UNIVERSITY OF TORONTO

ENERGY MODELING STANDARD

PART 1: GENERAL

1.01 RELATED DOCUMENTS

A. U of T Mechanical Design Standards

B. U of T Electrical Design Standards

C. U of T Lab HVAC Systems Design Standards

D. U of T Commissioning Standards

E. U of T Building Automation Design Standards

F. Link to U of T Standards for these documents:

http://www.fs.utoronto.ca/DesignStandards/PartTwo

1.02 INTENT

1. Building energy performance modeling during the design of a new building shall serve several purposes as detailed below. The primary objective is to inform design decisions in a way that guides the designs toward the University's goals of sustainable energy efficiency, reduced carbon footprint and optimal long term building performance and comfort. It is recognized that the detail and resolution of the performance assessment through modeling will refine as the design progresses from concept through design development to tendering and then on-going measurement and verification. For this reason there will be performance model milestones to be completed that give the *Project Consultant Team* opportunities to revise the energy and comfort parameters and ensure the University of Toronto's goal of optimized energy efficient facilities is met.

2. The U of T Policy Statement of Energy Efficiency (Policy) requirements for new buildings, effective January 1, 2017, is that all new buildings shall have an energy use index at a minimum, 20% better than that calculated using ASHRAE 90.1 – 2013, Appendix G "Performance Rating Method". In addition, the *Project Consultant Team* shall present design options that could achieve 40% better energy performance compared to ASHRAE 90.1-2013 preferably with payback of 15 years or less for consideration by the *U of T Implementation Committee*.

3. If energy performance modeling is not required by Code or other legislation, these Standards shall apply, unless advised otherwise by *U of T Implementation Committee* in the project specific request for proposals.

4. The *U of T Implementation Committee* shall have the right to select the final performance modeling parameters and acceptable EUI's for total building and/or program specific areas.

5. Performance characteristics shall include those for energy systems, envelope systems, fenestration, air systems, water systems, on-site generation and occupancy criteria (e.g., operating schedules, special use criteria such as for labs).

6. An objective of this modeling guideline is to yield performance metrics that are consistently derived across the various project types and occupancies and can be subsequently measured, verified and benchmarked using actual metered utility data.

7. It is the responsibility of the *Project Consultant Team* to acknowledge and follow the most current version of these Standards.

8. Modeling forms a part of design deliverables of the *Project Consultant Team*. Performance characteristics shall be reviewed and accepted by the *U of T Implementation Committee* before the design proceeds to subsequent design phases and post occupancy evaluation.

9. Results of the energy modeling may be used to perform Life Cycle Cost Analyses and/or Parametric analyses. Models of up to (3) three design options for the energy and water systems, including but not limited to HVAC systems, heat recovery systems, dedicated outside air systems, outside air reduction schemes, fenestration, envelope systems and on-site energy sources may be requested as defined by *U of T Implementation Committee* as specified in the request for proposals on a case by case basis.

10. Because of the uncertainty of energy prices and the lifetime of typical components, life cycle cost analysis for energy purposes will typically be done over a 20-year period. The *U of T Implementation Committee* shall define the discount rates and the acceptable Rate of Interest/Return on Investment (ROI) and lifetimes to be used for any LCCA analyses required.

11. The *Project Consultant Team* shall coordinate monitoring/metering equipment and systems required for measurement of the utilities with *U of T Implementation Committee*. U of T Facilities & Services shall be included whenever sub-metering is required for post-occupancy energy performance verification.

12. *U of T Implementation Committee* and the *Project Consultant Team* will agree upon a Measurement & Verification Plan (M&V Plan) at the Schematic Design Phase.

1.03 DEFINITIONS

1. Energy Utilization Index (EUI): Energy Utilization (or Use) Index is the measure of the energy consumed in a building or load, expressed as energy per gross square meter of building area, typically equivalent kWh/gross square meter, GJ/GSM or MMBTU/GSM.

2. ekWh: energy, Equivalent kWh used to present different energy sources in a common unit based on accepted energy conversion factors. EUI's are calculated and presented as ekWh.

3. Design Phases: Points at which the *U of T Implementation Committee* and *Project Consultant Team* design efforts require increasingly more in depth and comprehensive design decisions progressing from Project Initiation/Early Schematic Design through Schematic Design to Design Development and Construction Documents followed by post-occupancy evaluation. Each design phase requires sign off by the *U of T Implementation Committee* before moving on to the following phase.

4. M & V Plan: Measurement and verification planning document, following current International Performance Measurement & Verification Protocol, Concepts and Options for Determining Energy and Water Savings.

5. *U of T Implementation Committee*: A project group made up of U of T staff and/or assigned personnel as required for the project and any other parties as defined by the U of T with authority to develop and implement the project within U of T Design Standards.

6. *Project Consultant Team*: team of experts typically consisting of architects, modeling consultants, mechanical, electrical, plumbing consultants, etc., selected to provide guidance, designs, drawings, tender documents, contracts as specified by *U of T Implementation Committee* for the project. The *Project Consultant Team* shall not be altered without notification and acceptance by *U of T Implementation Committee*.

7. ASHRAE 90.1 – 2013; the Standard used as the basis for building component design parameters to meet minimum compliance for the U of T Policy using the "Performance Rating Method", Appendix G. The modeling program used for the baseline and proposed building shall meet the requirements in this Standard.

8. ASHRAE 140 – 2014; "Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs", the basis for acceptance of modeling tools used to assess energy performance.

9. LCCA: Life Cycle Cost Analysis is the preferred method for deciding which system and/or technology to implement in the design that results in the lowest life cycle costs. The cost of carbon shall be included in the analysis. LCCA shall include capital cost, maintenance, utility escalation, supplied by *U of T Implementation Committee* and operating cost including cost of renewal. The LCCA format shall be accepted by the *U of T Implementation Committee* before it is used.

10. Ontario Building Code (OBC): the current Ontario Building Code (2017) as required for permitting at the time of permit submission. The *Project Consultant Team* shall recognize that the OBC is updated (typically) on a three year cycle and accommodate designs in anticipation of updates that might take place during the permitting process.

11. Toronto Green Standards (TGS): the (current) Toronto Green Standards vs 2.0 (2017), Tier 1 which applies to any new building in the City of Toronto. The *Project Consultant Team* shall recognize that the TGS is (typically) updated within 12 months of any OBC update or revision. The *Project Consultant Team* shall be aware of this possibility and accommodate their designs in anticipation of updates that might take place during the permitting process.

1.04 BACKGROUND

1. The University of Toronto has committed to reducing energy use and carbon emissions associated with campus operations. The U of T Policy Statement of Energy Efficiency Policy (1.02.2) specifies that energy use in new buildings shall be lower than that required by ASHRAE 90.1-2013 by between 20% and 40% based on the Performance Rating Method in Appendix G (40% if those design changes can be demonstrated to have a 15 year or less payback). Designs that result in performance levels at the higher end of this scale shall be preferred.

2. The University of Toronto requires designs for most major structures with a >75 year life. Many existing structures in the University's portfolio are now in excess of 100 years old. The University of Toronto, as the owner and operator of those structures, bears the full lifetime operating costs, which in present value terms, is many times the initial cost of the building.

3. *U of T Implementation Committee* shall review and approve of all project energy performance criteria and metrics as a part of the design phase sign-off milestones.

4. As an element for achieving this goal, the University of Toronto is looking to significantly reduce the electrical and thermal energy use of buildings, new and existing, across University of Toronto campuses. New buildings are the focus of this effort, though energy conservation and optimized utilization is paramount for all designs.

5. Energy utilization indices (EUI) represent simulated/metered energy use metrics typically as ekWh/GSM for building end uses (see 2.03.B.3 for typical end use categories). At each design phase model submission, the *Project Consultant Team* will be expected to submit the energy model with EUI's to test the energy performance for alignment with U of T Policy and standards.

6. Buildings on Campus are typically a mix of space use/occupancy types within a common envelope; EUI values for specific occupancy types shall be calculated based on the specific use net square foot area for the programmed occupancy. The final EUI value for the facility shall be an aggregate of those EUI's to the entire building gross area.

1.05 MODELING OBJECTIVES

1. Energy modeling coupled with Life Cycle Cost Analyses will serve as tools throughout the design phases to evaluate design options and make appropriate choices that support the University of Toronto's pursuit of sustainable reduced energy use and lower carbon footprint with long term built space comfort.

2. Modeling and results may be used for LEED certification. The *Project Consultant Team* will be notified during Project Initiation/Early Schematic Design if LEED certification is to be formally pursued.

3. The model shall be suitable for use by *U of T Implementation Committee* to predict building energy costs for budget planning and life cycle costs. Utility costs and escalations will be supplied by *U of T Implementation Committee*.

4. Modeling process, software, input parameters, output format, energy metrics and results shall be reviewed and accepted by the *U of T Implementation Committee* prior to Schematic Design Phase initiation.

   Modeling of renewable energy or on-site energy generation shall present monthly estimates for a typical meteorological year. Simulation tools are to be reviewed and accepted by *U of T Implementation Committee* prior them being used.

1.06 ENERGY PERFORMANCE MODELING SOFTWARE

1. Preference is given to computer based energy modeling software that meets, is approved and listed by ASHRAE 140 "Standard Method for the Evaluation of Building Energy Analysis Computer Programs". The most recent version of EnergyPlus (≥ vs8.6) as supported by the US Dept of Energy (DOE) is the basis for acceptance.

2. The use of other or custom modeling software packages shall be approved and accepted by the *U of T Implementation Committee* upon specific request and before the simulation software is used for any project energy modeling and performance evaluation.

3. The *Project Consultant Team* is responsible for ensuring the simulation program used meets the criteria for acceptance by the permitting process as required by the OBC and the Toronto Green Standards, Tier 1 when within the City of Toronto jurisdiction.

4. The *Project Consultant Team* will make available the input and output files and parameters used to define the energy performance in the simulation program for *U of T Implementation Committee* review, acceptance and use.

5. The *Project Consultant Team* shall prepare and submit energy performance simulation results that reflect the project at Schematic Phase, Tender Design and Commissioning Phase to the *U of T Implementation Committee* for acceptance and sign-off before moving on to any subsequent design phases. Any changes to the model input parameters as determined by *U of T Implementation Committee* shall be implemented by the *Project Consultant Team* and resubmitted for approval.

1.07 CLIMATE DATA

1. The performance modeling tool shall us hourly climate data as supplied by the Government of Canada for Toronto City, Climate ID #6158355 at St. George campus; Toronto Int'l, Climate ID #6158731 at Mississauga campus; Toronto North York, Climate ID #615S001 at Scarborough campus. Deviation from using these data sets requires acceptance by the *U of T Implementation Committee* prior to being used at any stage.

2. The *U of T Implementation Committee* shall verify and accept the typical meteorological year to use for the performance simulations (both utility use and on-site generation).

PART 2: ENERGY MODELING REQUIREMENTS

2.01 *PROJECT CONSULTANT TEAM* SCOPE OF SERVICES

1. The following information clarifies the expectations with regard to energy modeling for the *Project Consultant Team* proposing work on U of T buildings.

2. The *Project Consultant Team* is responsible for all aspects of the energy modeling required by these Standards and must coordinate their work and sign off with the *U of T Implementation Committee* only.

3. Where there is any discrepancy or need for clarification, it is the responsibility of the *Project Consultant Team* to notify and request such clarification from the *U of T Implementation Committee* before proceeding.

4. The *Project Consultant Team* will assist *U of T Implementation Committee* in making sound capital investments during the design and construction of a structure so as to reduce the life cycle operating costs, energy use and carbon emissions. Where the present value of the reduction in operating cost exceeds the amount of the construction cost increase, and it meets with payback criteria, that design approach should be used to minimize the life-cycle operating cost. In performing life-cycle analysis, the design life of components or systems should never be less than the analysis period and typically 20 years unless otherwise stipulated by *U of T Implementation Committee*.

5. Mention is made in this Standard for parametric and/or modification model runs. The *Project Consultant Team* should anticipate up to three (3) model runs at each design phase following the Project Initiation/Early Schematic design phase at the request of the *U of T Implementation Committee* to refine design considerations and/or establish the better of available design options.

2.02 ENERGY PERFORMANCE MODELING PLAN

1. The *Project Consultant Team* responsible for the energy performance modeling shall present an energy modeling plan that describes the intended modeling approach through the course of design phases and after the building has been occupied and fully commissioned.

2. This plan must be approved by the *U of T Implementation Committee* prior to starting the Schematic Phase, and shall be consistent with these U of T Energy Modeling guidelines. The plan shall define the following for each phase of modeling submissions:

    i. Model inputs that are required and anticipated to be known or assumed at that point of design.

    ii. Modeling software to be used and how the data/parameter files will be presented and delivered to *U of T Implementation Committee*.

    iii. The anticipated building and system options that will be evaluated at each phase, including options considered but not pursued or recommended to be pursued

    iv. Model result level of detail, format and presentation method.

3. The *Project Consultant Team* shall be prepared to provide a LCCA for a minimum two preferred proposed options at the Schematic Design Phase. If there is major change to the proposed design in the subsequent Design Phases LCCA shall be updated as a part of the performance modeling and evaluation.

4. Energy (and on-site generation if applicable) modeling results shall be provided and updated at each Design Phase.

2.03 PROJECT INITIATION/EARLY SCHEMATIC DESIGN PHASE

1. Intent: During this phase, *U of T Implementation Committee* and the *Project Consultant Team* will be making decisions that impact building site, orientation, glazing, HVAC, occupancy schedules, envelope and massing concepts. The intent of Project Initiation/Early Schematic Design Phase energy performance is to assess the potential impact on subsequent design modeling phases and better define the starting point for the Schematic Phase modeling.

2. Considerations for Project Initiation/Early Schematic Design Phase elements for modeling;

    a. Orientation and Massing: the shape and envelope mass of the building for impact on heating and cooling loads.

b. Fenestration: fenestration/wall ratios, insulation levels, solar for gains and lighting.
c. Envelope insulation: the effect of wall and roof insulation levels on heating and cooling loads.
d. HVAC: Systems suitable for the project by the *Project Consultant Team* and reviewed and accepted by the *U of T Implementation Committee* for initial modeling and design comparison to be completed in the Schematic Design phase.
e. Operating Hours: proposed operating hours and occupancy levels through a typical year, including holidays and other down-time scheduling. If there is a reason to believe schedules for the modeled building will not be in alignment with the schedules defined by the *U of T Implementation Committee*, the *Project Consultant Team* will bring this to the attention of the *U of T Implementation Committee* for clarification.
f. Provide key input assumptions. Assumptions and minimum efficiencies shall be in line with ASHRAE 90.1 – 2013 Appendix G "Performance Rating Method" to ensure an understanding of the parameters to be used during the design analysis process.
g. Where renewable energy systems or on-site generation is being considered, the simulation tool and assumptions shall be reviewed and accepted by *U of T Implementation Committee* before it is used.
h. The *Project Consultant Team* shall endeavour to present maximum energy efficiency solutions for the project at the Project Initiation/Early Schematic Design Phase.
i. Modeling output formats to be reviewed by *U of T Implementation Committee*

3. The *Project Consultant Team* shall present the modeling results as ekWh and ekWh/GSM for the following loads:

    a. Monthly sub-metered loads. For both electrical (kWh) and thermal (ekWh) loads;
        i. Lights
        ii. Internal equipment loads
        iii. Service water heating equipment
        iv. Space heating equipment
        v. Space cooling and heat rejection equipment
        vi. Fans and other HVAC equipment (such as pumps)
        vii. On-site energy generation

    b. Carbon emissions, equivalent tonnes eCO_2 for the total project. *U of T Implementation Committee* will provide carbon conversion factors for the utilities required or as displaced by on-site or renewable energy systems.

    c. Utility costs and escalation factors will be provided by *U of T Implementation Committee*.

4. The *Project Consultant Team* shall recognize that a LCCA may be required for up to three energy efficiency options during the design process. The *Project Consultant Team* shall be prepared to allow for a LCCA during the following design phases in order to gain a full understanding of the design implications and to inform selection of the building systems /envelope before moving into Design Development and Construction Design Phase.

2.04 SCHEMATIC DESIGN PHASE (≤ 30% design)

1. The energy modeling during this phase is required to support informed decisions and to test that the design is on track with U of T Policy Statement of Energy Efficiency. Relevant design decisions to be made during this phase affect, but not limited to, the envelope, fenestration areas and performance, HVAC systems, ventilation loads, water systems, control sequences of operation, criteria for space conditions, occupancy schedules, lighting systems, anticipated plug loads and on-site generation.

2. The *Project Consultant Team* shall allow for up to three (3) energy model parametric runs to tune the selections such that the U of T Policy will be met. Variations of the building components (e.g., glazing, insulation, HVAC, domestic hot water, process loads, plugs loads, lighting systems) will be evaluated either as parametric comparisons or as additional runs of the model.

3. All energy modeling parameters and results to be presented to *U of T Implementation Committee* for acceptance and sign-off before moving on to the next design phase.

A. Modeling Requirements

a. Mechanical Systems: *Project Consultant Team* to allow for up to three (3) HVAC system types to be considered at the Schematic Design Phase. The *U of T Implementation Committee* shall approve system types to ensure that range and/or variety is sufficient to make them individually "significant" for comparison and potential for LCCA evaluation.
b. Envelope – Conduct a parametric study of wall insulation values and fenestration options/trade-offs to optimize the energy performance of the total envelope with the capability of using outputs for a LCCA evaluation.
c. Ventilation - Airflow Reduction Strategies to reduce outside air requirements and air change rates while maintaining minimum fresh air.
d. Lighting – Reduction of electric lighting power density and use of daylighting as much as possible. LED lighting is the default technology for design including lighting control strategies for each space, such as occupancy, dimming and daylight sensors.
e. Renewable energy/on-site generation. Prepare monthly renewable energy and on-site energy generation estimates where

included. All on-site energy generation shall be considered as "displacement" energy.

f. Buildings that are not served by the University of Toronto central utility grid (steam, high temperature water, chilled water at St. George Campus) should allow for modeling of alternate heating and cooling systems, such as ground source heat pumps as well as extension and use of the Campus central utility systems if it is available.

B. Simulation Input Assumptions:

a. Provide key input assumptions for review by *U of T Implementation Committee*.
b. Provide any calculations that support assumptions (e.g., R-value calculations, HX performance, boiler performance, COP, etc.).
c. Using the Building Performance Rating Method modeling protocols as detailed in Appendix G of ASHRAE 90.1-2013, present a preliminary baseline building model for benchmarking.
d. All associated energy use and costs must be included. This baseline model should establish basic load calculation parameters using the Schematic Design.
e. Identify energy requirements based on the programmatic needs and project goals.
f. The model shall reflect *U of T Implementation Committee* supplied occupied/unoccupied schedules, temperature setpoints, occupancy density, and specific space loads so there is consistency between modeling phases. If there is a reason to believe schedules for the modeled building will not be in alignment with the schedules defined the *Project Consultant Team* will bring this to the attention of the *U of T Implementation Committee* and agree on alternate use schedules for review and acceptance.

C. Simulation Output:

a. Life Cycle Cost Analyses (LCCA) when specified;
   i) Energy systems alternatives (up to three (3) versions) shall be evaluated using a life cycle cost analysis. The energy model shall be used to determine difference in energy performance between options.
   ii) Operating and maintenance costs and the project costs shall provide input on the capital and renewal cost over the life cycle term.
   iii) The *U of T Implementation Committee* will define financial input parameters to be used for LCCA calculations and output format.
   iv) The objective of the LCCA when used is to determine the

optimum design for lowest EUI and long term operating costs.

b. Parametric Analysis
   i) Where high performance components are being considered, parametric analyses may be required to justify the use. This analysis is not a complete run of the building model but is a differential analysis of the performance improvement and cost premium for this component.
   ii) Examples of components that may best be evaluated by a parametric analysis are: heat recovery options, glazing options, wall and roof insulation, chiller, boiler, high efficiency fume hoods.

D. Monthly energy consumption by utility;
   a. Chilled Water (MMbtu and ekWh)
   b. Electricity (kWh)
   c. Steam (MMbtu and ekWh)
   d. Natural Gas (M3 & ekWh)
   e. Water (M^3)

E. Peak energy demand by utility. Indicate estimated peak units and time of year peak is expected;
   a. Chilled Water (MBH & tons)
   b. Electricity (kW)
   c. Steam (MBH)
   d. Natural Gas (M3)

F. Monthly sub-metered loads. For both electrical (kWh) and thermal (ekWh) loads;
   a. Lights, kWh
   b. Internal equipment loads, kWh
   c. Service water heating equipment, kWh
   d. Space heating equipment, kWh and ekWh
   e. Space cooling and heat rejection equipment, kWh and ekWh
   f. Fans and other HVAC equipment (such as pumps), kWh
   g. On-site energy generation, kWh and ekWh as applies

G. Energy consumption and demand by utility and as a total facility aggregate ekWh/GSM/yr.

H. Monthly energy cost estimates, in design year dollars, by utility. Utility rates to be supplied by *U of T Implementation Committee*.

I. Monthly carbon footprint eCO_2 tonnes are to be calculated using conversion factors supplied by *U of T Implementation Committee* for each utility.

J. The *U of T Implementation Committee* shall conduct a review of the energy performance model results in relation to the project goals and U of T Policy. *U of T Implementation Committee* will sign off on all energy models before the next phase of modeling is started.

2.05 DESIGN DEVELOPMENT (≤60%)/CONSTRUCTION DOCUMENTS PHASE (≤ 90% design)

1. The intent of performing an energy model at these phases is to test that the design is on track to meet the U of T Policy Statement of Energy Efficiency before the project is tendered.

2. The *Project Consultant Team* shall allow for revised energy model runs with up to three (3) variations based on possible modifications to accommodate changes made between SD Phase and DD / CD Phase.
    a. Simulation Input Assumptions: All energy models run at this phase shall be defined as required in the approved SD Phase listed above with revised inputs as defined at sign-off.
    b. Simulation output for energy performance models at this phase shall be as required in the approved SD Phase listed above with revised inputs and outputs at sign-off.

3. The *U of T Implementation Committee* shall conduct a review of the energy model results from the revised simulation parameters to ensure the model is compatible with the U of T Policy Statement of Energy Efficiency.
    a. Any discrepancies between the approved SD model results and the DD/CD Phase model results shall be reconciled with the *U of T Implementation Committee* and approved or require further justification before proceeding to the issue of tender documents.

4. Design Development and Construction Documents Phase model outputs shall be presented to *U of T Implementation Committee* as in 2.04 – D to I inclusive.

2.06 POST OCCUPANCY/COMMISSIONING PHASE (@ 12 months min. post occupancy)

1. *U of T Implementation Committee* will compare energy performance results with the Construction Document Phase model results using actual metered energy use with a minimum of 12 months of post occupancy data, or to coincide with the time period prescribed in an approved Measurement & Verification Plan.

2. The results of this assessment will be shared with the *Project Consultant Team*, who will provide the following post design services to the *U of T Implementation Committee*:

    a. If results are within 10% of total energy use and metered use is consistent with the Construction Document Phase model, no

further follow up will be required. The M&V Plan is signed off by the *Project Consultant Team* and U of T.

b. If results vary from the model by 10 – 20% of total energy use, or metered use is not consistent with the model results by utility source. The *Project Consultant Team* shall respond in a written report to reconcile the discrepancies. The M&V Plan between *U of T Implementation Committee* and the *Project Consultant Team* is still in place.

c. If results vary by more than 20%, the *Project Consultant Team* shall conduct a building energy audit at a minimum of ASHRAE Level 2; participate in a reconciliation session, and issue a written report detailing their findings to the *U of T Implementation Committee* and recommendations as to how to remedy the discrepancies. The M&V Plan is still in place.

d. On completion of detailed reports (in ii and/or iii above) by the *Project Consultant Team, U of T Implementation Committee* and *Project Consultant Team* will meet to decide if the reconciliation measures warrant the sign off of the M&V Plan between the *Project Consultant Team* or if further effort outside of the M&V Plan is required to establish why the variation between Construction Document Phase results and actual performance differ.

e. Given the variation of energy supply for solar, on-site or other renewable energy systems, the *Project Consultant Team* is not accountable to variations in annual system performance.