, GHGI) with associated documentation at each stage of the design process to demonstrate ongoing compliance with these performance targets.

At the completion of the commissioning, the simulation must be updated to reflect the as-constructed building characteristics. This will form the basis of the baseline performance.

5.1.1 New Construction: Targets for Scheduled occupancy dates between 2020 to 2022

Building Type	Thermal energy Source	TEUI	GHGI	TEDI - Heating	TEDI - Cooling
		ekWh/m²/yr	kg eCO_2/m²/yr	ekWh/m²/yr	ekWh/m²/yr
Academic	District Energy	105	16	40	25
	Non-District	80	6		
Office	District Energy	105	16	40	25
	Non-District	80	6		
Wet Labs	District Energy	510	50	100	100
	Non-District	430	30		
Dry Labs	District Energy	230	16	20	110
	Non-District	210	11		
Retail	District Energy	130	16	25	25
	Non-District	105	11		
Residence	District Energy	105	11	30	20
	Non-District	80	6		
Athletic	District Energy	112	16	40	35
	Non-District	85	6		
Library	District Energy	100	15	38	24
	Non-District	75	6		

5.1.2 Future Targets (2022 – 2030)

The targets will be revisited and adjusted regularly to ensure U of T remains in a leadership position. The progression of targets depends on numerous factors, many of which are outside U of T's direct control (e.g., the rate at which new technologies come to market). However, projects should anticipate the following adjustments for 2022-2026 (Table 5.1.2) and 2026-2030 (Table 5.1.3) for all the key performance indicators included in the standard.

5.1.2 New Construction: Targets for Scheduled occupancy dates between 2022 to 2026

Building Type	Thermal energy Source	TEUI ekWh/m²/yr	GHGI kg $eCO_2/m^2/yr$	TEDI - Heating ekWh/m²/yr	TEDI - Cooling ekWh/m²/yr
Academic	District Energy	97	15	37	23
	Non-District	75	5		
Office	District Energy	97	15	37	37
	Non-District	75	5		
Wet Labs	District Energy	470	46	95	95
	Non-District	395	28		
Dry Labs	District Energy	212	15	20	104
	Non-District	195	10		
Retail	District Energy	120	15	24	24
	Non-District	195	10		
Residence	District Energy	97	10	28	19
	Non-District	74	5		
Athletic	District Energy	103	15	38	33
	Non-District	78	5		
Library	District Energy	92	14	24	19
	Non-District	69	6		

The targets and resulting budgets in during scheduled occupancy between 2022 - 2026 are approximately 10% less than those in the Table 5.1.1. This assumes technologies, designs and construction capabilities will have improved in keeping with industry best practices to achieve high performance buildings.

5.1.3 New Construction: Targets for Scheduled occupancy dates between 2026 to 2030

Building Type	Thermal energy Source	TEUI ekWh/m²/yr	GHGI kg $eCO_2/m^2/yr$	TEDI - Heating ekWh/m²/yr	TEDI - Cooling ekWh/m²/yr
Academic	District Energy	78	12	30	18
	Non-District	59	4		
Office	District Energy	78	12	30	18
	Non-District	59	4		
Wet Labs	District Energy	376	37	76	76
	Non-District	316	22		
Dry Labs	District Energy	170	12	16	83
	Non-District	156	8		
Retail	District Energy	96	12	19	19
	Non-District	78	8		
Residence	District Energy	78	8	22	15
	Non-District	59	4		
Athletic	District Energy	82	12	30	26
	Non-District	62	4		
Library	District Energy	75	10	19	15
	Non-District	57	3		

The targets and resulting budgets assigned to scheduled occupancy between 2026 and 2030 are approximately 20% lower than those in Table 5.1.2 to account for increased capabilities of designers, technologies and the industry practices to meet net zero targets by 2030 in many jurisdictions, including the City of Toronto.

5.1.4 Air Leakage

Uncontrolled air in/ex-filtration is a significant and unpredictable energy load for the life of the building. The University shall require the envelope and air barrier provide a high performance reliable, continuous and durable air barrier for all designs.

All new buildings and whole building renovations must undergo air leakage testing following the U.S. Army Corps of Engineers Air Leakage Test Protocol for Building Envelopes, version 3 (May 11, 2012). The final air leakage testing results and report must be submitted to the U of T Implementation Committee, and the result used in the final occupancy energy model. See the U of T Utilities & Building Operations Commissioning Process for Overall Building Commissioning (refer to the Reference section for a link).

There is no maximum required whole-building air leakage rate for new construction projects; however, a target whole building air leakage rate must be presented and accepted by the U of T Implementation Committee at/during the Project Initialization before use in all design phase energy modelling.

Assumptions used by the energy modelling team as regards to air leakage shall be presented to the Project Consultants and Implementation Committee for description, consideration and review before being used in

the model. If a reduced infiltration rate is suggested, the project must commit to achieving the air tightness target and confirmed by mandatory air tightness testing.

Air leakage testing shall be completed by a third party, not associated with the Project Consulting Team proficient in these tests and the report(s) presented to the U of T Implementation Committee.

The results from any air leakage testing shall be made available to the energy modelling team as soon as possible to refine the air leakage factor inputs to complete the final model report.

5.1.5 Water

To further reduce GHG emissions, indoor and outdoor water consumption performance targets have been set in accordance with the higher levels of performance in LEED™ version 4 as follows:

- A minimum indoor water use reduction of 50% below the LEED™ version 4 baseline consumption; and
- A minimum outdoor water use reduction of 60% below the LEED™ version 4 baseline consumption.

The Project Consultant Team must submit a completed LEED™ v4 indoor water use reduction calculator and an outdoor water use reduction calculator to demonstrate the design fixture flush and flow rates will meet the required indoor and outdoor water use reductions. The current excel based LEED™ v4 calculators can be found online on the LEED™ New Construction website (refer to the Reference section for a direct link).

5.1.6 LEED™

The University requires that all new buildings and major renovations shadow LEED™ Silver compliance as a minimum. The Project Consultant shall prepare a LEED™ Scorecard illustrating that if the project were to pursue certification it would collect sufficient points to meet LEED™ Silver (50-59 points).

Maximizing points in the Energy & Atmosphere, Sustainable Sites, Water Efficiency, Indoor Environment, and Enhanced Commissioning shall be pursued.

The Project Planning Report and/or Project Initialization step will define if LEED™ certification is to be pursued.

5.1.7 Other Considerations

New construction will increasingly include multiple uses and occupancies resulting in “mixed use buildings”. As indicated, the energy performance targets and resulting budgets will be based on the area weighted aggregate as calculated by the Charter. Care is required when assigning the use areas when completing the Charter. For example, a large commercial kitchen would best be assigned as a wet or dry

lab depending on and to account for the high ventilation loads, a math lab might be closer to an office space as it likely only includes medium plug loads and lighting but not high ventilation.

Heat or energy recovery ventilators shall be modelled according to design even when the modelling software has limited capacity to predict energy performance. Sensible recovery efficiency is to be used to define the energy performance. If work-arounds are required, the Project Consultant shall describe the procedures used and the effect on energy calculations.

Thermal bridging shall be taken into consideration when the over-all thermal U-value of wall assemblies are defined. For energy modelling.

District Energy includes that energy supplied from a central steam or other gas fired network. For networks supplied from low temperature heating sources (heat pumps, heat reclaim energy) the non-district system targets and factors will be used. See Section 7.10 and 7.11for efficiencies and factors for these system applications.

5.2 Documentation Requirements for New Construction Projects

To ensure projects are developing in accordance with the utility performance requirements, documentation must be completed by the Project Consultant Team and/or the U of T Implementation Committee at each project milestone, table 5.2.1, below, summarizes the documentation that must be submitted at each milestone of a new construction project. For each documentation item, the expectations and responsible parties are outlined in sections that follow.

PPR: Project Planning Report. This document, prepared by U of T staff, contains the basic description of the project including program uses, planned NASMs, and anticipated occupancy date. This document is used to develop the scope of work for the design teams and is included in any request for proposals. It will include the energy Charter.

Project Initialization: The design team(s) and/or Project Consultant Team and U of T Implementation Committee have been established. At this point the energy performance criteria have been defined. In the case of renovations, the scope of work and target energy performance criteria have been defined and communicated to the teams. When available, existing energy/GHG use indices will be used to define the baselines for renovation projects.

SD: Schematic design. Typically considered a design at ~30% and includes sufficient detail for the modeling team to define the preliminary energy and GHG performance. This will give the Implementation Committee and Project Consultant sufficient indication of the energy performance direction and if designs require tuning in order to meet the defined targets.

DD: Detailed design. Typically considered a design at ~60% complete with major design elements defined. Energy modelling at this milestone will be based on refinements at the SD stage. At this milestone, major modifications to energy performance inputs should be confined to operational refinement; hours of operation and all envelope and energy systems design details are expected to be defined.

CD: Construction design. Considered construction ready documents. Minor modifications may occur at this milestone that should not significantly impact the design or performance of energy systems. The final model at this point is used as the baseline energy performance for post-occupancy evaluation.

Occupancy: The building has been commissioned and program use can begin. Any changes that are noted during the commissioning must be included in to the model and a revised model completed as the adjusted baseline. A post-occupancy energy performance evaluation will be completed by U of T facilities & Services staff. The energy and GHG performance indices will be compared to that delivered at the CD stage. *If the actual energy performance exceeds the predicted performance by more than 15%, the design team/modelers will be asked to comment and assist U of T to determine the possible reasons for the variation.*

5.2.1 New Construction: Documentation Submission Requirements by Project Milestone

Documentation	Project Stage					
	PPR	Project Initialization	SD	DD	CD	Occupancy
Project Charter – PPR Form	●					
Project Charter – Design Form		●				
Project Charter – Project Submissions Checklist		●	●	●	●	●
Energy Simulation Files			●	●	●	●
Energy Performance Report			●	●	●	●
Water Efficiency Worksheets			●	●	●	●
Summary of Changes from Previous Submission				●	●	●
Equipment Cut Sheets						●
Air Leakage Test Report						●

At multiple milestones in the design process, the Project Consultant Team will also be required to submit documents to the municipal Authority Having Jurisdiction. The municipal document submission requirements for Toronto and Mississauga align with the U of T project milestones as shown in Table 5.2.2:

5.2.2 Regulatory Submissions vs U of T Project Milestones

Regulatory Submission	U of T Project Stage
Zoning Bylaw Amendment / Official Plan Amendment (if required)	SD
Site Plan Control Application	DD
Building Permit	CD
Occupancy Permit	Occupancy

5.2.3 Project Charter

The Project Charter is a calculation tool to define the project-specific performance targets and resulting budgets and provide a central repository for the assumptions and design characteristics that drive the utility performance of buildings.

It is comprised of three parts: the PPR Form; the Design Form; and the Project Submissions Checklist. The Project Charter serves as a reference point throughout the design process to ensure the performance goals

are clearly understood by all involved parties and ultimately achieved. It is typically prepared by staff within University Planning, Facilities & Services and Property Management Design & Construction.

The Charter is defined no later than the start of Project Initialization and intended to inform the design teams of energy and GHG budgets for their understanding during the tender and selection process.

5.2.4 Project Planning Report (PPR) Form

The PPR Form of the Project Charter will be completed by the U of T Implementation Committee and provided to the Project Consultant Team. This will typically be included with the design team request for proposal for new and major renovations.

The PPR Form calculates project-specific performance targets based on attributes known at the PPR milestone, such as floor area and space use type. The PPR Form will be completed by Campus and Facilities Planning in consultation with Facilities and Services.

The equivalent for a minor renovation is a project scope description and typically prepared and presented at the Project Initialization stage.

The final PPR Form must be reviewed and approved by Facilities and Services (F&S) representatives listed in Table 5.2.5:

5.2.5 F&S Representatives for PPR Form Review

Campus	F&S Representative
St George	Paul Leitch, Director of Sustainability, St. George
Scarborough	Jeffrey Miller, Director of Facilities & Services, UTSC
Mississauga	Ahmed Azhari, Director, Utilities & Sustainability, UTM

5.2.6 Design Form

The Design Form of the Project Charter will be completed by the Project Consultant Team and reviewed and approved by the U of T Implementation Committee and F&S Representative.

The Design Form is used to confirm the utility performance targets that were established on the PPR Form and record the project characteristics that are drivers of utility performance. The Project Consultant Team must confirm the energy modelling software, weather file, and target whole building air leakage rate that will be used for the project.

In addition to the completion of the Design Form, the Project Consultant Team shall outline the intended energy modelling approach and reporting format, for approval by the U of T Implementation Committee.

5.2.7 Project Submissions Checklist

The Project Submissions Checklist included in the Charter summarizes the documentation requirements and creates a centralized summary of the utility performance metrics at each submission. The Project Consultant Team must complete and submit the checklist at each project milestone.

5.2.8 Energy Simulation Files

The Project Consultant Team must submit all model simulation files (input, output, weather files, and any external calculations) to demonstrate that the proposed design will achieve the required performance budgets as defined in the Project Charter.

All simulation data files and output formats must be accepted by the Implementation Committee before any subsequent design stages are initiated. A

The modelling team shall be prepared to implement any changes discovered during the commissioning that impact the energy performance and must be included into the energy model and the model updated to reflect actual as-built conditions and installed equipment.

When an energy simulation is used for any renovations (e.g., to size a new HVAC system) the results of the sizing exercise shall be presented to the Implementation Committee. Energy use indices shall be compared to existing building energy baseline indices, prepared and presented by the Implementation Committee.

5.2.9 Energy Performance Reports

The Project Consultant Team must submit an Energy Performance Report that includes the following:

- Reports are to be submitted at each design milestone;
- Summary of key energy model inputs, including any specific operational measures assumed or used that will impact the performance indices;
- Performance results for four key metrics (TEUI, GHGI, TEDI-Heating, and TEDI-Cooling);
- Ventilation loads presented as ekWh/m² to assess the impact on the TEDI budget;
- Building energy use broken down by end-uses and fuel type;
- Calculated whole-enclosure effective thermal performance (i.e. the area-weighted U-value) following the methodology outlined in TGS v3;
- Graph of annual hourly thermal demand with a table to report the peak heating and cooling demand (kW) and annual heating and cooling demand (kWh);
- Narrative and analysis describing the thermal autonomy of the building (i.e., the fraction of time that a building can maintain an acceptable indoor condition, despite the failure of active building systems);
- Description of air leakage control measures, including the modelled air leakage rate and all plans, measures, and protocols being implemented to improve enclosure air tightness;
- Design details and calculations for any on-site renewable energy generation;
- Explanation of any externally calculated energy performance; modelling software limitations;

- Any additional information that is provided as part of the project's submission to the Authority Having Jurisdiction;
- If LEED™ is not being pursued, illustrate how many points would be eligible for LEED™ Silver in the Energy and Atmosphere category.

5.2.10 Water Efficiency Worksheets

The Project Consultant Team must submit a completed LEED™ v4 indoor water use reduction calculator and an outdoor water use reduction calculator to demonstrate the design fixture flush and flow rates will meet the required indoor and outdoor water use reductions.

The current excel based LEED™ v4 calculators can be found online on the New Construction website (refer to the Reference section for a direct link).

5.2.11 Summary of Changes

For submissions that update previously submitted documentation, the Project Consultant Team must provide a summary narrative that clearly outlines any changes at any project design stage.

5.2.12 Equipment Cut Sheets

Cut sheets and documentation of the proposed and modelled equipment shall be presented to the U of T Implementation Committee during the Schematic Design stage to verify proposed energy performance opportunities.

Any changes to the proposed equipment must be approved by the U of T Implementation Committee.

5.2.13 Air Leakage Test Report

The project team may be required to complete an air leakage test during the construction. The energy modelling team shall be prepared to update the energy modelling based on actual air leakage testing results.

The air leakage tests, when specified, will be used to refine the air leakage factors in the energy modelling process. Per the U of T Commissioning Process, the Project Consultant Team must conduct whole-building air leakage testing. An air leakage testing report must be submitted to the U of T Implementation Committee using the reporting template found in Appendix A of the U.S. Army Corps of Engineers Air Leakage Test Protocol for Building Envelopes, version 3 (May 11, 2012), and the tested air infiltration rate must be used in the energy model at Occupancy stage.

A third party group, not in any way associated with the Project Consultant Team and expert in air leakage testing must be used. The results shall be made available to the energy modelling team as soon as they are

available. The energy modelling team shall use the actual air leakage test results for inputs to the energy performance model.

6 RENOVATION PROJECTS

6.1 Scale of Renovation Projects

The renovation of existing buildings plays a critical part in U of T's plan to achieve the established 2030 GHG emission reduction target.

As such, all renovation projects at U of T are expected to strive towards high performance energy, GHG, water efficiency and sustainability; however, the opportunity for GHG emission reduction varies as projects range in scope.

To accommodate this, the Standard has different requirements for minor and major renovations. Examples of minor renovation projects include but are not limited to: deferred maintenance, lighting or BAS upgrades or tenant fit-out. Major renovation projects include but are not limited to: space use conversion, whole-building revitalization, new windows or cladding replacement.

Each project will be designated Minor Renovation or Major Renovation by the U of T Implementation Committee, as approved by the F&S Representative listed in Table 6.1.1 below.

6.1.1 F&S Representatives for Renovation Designation

Campus	F&S Representative
St George	Paul Leitch, Director of Sustainability, St. George
Scarborough	Jeffrey Miller, Director of Facilities & Services, UTSC
Mississauga	Ahmed Azhari, Director, Utilities & Sustainability, UTM

6.2 Utility Performance Requirements for Minor Renovation Projects

The utility performance requirements for minor renovation projects form a prescriptive list, intended to accommodate a wide variety of project scopes.

Projects within this category are typically completed by Property Management, Facilities & Services. Typically Minor Renovations do not require an energy load calculation, e.g., lighting retrofits, low-flow water fixtures, high efficiency appliances, classroom furniture, thermostat refit.

Minor renovations are directed in cooperation with the internal engineering department. The scope will be defined at the Project Initialization step. Whenever the scope includes measures that impact energy use, high performance, low energy/GHG designs shall be pursued.

Alterations that include some HVAC modifications can border on major renovations. If an energy load calculation is required, energy targets presented here shall be included in the project scope. A baseline shall be defined using existing energy use indices where available for target comparison.

When the project scope has been defined to the Project Management team, the project consultants shall meet with Facilities & Services to determine the project as major or minor. See Tables 6.3.2, 6.3.3 and 6.3.4 for energy reduction targets for minor and major renovations.

6.2.1 Energy

Where applicable (e.g., there will be an impact on energy use), all minor renovation projects must meet the mandatory and prescriptive provisions of SB-10 Division 3 Chapter 2 "Additional Requirements to 2013 ANSI/ASHRAE/IES 90.1" for all improvements. In addition, projects must comply with all applicable requirements as follows:

- Provide a separate control zone for each solar exposure and interior space. Provide controls capable of sensing space conditions and modulating the HVAC system in response to space demand for all private offices and other enclosed spaces (e.g. conference rooms, classrooms). Refer to the LEED version 4 Reference Guide for Interior Design and Construction for more information (refer to the Reference section for a link).
- Reduce the connected interior lighting power density by 25% below that allowed by SB-10 Division 3 Chapter 2 as calculated using the space-by-space method.
- Install daylight-responsive controls in all regularly occupied daylit spaces within 4.5 m (15 ft) of windows and under skylights for at least 25% of the connected lighting load. Daylight controls must switch or dim electric lights in response to daylight illumination in the space.
- Design exterior lighting to meet Dark Sky criteria.
- Install occupancy sensors for at least 75% of connected lighting load.
- Install Energy Star appliances, office equipment, electronics, and commercial food service equipment for 100% of equipment and appliances.
- Comply with the requirements of SB-10 Division 3 Chapter 2 for the performance of all exterior building envelope components impacted by the renovation project.
- Comply with the requirements of SB-10 Division 3 Chapter 2 for the performance of all HVAC components impacted by the renovation project.
- When enhanced or improved controls are installed, energy conservation sequences including but not limited to time of day scheduling, night setback/day setup, and occupancy setpoints shall be included.

6.2.2 Water

Where minor renovation projects involve changes to water-consuming fixtures, water consumption must be reduced as follows:

- Indoor water use must be reduced by 50% below the LEED™ version 4 baseline consumption.
- Outdoor water use must be reduced by 60% below the LEED™ version 4 baseline consumption.

The project team must submit a completed LEED™ v4 indoor water use reduction calculator and an outdoor water use reduction calculator to demonstrate the design fixture flush and flow rates will meet the required indoor and outdoor water use reductions.

The current excel based LEED™ v4 calculators can be found online on the LEED™ New Construction website (refer to the Reference section for a direct link).

6.2.3 LEED™

LEED™ ID+C may be considered for renovation projects (minor and major) and also shadow LEED™ Silver minimum. U of T recognizes LEED™ may not always be applicable for minor renovations and assess on a project by project basis and announced to within the issue of any design or project implementation tender documents. If any renovation project requires an energy load model, LEED™ prescriptive compliance shall be considered. In all cases, the design team shall review the project scope in terms of LEED™ compliance by Project Initialization.

6.3 Utility Performance Requirements for Major Renovation Projects

The utility performance requirements for major renovation projects are intended to provide a performance-driven approach, rather than prescriptive, while accommodating a wide variety of project scopes, goals, and limitations.

Major renovations typically require a request for tender process with scope of work included to select an outside architect/engineering companies.

Project-specific energy and water reduction targets will be developed for each major renovation project based on renovation area and building use type and included in the project request for proposal.

This information will be recorded in the Project Charter. A major renovation can be comprised of multiple space use categories, and this is accounted for in the Project Charter using an area-weight approach.

6.3.1 Energy

To accommodate variety in the scope of major renovation projects, including building-specific constraints (e.g. heritage buildings) the components of major renovation projects have been categorized as follows:

1. Interior System Renovations: upgrades to the interior portions of the building (e.g., lighting upgrade);
2. Mechanical System Renovations: upgrades to the mechanical systems serving the building (e.g., heating system upgrade); and
3. Envelope Renovations: upgrades to the building envelope (e.g., window upgrade).
4. Space use conversion (e.g., from office to lab space)

Projects will be characterized into one or multiple of these categories when determining the performance requirements.

If the project will impact multiple building components, it will be held to the performance level of the most relevant renovation category, or the sum of multiple categories. For example, if an existing building is upgrading its interior and envelope systems, it will be required to meet the combined Interior and Envelope targets.

The category assignment will be done by the U of T Implementation Committee on a project-specific basis.

In addition, the renovation project areas will be assigned to an appropriate building type or mix of types. These building types follow the archetype building types used in New Construction targets.

The categorization and building type will be input to the Project Charter to calculate an energy use reduction that the project must achieve, using the per cent reductions listed in **Error! Reference source not found.**3.2, 6.3.3 and 6.3.4 depending on when the project is scheduled for occupancy. For buildings with mixed uses, the targets will be area-weighted using the Project Charter to determine a performance target that is representative of the building programming.

All renovation Targets are minimum requirements and relative to the baseline year energy performance calculated using actual utility data from the 12 months (min) prior to the project design start. If actual utility data is not available, an estimated energy use index can be calculated using a building from the same benchmark category or the TEUI targets in Table 5.1.1 "New Construction Targets for occupancy between 2020 to 2022".

The total project GSM area will be the sum of prorated areas and indices according to the use type found in Table 5.1.1.

Major renovation energy reduction targets are shown in Table 6.3.2;

6.3.2 Major Renovation: Targets for Scheduled Occupancy between 2020 to 2022

Building Type	Interior Renovations: Target % Reduction	Mechanical Renovations: Target % Reduction	Envelope Renovations: Target % Reduction
Academic	6%	30%	20%
Offices	6%	30%	20%
Wet Lab	2%	36%	3%
Dry Lab	5%	26%	5%
Retail	11%	26%	2%
Residence	12%	17%	17%
Athletics	9%	21%	16%
Library	6%	20%	20%

6.3.3 Future Targets

The targets will be revisited regularly (minimum annually) to ensure U of T remains in a leadership position.

How the targets step forward will be dependent on several factors, many of which are outside U of T's direct control (e.g., the rate at which new technologies come to market). However, projects should anticipate a step forward in 2022 and 2026, as shown in Tables 6.3.4 and 6.3.5.

It is the responsibility of both the U of T Implementation Committee to verify and specify which iteration is to be used for the targets and estimated energy/carbon budgets.

6.3.4 Major Renovation: Targets for Scheduled occupancy between 2022 to 2026

Building Type	Interior Renovations: Target % Reduction	Mechanical Renovations: Target % Reduction	Envelope Renovations: Target % Reduction
Academic	8%	33%	22%
Offices	8%	33%	22%
Wet Lab	3%	38%	3%
Dry Lab	6%	28%	6%
Retail	12%	28%	2%
Residence	13%	19%	19%
Athletics	10%	29%	18%
Library	7%	25%	22%

6.3.5 Major Renovation: Targets for Scheduled occupancy between 2026 to 2030

Building Type	Interior Renovations: Target % Reduction	Mechanical Renovations: Target % Reduction	Envelope Renovations: Target % Reduction
Academic	8%	38%	25%
Offices	8%	38%	25%
Wet Lab	3%	45%	4%
Dry Lab	6%	33%	6%
Retail	14%	33%	3%
Residence	15%	21%	21%
Athletics	11%	34%	20%
Library	8%	30%	25%

6.3.6 Water

Where major renovation projects involve water fixtures, water consumption must be reduced as follows:

- Indoor water use must be reduced by 50% below the LEED™ version 4 baseline consumption.
- Outdoor water use must be reduced by 60% below the LEED™ version 4 baseline consumption.

The project team must submit a completed LEED™ v4 indoor water use reduction calculator and an outdoor water use reduction calculator to demonstrate the design fixture flush and flow rates will meet the required indoor and outdoor water use reductions.

The current excel based LEED™ v4 calculators can be found online on the New Construction website (refer to the Reference section for a direct link).

6.3.7 LEED™

LEED™ ID+C may be considered for renovation projects (minor and major) and also shadow LEED™ Silver minimum.

U of T recognizes LEED™ may not always be applicable for minor renovations and will assess on a project by project basis and announced within the issue of any design or project implementation tender documents.

If any renovation project requires an energy load model, LEED™ prescriptive compliance shall be considered. In all cases, the design team shall review the project scope in terms of LEED™ compliance by Project Initialization.

6.4 Documentation Requirements for Renovation Projects

To ensure projects are developing in accordance with the utility performance requirements, documentation must be completed by the Project Consultant Team and/or the U of T Implementation Committee at each project stage.

Table 6.4.1, below, summarizes the documentation that must be submitted at each stage of a renovation project. For each documentation item, the expectations and responsible parties are outlined in sections that follow.

6.4.1 Renovation Documentation Submission Requirements by Project Stage

Documentation	Project Stage					
	PPR	Project Initialization	SD	DD	CD	Occupancy
Project Charter – PPR Form	●					
Project Charter – Design Form		●				
Project Charter – Project Submissions Checklist		●	●	●	●	●
Utilities Performance Report			●	●	●	●
Water Efficiency Worksheets			●	●	●	●
Summary of Changes from Previous Submission				●	●	●
Equipment Cut Sheets						●

6.4.2 Project Charter

The Project Charter has been developed to aid in the calculation of the project-specific performance targets and provide a central repository for the assumptions and design characteristics that drive the utility performance of buildings.

It is comprised of three parts: the PPR Form; the Design Form; and the Project Submissions Checklist.

The Project Charter serves as a reference point throughout the design process to ensure the performance goals are clearly understood by all involved parties and ultimately achieved.

Not all renovation projects require or prepare a PPR. The internal engineering department will prepare a scope of work to be completed and presented to the design team assigned.

All renovation Targets are relative to an approved baseline year energy performance calculated using actual utility data from the 12 months (min) before the project design start.

If actual utility data is not available, an estimated pre-project energy use index can be calculated from the existing building energy performance indicators for each space use, aggregated and applied to the area being renovated.

The energy and GHG use indices to calculate the baselines will be provided by the U of T Implementation Committee.

6.4.3 PPR Form

The PPR Form (or equal as a scope) of the Project Charter will be completed by the U of T Implementation Committee and provided to the Project Consultant Team.

The PPR Form will identify whether the project is a minor or major renovation project.

For major renovations, the PPR Form calculates project-specific performance targets based on renovation categorization, building use type, renovation project area, and historical building energy usage.

The PPR Form will be completed by Campus and Facilities Planning (or as assigned) in consultation with Facilities and Services. The PPR Form must be reviewed and approved by Facilities and Services (F&S) representatives as listed in Table 6.4.4:

6.4.4 F&S Representatives for PPR Form Review

Campus	F&S Representative
St George	Paul Leitch, Director of Sustainability, St. George
Scarborough	Jeffrey Miller, Director of Facilities &Services, UTSC
Mississauga	Ahmed Azhari, Director, Utilities & Sustainability, UTM

6.4.5 Design Form

The Design Form of the Project Charter will be completed by the Project Consultant Team and reviewed and approved by the U of T Implementation Committee and F&S Representative.

- For major renovations, the Design Form is used to confirm the utility performance targets that were established on the PPR Form and record the proposed calculation methodology.
- For minor renovations, the Design Form is used to confirm which prescriptive measures are applicable to the project.
- For minor renovations with HVAC renovations, the Design Form is used to describe the proposed baselines and proposed energy reductions.

In addition to the completion of the Design Form, the Project Consultant Team may be asked to outline the intended reporting format for approval by the U of T Implementation Committee.

6.4.6 Project Submissions Checklist

The Project Submissions Checklist summarizes the documentation requirements and creates a centralized summary of the utility performance metrics at each submission.

The Project Consultant Team must complete and submit the checklist at each project milestone.

6.4.7 Utilities Performance Report

The Project Consultant Team shall submit a Utilities Performance Report to the U of T Implementation Committee outlining how the proposed renovation will achieve the required energy and water reduction targets as defined in the Project Charter.

The Utilities Performance Report must include:

- Description of the renovation elements that will impact building energy and water consumption;
- Description of the baseline energy and how it was calculated;
- Demonstration that the prescriptive requirements are met by the proposed renovation (minor renovation);
- Energy and water reduction calculation results, demonstrating achievement of the reduction target (major renovation) based against the approved baseline energy/GHG use; and
- Description of the calculation methodology.

6.4.8 Water Efficiency Worksheets

When applicable, the Project Consultant Team must submit a completed LEED™ v4 indoor water use reduction calculator and an outdoor water use reduction calculator to demonstrate the design fixture flush and flow rates will meet the required indoor and outdoor water use reductions.

The current excel based LEED™ v4 calculators can be found online on the LEED™ New Construction website (refer to the Reference section for a direct link).

6.4.9 Summary of Changes

For submissions that update previously submitted documentation, the Project Consultant Team must provide a summary narrative that clearly outlines any changes and/or assumptions.

6.4.10 Equipment Cut Sheets

Cut sheets and documentation shall be prepared and presented to the U of T Implementation Committee during the Project Initialization phase. Any changes to previously submitted documentation shall be accepted by the U of T Implementation Committee before including into the design. Data sheets will be used to verify proposed energy performance opportunities and during project commissioning.

7 ENERGY PERFORMANCE MODELLING REQUIREMENTS

7.1 Compliance

New construction and major renovations projects must demonstrate compliance with the energy performance targets as defined in the Charter using computer-based energy modelling software packages. All building components must be included in the energy model and may not be excluded as a result of any prescriptive requirements.

7.2 Simulation Software Specification

The simulation software must meet the requirements set out in ASHRAE Standard 90.1-2013 Clause G2.2 and be verified according to ASHRAE Standard 140. The Project Consultant Team is responsible for ensuring the simulation program used meets the criteria for acceptance by the authority having jurisdiction (AHJ).

7.3 Acceptance of Modelling Process

The U of T Implementation Committee shall review and accept the modelling process, software, input parameters, output format, energy metrics and results. The modeler will provide the model input and output files at each submission for U of T review, acceptance, and use. Modelling software used for renewable energy systems shall be presented to the U of T Implementation Committee for approval before being used.

7.4 Inputs not specified

Modelling inputs not specified in these standards shall represent the actual designs. Modelling software limitations shall not limit the accuracy of the energy modelling to show compliance with the standards targets. Project Consultants are expected to overcome software limitations with best practices engineering calculations. All other modelling inputs not discussed in these standards shall be based on best practices engineering.

7.5 Modelled versus actual Results

The results of modelling to meet these standards are intended for both regulatory purposes (when required) and to determine whether a project design complies with the targets and budgets established by the Charter. Through standardizing the target setting and modelling process, the U of T will be able to compare performance between buildings and post-occupancy.

7.6 Resubmission of Performance Model

When the energy modelling submission or performance results are not accepted by the U of T Implementation Committee at any design stage, revised design model input parameters shall be implemented and rerun by the Project Consultant Team and resubmitted for approval before proceeding to the next design stage.

7.7 Minor Renovation Energy Model

Minor renovations may not require energy modeling except when HVAC systems are affected. Internal or external engineering services may be used to design the HVAC system upgrade (e.g., rooftop unit replacement).

Sizing modelling for HVAC upgrades/replacement shall be treated as energy performance modelling. Energy performance results shall be presented and compared to the calculated energy performance baselines.

7.8 Energy Performance Model delivery

The Project Consultants shall meet with the Project Management and F & S teams at Project Initialization to ensure the appropriate targets are defined. When an energy performance model is required to size the renovation, the model shall be presented to the U of T design team responsible and accepted before the renovation design is implemented.

In all cases, high performance and reduced GHG targets are to be pursued.

7.9 Model Input Modifications

The energy modelling team shall be prepared to modify inputs through the design process within reason. Modifications required as a result of design changes to meet the targets shall be carried out as within scope.

Alterations or parametric evaluation requested during the design process shall be discussed with U of T and the Project Consultant before the work is started and approved by U of T Implementation Committee.

They shall be prepared to revise the final energy performance model as a result of commissioning should the results of the commissioning indicate differences in design criteria that will materially affect the energy performance estimates.

Modelling tools or software shall not be changed during the project without approval by the U of T Implementation Committee.

7.10 Post Occupancy Evaluation

If the actual energy performance after 12 months of continuous operation exceeds the predicted performance by more than 15%, the design team/modelers will be asked to comment and assist U of T to determine the possible reasons for the variation.

7.11 Climate Data

Unless otherwise stated by the U of T Implementation Committee, the energy model shall use the following hourly weather data, in the form of Canadian Weather Year for Energy Calculation (CWEC_v_2016) datasets from the Government of Canada, available for free download at https://climate.weather.gc.ca/prods_servs/engineering_e.html.

- Projects on St. George and UTSC campuses shall use the CWEC_v_2016 file: CAN_ON_TORONTO-CITY_6158355_CWEC
- Projects on UTM campus shall use the CWEC_v_2016 file: CAN_ON_TORONTO-INTL-A_6158731_CWEC
- Where required, Climate Zone 6A shall be used. Note that this zone is showing a trend to a lower zone category.
- For projects beyond 2030, review of the zone category will be required and moving to zone 5A will be considered for use post-2030.

7.12 Greenhouse Gas Emission Factors

Projects shall use the greenhouse gas emission factors listed in the Ontario Building Code 2012 Supplementary Standard SB-10 2017 Division 3, Chapter 1, Table 1.1.2.2. "CO_2e Emission Factors." Electricity and natural gas emission rates are listed for convenience in Table 7.10.1 below. These factors may be subject to review and adjustment by U of T.

When renewable energy systems are installed, an annual marginal emissions factor shall also be used to calculate annual emissions avoided and presented along with the results of the emissions avoided using the factors in Table 7.10.1.

7.12.1 GHG Emission Factors

Fuel Type		Annual GHG Emission Factor	EF Units
Electricity	Purchased	0.043	kg CO_2/kWh
	On-site Generation	0.04	kg CO_2/kWh
	Marginal generation*	0.148	kg CO_2/kWh
Natural Gas		1.899	kg CO_2/m^3

*Marginal emissions factors will be calculated and presented in energy modeling reports as well as those from on-site generation. U of T will use this information internally and to report to AHJ as required.

7.13 Thermal Plant Equipment

Projects connecting to U of T district energy systems shall model the building using a "virtual plant" with the characteristics outlined in Table 7.11.1 below unless otherwise specified/approved by the Implementation Committee. Greenhouse gas emission factors are applied per Section 7.10 based on the listed fuel type.

7.13.1 District Energy System Connection Characteristics

District Connection	Virtual Plant Total Average Efficiency	Fuel Type	GHG Emission Factor
Heating	80% efficient	Natural Gas	1.899 kg CO_2e/m^3
Cooling	COP of 5.5	Electricity	0.050 kg CO_2e/kWh

Projects with on-site plant equipment shall be modelled according to the proposed mechanical design characteristics. For buildings with hybrid systems (e.g., district heating with on-site cooling), the district connections shall follow the above virtual plant characteristics while the on-site equipment shall match the mechanical design characteristics.

Hybrid buildings are considered "District Connected" when calculating performance targets using the Project Charter.

7.14 Other Modelling Requirements

The model should reflect U of T values for schedules, set points, occupancy density, and space loads so there is consistency between modelling phases.

The Project Consultant Team shall ensure the modelling variables required by U of T are completely understood and utilized.

If there is a reason to believe values for the modelled building will not be in alignment with the schedules defined in the Design Form of the Project Charter, the modeler shall bring this to the attention of U of T and propose more appropriate values.

The Project Consultant team shall not assume conventional occupancy schedules are always appropriate for U of T and shall be presented to U of T for verification before these are used in the models.

The Project Consultant Team must take responsibility for their ultimate approval.

7.15 Air infiltration Rate

During the design phases of the project, air infiltration shall be modelled at the target whole building air leakage rate for the project, as recorded in the Design Form of the Project Charter. The Occupancy Submission energy model must be modelled using the actual tested air leakage rate.

Note that air leakage test results are often normalized by the total envelope surface area, which is different than the above ground wall and window areas, due to the inclusion of floors and roofs. When converting from an air leakage test to modelled infiltration or vice-versa, the difference in surface areas must be accounted for.

Projects proposing reduced infiltration rates will be required to prepare and present documentation to support the use of and means to verify the lower rate. The University is interested in assessing the value of reduced infiltration rates and encourages the modeling team to prepare standard and reduced infiltration models to illustrate the effect on the energy and GHG budgets.

7.16 Enclosure Performance

The enclosure components must be modelled using effective thermal performance following the guidance in the TGS version 3 Energy Modelling Guidelines, "Calculating Envelope Heat Loss". Refer to the References section for a direct link.

8 REFERENCES

LEED™ for New Construction and Major Renovations, Version 4. Online, Available: https://www.usgbc.org/credits/new-construction/v4

LEED™ for New Construction and Major Renovations Indoor Water Use Calculator. Online, Available: https://www.usgbc.org/resources/indoor-water-use-calculator

LEED™ for New Construction and Major Renovations Outdoor Water Use Calculator. Online, Available: https://www.usgbc.org/resources/outdoor-water-use-reduction-calculator

LEED™ for Interior Design and Construction, Version 4. Online, Available: https://www.usgbc.org/credits/commercial-interiors/v4

Toronto Green Standard, Version 3 (2019). Online, Available: https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/toronto-green-standard-version-3/

Energy Efficiency Report Submission & Modelling Guidelines for the Toronto Green Standard (TGS) Version 3 (February 2019). Online, Available: https://www.toronto.ca/wp-content/uploads/2019/02/93d5-CityPlanning_V3-Energy-Modelling-Guidelines-Feb-2019.pdf

US Army Corps of Engineers Air Leakage Test Protocol for Building Envelopes. Online, Available: http://www.wbdg.org/FFC/ARMYCOE/usace_airleakagetestprotocol.pdf

University of Toronto Utilities & Building Operations Commissioning Process for Overall Building Commissioning, Available: https://www.fs.utoronto.ca/wp-content/uploads/standards/commissioning/BuildingCommissioningProcess.pdf

New Construction Project Charter

Input Cells

PPR Form

Project Characteristics

Project Name Sample

Proposed Occupancy Date 2022-2026

Programming Breakdown

Categorize the project's programmed areas as net assignable floor area ("NASM") into the appropriate use-types, following the descriptions provided below. Apply multipliers as appropriate to reach the total anticipated gross floor area ("GSM") of the project. When all space uses have been assigned, the total NASM and GSM should align with the PPR.

10.76 sq.ft./sq.m.

Space Use Types	NASM (m2)	Multiplier	GSM (m2)	Notes
Residence Space - including living quarters, amenity and common spaces, laundry rooms, etc.	1,250.0	1.0	1,250.0	
Retail Space - including sales area, kitchen, dining/seating area, servery, etc.	150.0	2.0	300.0	
Athletic Space - including exercise rooms, gymnasiums, change rooms, lockers, multi-purpose rooms, etc.	100.0	2.0	200.0	
Wet Laboratory Space - laboratory and lab support/storage spaces that have high ventilation exhaust requirements and high equipment power density.	0.0	2.0	0.0	
Dry Laboratory Space - laboratory and lab support/storage spaces that have high equipment power density but no ventilation exhaust requirements.	0.0	2.0	0.0	
Office Space - including staff, faculty & grad offices, and associated areas	2,000.0	2.0	4,000.0	
Academic Space - including classroom and lecture, meeting rooms, multipurpose academic spaces, etc.	1,000.0	2.0	2,000.0	
Library - stack, reading rooms, meeting rooms, study areas	100.0	1.0	100.0	
Other Areas - any spaces not attributed above	150.0	1.0	150.0	
Total (m2)	4,750.0		8,000.0	

Connected to District Steam System? No

"No"assumes heating by low temp source (<65C)

"Yes" assumes high temp heating (>65C)

Performance Targets

			Performance Budgets	
Total Energy Use Intensity	72.8	ekWh/m2/yr	582,019.8	ekWh/year
Greenhouse Gas Intensity	5.2	kg CO2e/m2/yr	41.3	tonnes CO2e/year
Heating Thermal Energy Demand Intensity	35.4	ekWh/m2/yr	283,128.7	ekWh/year. See Stds for definition
Cooling Thermal Energy Demand Intensity	22.7	kWh/m2/yr	181,544.6	ekWh/year. See Stds for definition
Indoor Water Use Reduction	50%			
Outdoor Water Use Reduction	60%			
On-Site Renewable Requirements	5%			

Charter Agreement

Name	Role	Initials	Date
Design Team Leader		AT	7/1/2020
F & S Team leader		PDL	7/1/2020