Energy Efficiency Report Submission & Modelling Guidelines

For the Toronto Green Standard (TGS) Version 4

City of Toronto

Environment and Energy Division & City Planning Division

Effective May 1, 2022

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1.0 Introduction

The Toronto Green Standard ("TGS") is a tiered set of performance measures with supporting guidelines for new development. The standard promotes sustainable site and building designs that address air quality, greenhouse gas emissions, energy efficiency, water quantity and quality, ecology and solid waste objectives for new developments in the city of Toronto.

New planning applications, including Zoning Bylaw Amendments, Site Plan Approval and Draft Plan of Subdivisions are required to meet Tier 1 of the TGS performance measures. Developers who choose to meet Tier 2 or higher (voluntary levels of environmental performance), may be eligible for a partial refund on Development Charges paid to the City. More information is available on the City of Toronto Development Charge Refund Program website.

The TGS v4 Buildings Energy, Emissions and Resilience section of the TGS sets out greenhouse gas intensity caps and energy performance targets for large buildings (i.e. buildings that follow Part 3 of the Ontario Building Code). The submission of a Design Development Stage Energy Report ("DDSER") is required to demonstrate compliance with the TGS.

This guideline outlines the energy modelling and reporting that is required by the TGS version 4 ("TGS v4"), with the aim of standardizing DDSER and compliance documentation submissions. It describes the information and supporting documents that are required to be provided to allow for a clear understanding of the energy conservation measures to be applied to the new development, and the simulation process is undertaken to achieve the energy performance claimed.

Please be advised that the City has the sole discretion to accept or reject a Design Development Stage Energy Report submitted for compliance with Toronto Green Standard requirements.

1.1. Definitions

Building – A wholly enclosed structure used or intended for supporting or sheltering any use or occupancy. Buildings that are subject to the practices outlined in this Guideline include Part 3 buildings under the Ontario Building Code, with the exception of industrial and warehouse buildings according to the OBC SB10 section 1.2. Application.

Clear Field Assembly – An opaque wall or roof assembly with uniformly distributed thermal bridges, which are not practical to account for on an individual basis for U-value calculations. Examples of thermal bridging included in the Clear Field are brick ties, girts supporting cladding, and structural studs. The heat loss associated with a Clear Field assembly is represented by a U-value (heat loss per unit area).

Greenhouse Gas Intensity ("GHGI") – 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 3.3 of this guideline. GHGI shall be reported in kg eCO_2/m^2/year.

$$GHGI\left[\frac{kgCO_{2e}}{m^2a}\right] = \frac{\sum\left(Site\ Energy\ Use\ \left[\frac{kWh}{a}\right] \times\ Emissions\ Factor\ \left[\frac{kgCO_{2e}}{kWh}\right]\right)}{Modelled\ Floor\ Area\ [m^2]}$$

Interface Details – Thermal bridging related to the details at the intersection of building envelope assemblies and/or structural components. Interface details interrupt the uniformity of a *clear field assembly* and the additional heat loss associated with interface details can be accounted for by linear and point thermal transmittances (heat loss per unit length or heat loss per occurrence, respectively). Examples of linear interface details include intermediate floor junctions, balconies, wall-to-roof transitions, and window-to-wall transitions. Examples of point interface details include structural columns and beams that protrude from the building envelope.

Mechanical and Electrical Design Brief – Dated description of the intended mechanical and electrical design, intended efficiencies, and ventilation strategies, on the engineering consultant's letterhead.

Modelled Floor Area ("MFA") – 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%.

Notice of Approval Conditions ("NOAC") – This letter is officially issued by the Community Planning Director. The NOAC lists and secures all approved plans, drawings and reports and provides any additional pre-and post-approval conditions that need to be cleared prior to *site plan approval* and registration of the site plan agreement.

Site – The *building*(s) and all associated area where energy is used or generated. A site may include one or more buildings, either as independent structures or interconnected. For the purposes of these guidelines, sites containing multiple buildings may be divided into separate sites where desirable, and larger sites may be required to divide sites by block or parcel.

Site Energy Use – All energy used on site including all end-uses, such as heating, cooling, fans, pumps, elevators, parkade lighting and fans, and exterior lighting, among others. It incorporates all site efficiencies, including the use of heat pumps or re-use of waste heat, but does not include energy generated on site.

Site Plan Approval – An approved *Site Plan Control Application* (SPA) is awarded Site Plan Approval.

Site Plan Control Application ("SPA") – Site Plan Control Application is required in accordance with the City of Toronto Site Plan Control Bylaw in effect, for the majority of lands undergoing change across the city of Toronto.

Site Renewable Energy Generation – Energy generated on site from renewable sources, such as solar or wind, solar thermal, and geo-exchange. Where a site is not able to send energy off-site (e.g. connected to the electricity grid), the only energy that can be consumed (or stored and then consumed) on site shall be counted as Site Renewable Energy Generation.

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

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 (stoves, dryers), heat tracing, etc. TEDI shall be reported in kWh/m^2/year. Provide supporting documentation using Appendix C.

$$TEDI\left[\frac{kWh}{m^2 a}\right]=\frac{\sum Space\ and\ Ventilation\ Heating\ Output\left[\frac{kWh}{a}\right]}{Modelled\ Floor\ Area\left(m^2\right)}$$

Total Energy Use Intensity ("TEUI") – The sum of all energy used on site (i.e. electricity, natural gas, and district heating and cooling), minus all *Site Renewable Energy Generation*, and divided by the *Modelled Floor Area*. TEUI shall be reported in kWh/m^2/year.

$$TEUI\left[\frac{kWh}{m^2 a}\right]=\frac{\sum Site\ Energy\ Use\left[\frac{kWh}{a}\right]-\sum Site\ Renewable\ Energy\ Generation\left[\frac{kWh}{a}\right]}{Modelled\ Floor\ Area\left(m^2\right)}$$

1.2. Acronyms Used in this Guideline

ACSER – As-Constructed Stage Energy Report

ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers

DDSER – Design Development Stage Energy Report

EED – Environment and Energy Division

GHGI – Greenhouse Gas Intensity

MURB – Multi-Unit Residential Building

NECB – National Energy Code of Canada for Buildings

NOAC – Notice of Approval Conditions

OBC – Refers to the Ontario Building Code 2012

SB-10 2017 – Refers to the Ontario Building Code 2012 Supplementary Standard SB-10 2017

SPA – Site Plan Control Application

TEDI – Thermal Energy Demand Intensity

TEUI – Total Energy Use Intensity

TGS – Toronto Green Standard

1.3. TGS v4 Energy Requirements Overview

The Toronto Green Standard Version 4 ("TGS v4") is effective for any Site Plan Control Application ("SPA") submitted on or after May 1, 2022, that is greater than 2,000 m^2 gross floor area. Three development features within TGS v4 pertain to buildings emissions and energy efficiency requirements: GHG 1.1, GHG 1.2, Mid to High Rise and Non-residential standard and for City-owned Facilities greater than 100 m^2 gross floor area.

1.3.1. Absolute Performance Targets Pathway

The absolute performance targets pathway establishes a minimum performance level for proposed buildings that match one of five available building archetypes, with targets for Total Energy Intensity ("TEUI"), Thermal Energy Demand Intensity ("TEDI"), and Greenhouse Gas Intensity ("GHGI") – refer to Appendix D for the description of archetypes and targets. There is no reference building under this pathway. All buildings that match these archetypes should follow this pathway. City Agency, Corporation & Division-owned Facilities shall be designed to demonstrate the net zero energy and emission requirement.

Note that according to OBC SB10 Section 1.2. Application, industrial and warehouse buildings are exempt from the TGS energy performance requirements to maintain consistency with the Ontario Building Code ("OBC"). The applicant is responsible for providing building classification confirmation for exemption purposes.

1.3.2. Relative Performance Targets Pathway

Any buildings that do not match the archetypes outlined in Appendix D should follow the relative performance targets pathway. This pathway establishes a minimum performance level for buildings that are outside of the defined archetypes (e.g. hospitals, or schools).

This pathway requires demonstrated energy savings over a code-compliant reference building to show compliance with TGS. The *OBC 2012 Supplementary Standard SB-10 2017* ("SB-10 2017") Division 3 is used as the reference code for TGS v4. A 25% improvement over SB-10 2017 is required for Tier 1, and a 35% improvement for Tier 2.

City Agency, Corporation & Division-owned Facilities shall be designed to demonstrate the net zero energy and emission requirement.

1.4. Rationale

This guideline is provided to assist design teams in meeting the new TGS v4 performance targets. Requiring energy performance analysis at the SPA submission stage facilitates the following key outcomes:

- Early consideration of the potential impact of various design strategies on energy performance to reduce energy costs and stresses on the electrical grid.
- Use of the building architecture and passive design strategies to minimize energy consumption, improve occupant comfort and provide thermal resilience during power disruptions.
- An integrated design process, by collaborating on ideas, issues, and concerns early in the design process to help avoid later redesign activities to meet energy efficiency and greenhouse gas reduction goals.
- Allows the design team and owner(s) to make informed decisions about the most effective strategies to reduce energy use, emissions and costs and to consider design development of low energy, low emissions buildings.

The stepped absolute performance targets are intended to reduce energy use from buildings to near zero emissions by 2030 within the city of Toronto. By promoting better design and more efficient buildings, TGS v4 will help Toronto reduce its energy and emissions footprint and assist in achieving City-wide and provincial GHG reduction targets of net zero by 2040.

Detailed information on the rationale and development of the new targets can be seen in the *City of Toronto Zero Emissions Buildings Framework*.[1]

2.0 Submission Requirements

For buildings greater than 2,000m^2, compliance with TGS v4 requires the submission of a Design Development Stage Energy Report ("DDSER") at SPA. For projects targeting the higher voluntary targets (Tier 2 or 3 projects), an As-Constructed Stage Energy Report ("ACSER") is also required to be submitted directly to one of the City's prequalified third-party project evaluators, registered with the City of Toronto. The ACSER will be necessary to document compliance with TGS Tier 2 (or above) requirements and to demonstrate consistency from design through to construction. Once the ACSER has been reviewed, a representative from the third-party project evaluator will conduct a site visit to ensure that equipment has been installed per the report.

[1] The City of Toronto Zero Emissions Buildings Framework. Prepared for the City Planning Division, City of Toronto, by EQ Building Performance, Morrison Hershfield, and Integral Group. 2017. Accessed from the City of Toronto Planning Division website.

A separate DDSER is required for each individual building. Some examples are as follows:

- If one SPA submission contains two physically separated buildings served by two separate mechanical plants, **two** reports will be required.
- If one SPA submission contains a single building with two physically separated towers with a shared podium.
    - If the building is served by a single mechanical plant, **one** report would be required.
    - If the building is served by two mechanical plants (e.g., one per tower, and a split podium), **two** reports will be required.
    - If the building is served by three mechanical plants (e.g., one per tower, and one for the podium), **three** reports will be required.
- If one SPA submission contains a single building served by two separate mechanical plants (e.g., top and bottom), **one** report will be required.

Project-specific guidance can be obtained from the EED prior to SPA submission. For projects targeting Tier 2 or above, a separate ACSER is required for each individual building.

2.1. Design Development Stage Energy Report Submission

The DDSER is aligned with design stage drawings, information, and reports available during SPA. At this stage, it is understood that some of the building design-specific details about the various equipment and other required inputs are not finalized. The applicant is to provide sufficient information and supporting documents to describe the energy conservation measures to be applied to the project, including measures related to the followings:

- Building configuration
- Orientation
- Building envelope
- Glazed area
- Solar control, such as external shading devices
- System selection and major mechanical and electrical energy decisions.

Where a building system or part of a building system has not been fully specified, it shall be assumed and modelled as equal to the prescriptive requirements of SB-10 2017. Reasonable assumptions around mechanical and electrical systems are permitted and should be documented in the Mechanical and Electrical design briefs.

2.1.1. Timing of Design Development Stage Energy Reports

The submission of an energy model at SPA provides an important initial indication of a project's ability to meet the TGS requirements. It is expected that the project's performance as modelled at SPA will be maintained (or improved) throughout the remainder of the design and construction process. To ensure the project's compliance with the TGS, the design team will need to leverage their past project experience in order to understand and foresee the implications of select design decisions that have not yet been finalized by the SPA stage.

It is expected that energy models submitted at SPA will be reflective of the systems that are likely to be designed and built and that any performance liabilities have already been understood and mitigated in the form of the assumptions used in the energy model.

While energy models are encouraged to be started as early in the design process as possible to maximize impact on design, the DDSER is only required to be submitted prior to Notice of Approval Conditions ("NOAC"), and once all minimum required documentation is available. It is recommended that project teams aim to submit the DDSER during the first SPA submission.

2.1.2. Documentation Requirements

Submit the DDSER to City Planning in conjunction with the SPA submission and prior to approvals.

The DDSER is to include the following:

- Workbooks (Appendices)
  - TGS Energy Efficiency Report (Appendix-A1 or A2), completed and signed by an Energy Modeller (C.E.T., B.E.M.P., or Professional Engineer) and a licensed Architect
  - TGS Energy Modelling Simulation Summary Report (Appendix-B1 or B2)
  - TGS Thermal Energy Demand Intensity (TEDI) Documentation (Appendix-C)
- Energy Modelling Report
- Electronic simulation files
- Mechanical and Electrical Design Brief
- Related supporting drawings and calculations
- Thermal Bridging Calculations
  - Typical details for opaque clear fields including the wall, roof, and window assemblies, along with area takeoff and transmittance value calculations and sources
  - Transmittance values of the selected glazing. Example: Frame Plus screenshot to demonstrate the transmittance values of the selected glazing
  - Typical linear interface details with takeoff and transmittance value calculations and sources
  - Show the effective R-value using a thermal performance calculator, preferably the Building Envelope Thermal Bridging Guide (BETBG) calculator
  - Include the envelope consultant's signature within the submission to confirm the claimed thermal bridges
- Other documents as may be required

2.2. As-Constructed Stage Energy Report Submission

The ACSER reflects the building's final design including any changes made during the construction phase. The ACSER may be evaluated by a third-party contracted by the City of Toronto. The ACSER is required for buildings targeting Tier 2 or above levels of performance and that have applied to the City's Development Charge Refund program.

2.2.1. Timing of As-Constructed Stage Energy Report

The ACSER should be submitted after occupancy begins and once all necessary shop drawings are available to create the energy model. It should reflect the building's final design including any changes made during the construction phase in accordance with the As-Built drawings or Issued for Construction drawings with applicable site instructions.

As a part of the ACSER review, a third-party project evaluator will conduct a site visit to ensure that equipment has been installed as per the design documentation. The evaluator cannot conduct this review while the project is still considered a construction site. The ACSER should be submitted so that the site review can be completed within a reasonable timeframe of the model review being completed.

2.2.2. Submission Requirements

The ACSER is to include the following:

- Workbooks (Appendices)
  - TGS Energy Efficiency Report (Appendix-A1 or A2), completed and signed by an Energy Modeller (C.E.T., B.E.M.P., or Professional Engineer) and a licensed Architect
  - TGS Energy Modelling Simulation Summary Report (Appendix-B1 or B2)
  - TGS Thermal Energy Demand Intensity (TEDI) Documentation (Appendix-C)
- Energy Modelling Report
- Electronic simulation files
- Modelling Notes: General, Building Level, Plant Level, System Level, Occupancy and Minimum Outdoor Air Rates and Warnings, Errors and Troubleshooting.
- Take-off Calculations (Modeller's external calculations to support the model input). If applicable, the calculation for model work-around, exceptional calculations, process energy savings, renewable energy systems, district energy systems, or other required calculations.
- Zoning Diagrams.
- Outdoor Air calculation spreadsheets.
- Architectural, Mechanical, and Electrical Drawings and Specifications (issued for construction/as-built).
- Product cut sheet(s) / spec sheet(s) / shop drawings for installed energy efficient measure(s).
- Declaration template filled in by the energy modeller confirming that the as-constructed energy model incorporates the equipment, schedules, operations, etc. as described in design documentation, and also signed by the Architect, Mechanical and Electrical Engineers/Consultant confirming that the equipment installed on site is as per the design documents and energy modelling report.
- Thermal Bridging Calculations
  - Typical details for opaque clear fields including the wall, roof, and window assemblies, along with area takeoff and transmittance value calculations and sources

- Transmittance values of the selected glazing. Example: Frame Plus screenshot to demonstrate the transmittance values of the selected glazing
- Typical linear interface details with takeoff and transmittance value calculations and sources
- Show the effective R-value using a thermal performance calculator, preferably the Building Envelope Thermal Bridging Guide (BETBG) calculator
- Include the envelope consultant's signature within the submission to confirm the claimed thermal bridges

- Other documents as may be required

3.0 Building Simulation Details

The reference building performance shall be calculated according to SB-10 2017 Division 3, using a computer simulation model for the entire building project. See Section 3.1 for accepted software.

The proposed design must meet the following requirements and criteria:

- Toronto Green Standard requirements.
- Comply with the mandatory provisions of the current OBC and any of its referenced energy codes.
- Inclusion of all the building energy consumption within and associated with the building project.
- Compare against a baseline building that conforms to SB-10 2017 (only applicable to buildings following the relative performance targets pathway).

The simulation model must comply with the following

- Designed to meet the energy performance targets of TGS v4; AND
- City of Toronto Energy Efficiency Report Submission & Modelling Guidelines; AND
- ANSI/ASHRAE/IESNA Standard 90.1-2013 as modified by SB-10 2017 Division 3 Chapter 2 (as applicable); OR
- National Energy Code of Canada for Buildings 2015 as modified by SB-10 2017 Division 3 Chapter 3 (as applicable).

Note: Tier 3 targets (near zero emissions), may also be applied and substituted for Tier 2 levels of performance. Alternative compliance options will be accepted for Tier 2 and 3 TGS including the CaGBC Zero Carbon Building Standard or Passive House Standards Certification. An energy model and report that meets the requirements of this guideline must be submitted as part of the DDSER. As part of the ACSER, alternative documentation may be accepted, as approved by the City Planning Division and the third-party project evaluator on a case-by-case basis.

3.1. Acceptable Energy Modelling Software

The simulation program shall meet the requirements as set out in ASHRAE 90.1-2013, G2.2.

Energy Model should be completed using the following software:

- eQUEST version 3.64 or higher
- Energy Plus
- IES Virtual Environment
- Passive House Planning Package only for the projects pursuing Passive House Standards Certification

3.2. Weather File

Projects shall use a Toronto CWEC 2016 or later Weather File.

3.3. Greenhouse Gas Emission Factors

Emission factors are sourced from Environment and Climate Change Canada's National Inventory Report (NIR).

3.4. Role of the Modelling Guidelines

For buildings pursuing the relative performance targets pathway, these guidelines are intended to be used in addition to rules for energy performance modelling as written in the reference standard selected for compliance. In the event of overlap between these guidelines and the modelling rules for proposed buildings in the chosen energy code, the following conditions shall apply:

a) Spaces where heating or cooling capacity has been purposely undersized, or where there is no heating or cooling equipment, shall be modelled as per the design. These spaces do not need to be modelled as fully-conditioned and do not contribute to annual unmet hours.

For buildings pursuing the absolute performance targets pathway, these guidelines are intended to be used in addition to rules for energy performance modelling as written in the energy code selected for compliance. In the event of overlap between these guidelines and the modelling rules for proposed buildings in the chosen energy code, the following conditions shall apply:

a) Spaces where heating or cooling capacity has been purposely undersized, or where there is no heating or cooling equipment, shall be modelled as per the design. These spaces do not need to be modelled as fully-conditioned and do not contribute to annual unmet hours;
b) Components of the building envelope shall be modelled per Section 5.5 with full thermal bridging accounted for.
c) Design ventilation rates (not minimum code requirements) shall be modelled.

3.5. Modelled Vs Actual Results

The energy models provided to indicate compliance with the TGS will be used for regulatory purposes only. The energy model is not a prediction of the actual energy consumption of the proposed design after construction. Actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, and precision of the energy modelling tool.

In addition to varying from actual energy use, the standardized assumptions used may vary from those used in other rating systems or modelling guidelines, which will create differences in modelled performance. As noted above, the standardized inputs in these guidelines were developed to facilitate comparison with absolute targets and between projects. The use of common values also ensures that modelled results for the performance metrics used by the Toronto Green Standard are accurate and consistent, given their sensitivity to changes in input parameters. For this reason, some assumptions may be higher or lower than other references and may be updated in future versions of this guideline.

4.0 TEDI

4.1. Understanding TEDI

TEDI has been a metric to the Toronto market since it was introduced to TGS version 3 in 2018 based on the City of Toronto's *Zero Emissions Buildings Framework*[2]. TEDI Targets, or Thermal Energy Demand Intensity and also known as 'Heating Demand,' are included in some of the most progressive building codes and voluntary standards (such as Passive House), which have demonstrated consistent energy savings over time. Heating demand is also used as a key metric in building performance requirements in Switzerland, Denmark, and other European nations. Canadian programs that have also incorporated TEDI metrics include the City of Vancouver's Zero Emissions Building Plan and the Canada Green Building Council's Zero Carbon Buildings program.

The use of a thermal energy demand metric requires building designers to optimize building characteristics related directly to heating demand, which are not prioritized under current and conventional economic criteria (e.g. low utility rates and short payback terms). The goal of such optimization is to improve thermal comfort, enhance building resilience, and future-proof buildings by integrating measures that are difficult or expensive to retrofit in the future. The two primary outcomes that low TEDI values achieve are associated with 1) architecture and 2) ventilation. Architecture, orientation, solar access, building envelope performance, and other passive design measures must be addressed to ensure a low TEDI. With regard to ventilation: efficient delivery and waste heat recovery are also captured by the TEDI metric, and are measures that are best implemented in new construction (rather than existing buildings). Initial TGS performance limits have been developed such that both architectural and ventilation measures

[2] The City of Toronto Zero Emissions Buildings Framework. Prepared for the City Planning Division, City of Toronto, by EQ Building Performance, Morrison Hershfield, and Integral Group. 2017. Accessed from the City of Toronto Planning Division website.

must both be addressed to levels of best practice, while further reductions of TEDI are possible through additional improvements to either measure or both.

Below is an expanded description of how TEDI is to be calculated for compliance with the TGS, what it includes in more specific detail, and how this is impacted by certain mechanical system choices. Note that in the event that building design involves situations that are not specifically accounted for below, the above-noted definition should be used to guide calculations and energy model inputs.

4.2. Calculating TEDI

Under most circumstances, TEDI can be fairly simple to understand and to determine or calculate from energy models. However, when complex HVAC systems are used (e.g. heat pumps that recover waste heat, or VAV systems that use reheat energy), the concept of TEDI can be more challenging to understand. It is important to note that TEDI is intended to represent the heat delivered to the building, including any extra heat that may be required due to the use of HVAC systems (e.g. reheat energy in VAV systems). It also represents any heat provided by waste heat sources (e.g. recovered heat from cooling systems, waste heat supply from cogeneration, etc.). As such, the methodology presented below shall be used in all cases to determine or calculate TEDI from energy models to ensure consistency, regardless of HVAC system type used.

TEDI shall be determined using the same energy model run, inputs, and assumptions as those used for determining the Performance Limits and that comply with the guidelines. Determining TEDI does not require any changes to energy models or additional energy modelling runs, other than what is required to comply with the Performance Limits and the guidelines. Thus, internal gains from people, receptacles, fans, and motors are all inherently included through the energy model in the calculation of TEDI.

When measured with modelling software, TEDI is the amount of heating energy delivered to the project that is outputted from any and all types of heating equipment, per unit of Modelled Floor Area. Heating equipment includes:

- Electric, gas, hot water, or DX heating coils of central air systems (e.g. make-up air units, air handling units, etc.);
- Terminal equipment (e.g. baseboards, fan coils, heat pumps, VRF terminals, reheat coils, etc.), and/or;
- Any other equipment used for the purposes of space conditioning and ventilation.

The heating output of any heating equipment that uses a source of heat that is not directly provided by a utility (electricity, gas, or district) must still be counted towards the TEDI. For example, heating from heating coils of any type that use a heat source derived from waste heat (e.g. from a cooling system or process such as a heat pump or VRF terminal unit, cogeneration waste heat that serves a building hot water loop connected to those heating coils) or a renewable energy source (e.g. solar thermal hot water collectors) must still be counted towards the TEDI.

While every software has different reporting features, TEDI can be calculated by summing up the heating output of all the heating coils in the building.

Specific examples of heating energy that are not for space conditioning and ventilation and therefore would not be included in the TEDI include but are not limited to:

- Maintaining swimming pool water temperatures
- Outdoor comfort heating (e.g. patio heaters, exterior fireplaces)
- Gas-fired appliances (stoves, dryers)
- Heat tracing

The documentation required for TGS submission is found in Appendix C.

5.0 Absolute Performance Targets Pathway Modelling Guidance

****This section of the report is only applicable to buildings pursuing the absolute performance targets pathway as defined in Section 0. All projects following the relative performance targets pathway shall follow the applicable reference standard as specified in Section 6.0.**

5.1. Introduction

This section of the Energy Modelling Guideline is intended to provide clarity on the energy modelling inputs necessary to show compliance with absolute performance targets pathway, as established by the TGS v4. The guideline has been developed to provide guidance for the five primary building types that fall under the purview of the TGS:

1) High-Rise Multi-Unit Residential;
2) Low-Rise Multi-Unit Residential;
3) Commercial Office;
4) Commercial Retail; and
5) Mixed-Use.

This section outlines the definitions, calculations, and allowable assumptions to meet the absolute performance requirements for TGS v4 Tier 1 through 3 energy performance requirements. The specific objectives are to:

- Standardize and clarify inputs to ensure that modelled building performance is comparable between projects with fixed performance limits, and;
- Reduce the portion of the performance gap that is not skewed by occupant behavior between energy models and the actual operating performance of buildings.

This section outlines standardized energy modelling inputs that may have a large impact on the achievement of the TGS performance targets, but are not integral to building system performance (e.g. schedules). It also clarifies and specifies modelling inputs where current industry practice for modelling those inputs does not support the intended outcomes of the TGS (e.g. failure to properly account for total envelope heat loss via thermal bridges). To further reduce performance gaps, this section may be updated in future versions with additional modelling guidance or to further calibrate standardized best practices.

This document is not intended to be an exhaustive set of technical and administrative requirements or best practices for energy modelling. Design-related modelling inputs not specified in this document shall represent the actual design. Software limitations shall not limit the accuracy of energy modelling to show compliance with the TGS; consultants are expected to overcome any software limitations with appropriate engineering calculations. All other modelling inputs not discussed in this section shall be based on accepted industry best practices.

Clarity on the building archetypes and performance metrics selected for inclusion into the TGS, as well as requirements for other building types, can be found in the City of Toronto's *Zero Emissions Buildings Framework* report[3].

5.2. Renewable Energy

5.2.1. Site-Generated Renewable Energy

As stated in the definition of TEUI, renewable energy generated on site may reduce the TEUI and subsequently the GHGI.

5.2.2. Purchased Renewable Energy

Where renewable energy is purchased directly from utilities, and guarantees of long-term supply (in the proportions used to demonstrate compliance) are provided to the satisfaction of the authority having jurisdiction, a GHG emissions factor of zero may be applied to the portion of the respective utility which is renewable.

5.3. District Energy & Combined Heat and Power

Contact the EED to discuss modelling requirements and documentation needed for projects proposing connection to a district energy system and/or use of a combined heat and power plant.

5.4. Standardized Assumptions

5.4.1. Schedules

Occupancy, temperature set points, lighting, plug load, domestic hot water ("DHW"), and ventilation fan schedules shall be as per the National Energy Code of Canada for Buildings 2015 ("NECB 2015") for the corresponding building type or building space type with the clarifications, additions, and exceptions listed below.

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[3] The City of Toronto Zero Emissions Buildings Framework. Prepared for the City Planning Division, City of Toronto, by EQ Building Performance, Morrison Hershfield, and Integral Group. 2017. Accessed from the City of Toronto Planning Division website.

Table 1: Schedule Requirements

Building or Space Type	NECB 2015 Schedule
Residential	Table A-8.4.3.2(1)G
Office	Table A-8.4.3.2(1)A
Retail	Table A-8.4.3.2(1)C
Hotel	Table A-8.4.3.2(1)G
Other Building Types	At modeller’s discretion
Residential Corridors	Lighting at 24 hours per day
Parking Garages	Lighting at 24 hours per day, Fans at 4 hours per day
Lighting Schedules only for spaces whose functions are not directly tied to the main building function (ex. stairways, Mechanical and Electrical rooms etc.)	Use recommended lighting annual hours as guidance
Exterior Lighting	Schedule on at night, using Astronomical clock

5.4.2. Internal Gains and Domestic Hot Water

Occupancy, plug loads, lighting power, and DHW shall be modelled according to the following:

Residential Suites
For Suites in multi-unit residential buildings (“MURBs”), use the following:

Occupancy Density – Use the values indicated in NECB 2015 for the appropriate space type

Plug Loads – 5 W/m^2 – This value is assumed to include all plug loads and appliances in suites. If there are gas-fired cooking appliances, then 1 W/m^2 shall be assigned to gas and 4 W/m^2 shall be assigned to electricity. If pursuing Tier 2 or above, credit for use of energy-efficient major appliances (dishwashers, clothes washers, dryers, refrigerators, ranges) may be applied, provided that the appliances use less energy than current ENERGY STAR® requirements for that appliance. Savings are to be determined based on the relative savings using the appliance kWh ratings, applied to the plug value of 5 W/m^2.

> Example – ENERGY STAR® minimum kWh ratings for suite appliances – 1,000 kWh
> Project’s kWh use for selected suite appliances – 900 kWh
> Reduction in plug load = 5 W/m^2 x 900/1000 = 4.5 W/m^2

As ENERGY STAR® is a moving target, ENERGY STAR®/Energuide rating documentation must be submitted as part of the ACSER submission. In order to assess the ENERGY STAR® minimum kWh rating, the latest version of the ENERGY STAR® Appliance Calculator[4] must be used and submitted to the EED.

Lighting – 5 W/m^2 or 0.46 W/ft^2 unless a complete suite lighting design is provided as part of the contract documents for the project. If suite lighting is being modelled per design, unlit areas (such as rooms with capped connections) shall assume 5 W/m^2.

Domestic Hot Water (DHW) – Use the values indicated in NECB 2015 for the appropriate space type. Reduction in DHW shall be determined using industry standard methods for hot water use estimates (e.g. LEED BD+C v4, Water Efficiency Prerequisite 1) with savings calculated relative to OBC requirements for maximum fixture flow rates.

Example: NECB 2015 specifies residential hot water usage at 500 W/person. It is assumed that OBC maximum plumbing flow rates for hot water fixtures are equivalent to this value. If by following the LEED BD+C v4 calculation methodology, the project has a 30% reduction in domestic hot water usage, 500 W/person x (100%-30%) = 350 W/person should be modelled.

All Other Space Types

All occupancy, plug, lighting, and DHW loads shall be based on design. If the design is unknown, they shall be modelled per Table A-8.4.3.3. (1) B of NECB 2015. Credit for lighting occupancy sensors can be applied as a reduction to the schedule or modelled lighting power density as per the methodology in NECB 2015, Section 4.3.2.10. Daylight sensors shall be modelled directly in the software, where the credit will be as per actual modelled results.

Elevators

Elevators shall be modelled using the acceptable industry standard methodology and good engineering practice.

Other Process Loads

All process loads expected on the project site are to be included in the energy model. This includes but is not limited to: appliances, IT/data loads, exterior lighting, swimming pool heating, heat tracing, etc. All loads are to be estimated using sound engineering principles.

5.4.3. Infiltration

Infiltration shall be modelled as per NECB 2015 at 0.00025 $m^3/s/m^2$ at 5 Pa (0.05 cfm/ft^2 at 0.02 in w.c.) of total, above grade exterior walls, and windows area.

Reduced air leakage rates may be modelled, provided the project team makes a commitment to achieve a minimum air leakage rate, to be confirmed by mandatory air tightness testing. Credit will be allowed down to the values required by Passive House, which approximately convert to 0.0001 $m^3/s/m^2$ at 5 Pa. Air leakage testing values determined at 75 Pa can be approximately

[4] The latest Appliance Calculator can be found on the ENERGY STAR® website.

converted by multiplying the value by 0.112. For example, a tested value of 0.0015 $m^3/s/m^2$ at 75 Pa would equate to 0.000168 $m^3/s/m^2$ at 5 Pa, to be used in the model, instead of the 0.00025 $m^3/s/m^2$ at 5 Pa indicated.

5.4.4. Ventilation

General
Ventilation rates are to be modelled as per design, including but not limited to ventilation for occupants according to building code requirements, make-up air for exhaust requirements, and corridor pressurization make-up air in MURBs, among others.

Demand Control Ventilation
Credit may be taken for demand control ventilation systems that monitor CO2 levels by zone and that have the ability to modulate ventilation in response to CO2 levels. Note that only reductions to the occupancy portion of the ventilation rate can be claimed based on the occupancy schedule from 2.1; the area portion of the ventilation rate must remain constant.

5.4.5. Other Considerations

Depending on the stage of the project for which the energy model is being developed, there may be the need to make a number of assumptions, of which many can have a significant impact on the performance of the building. While it is at the discretion of the design team and energy modeller to make reasonable assumptions based on past experience or engineering judgement, the items noted below are explicitly listed as they are often misrepresented in energy models.

Heat or Energy Recovery Ventilators
Heat or energy recovery ventilators shall be modelled according to design, even in instances where there exist software limitations. Appropriate workarounds or external engineering calculations are expected to be performed to accurately assess the performance of the as-designed systems. This includes the use of preheat coils and/or other frost control strategies.

Heat or energy recovery ventilators that use frost control strategies which limit the amount of ventilation supplied to the space (i.e. exhaust only defrost) shall be modelled as follows: An electric preheat coil shall be modelled before the heat or energy recovery ventilator that heats the air to the minimum temperature before frost control is employed, as indicated by the manufacturer. For example, if the minimum temperature prior to frost control being deployed is -5°C, then an electric preheat coil shall heat the incoming air to -5°C prior to it entering into the heat or energy recovery ventilator. The purpose of this approach is to not reward designs that reduce ventilation to occupants because of poor equipment selection. Similarly, this approach is intended to avoid unfairly penalizing projects that install heat recovery systems with pre heat coils so as to maintain adequate quantities of ventilation air.

Terminal Equipment Fans
Terminal equipment fans shall be modelled according to design. Specifically, ensure that fan power and fan control (i.e. cycling, always on, multi or variable speed) of terminal equipment represent the design and design intent as accurately as possible.

VAV and Fan-Powered Boxes
Modellers must ensure that minimum flow rates and control sequences of VAV terminals and Fan Powered Boxes are modelled according to the design, and if not available at the time of modelling, according to expected operation based on maintaining ventilation and other air change requirements as appropriate. Note that default values for minimum flows of VAV terminals are often unreasonably low in most energy modelling software.

Exhaust Fans
Suite exhaust fans that are not part of the ventilation system (ex. kitchen exhaust or bathroom exhaust not connected to an HRV or similar), shall have a runtime of 2 hours/day. All other exhaust fans, including heat recovery units, shall be modelled to reflect the design intent as accurately as possible.

Unmet Hours
Annual unmet hours for any zone in the energy simulation shall be limited to 100 hours or less, with the following exception: annual cooling unmet hours are allowed, provided that the cooling capacity has been purposely undersized according to the design intent. Unmet heating or cooling hours do not apply to zones with no heating or cooling equipment.

5.5. Calculating Envelope Heat Loss

One of the TGS key performance targets is TEDI, which is primarily a representation of the annual heating load required to offset envelope heat loss and ventilation loads. Choosing TEDI as a target supports the TGS direction to encourage energy efficient building envelopes. However, building envelope heat loss has historically been simplified due to past difficulties in cost-effectively providing more accuracy. This has generally led to overly optimistic assessments of building envelope performance by way of ignoring or underestimating the impact of thermal bridging.

Typical building envelope thermal bridging elements that can have a significant impact on heat loss that have historically been underestimated or unaccounted for include: balcony slabs, cladding attachments, window wall slab by-pass and slab connection details, interior insulated assemblies with significant lateral heat flow paths such as interior insulated poured-in-place concrete or interior insulation inside of window wall or curtain wall systems, and others. With the recent addition of industry resources that support more efficient and accurate calculations of building envelope heat loss, assemblies and associated thermal bridging elements must be accurately quantified for the purposes of complying with the TGS, according to the requirements below.

5.5.1. Opaque Assemblies

The overall thermal transmittance of opaque building assemblies shall account for the heat loss of both the Clear Field performance, as well as the heat loss from Interface Details. Additional heat loss from Interface Details are to be incorporated in the modelled assembly U-values, according to the provisions below.

Overall opaque assembly U-values can be determined using any of or a combination of the following approaches:

a) Using the performance data for Clear Fields and Interface Details from the Building Envelope Thermal Bridging Guide (BETBG), and the calculation methodology as outlined in 3.4 of the BETBG. A detailed example is provided in Section 5 of the BETBG and a supporting calculation spreadsheet is available from bchydro.com/construction, titled “Enhanced thermal performance spreadsheet”;
b) Using the performance data for Clear Field and Interface Details from other reliable resources such as ASHRAE 90.1-2010, Appendix A, ISO 14683 Thermal bridges in building construction – Linear thermal transmittance – Simplified Methods and default values, with the methodology described above in a);
c) Calculations, carried out using the data and procedures described in the ASHRAE Handbook – Fundamentals;
d) Two- or three-dimensional thermal modelling; or
e) Laboratory tests performed in accordance with ASTM C 1363, “Thermal Performance of Building materials and Envelope Assemblies by Means of a Hot Box Apparatus,” using an average temperature of 24±1°C and a temperature difference of 22±1°C.

Except where it can be proven to be insignificant (see below), the calculation of the overall thermal transmittance of opaque building envelope assemblies shall include the following thermal bridging effect elements:

- Closely spaced repetitive structural members, such as studs and joists, and of ancillary members, such as lintels, sills, and plates;
- Major structural penetrations, such as floor slabs, beams, girders, columns, curbs or structural penetrations on roofs and ornamentation or appendages that substantially or completely penetrate the insulation layer;
- The interface junctions between building envelope assembles such as: roof to wall junctions and glazing to wall or roof junctions;
- Cladding structural attachments including shelf angles, girts, clips, fasteners and brick ties;
- The edge of walls or floors that intersect the building enclosure that substantially or completely penetrate the insulation layer.

The following items need not be taken into account in the calculation of the overall thermal transmittance of opaque building envelope assemblies:

- Mechanical penetrations such as pipes, ducts, equipment with through-the-wall venting, packaged terminal air conditioners, or heat pumps.
- The impact of remaining small unaccounted for thermal bridges can be considered insignificant and ignored if the expected cumulative heat transfer through these thermal bridges is so low that the effect does not change the overall thermal transmittance of the above grade opaque building envelope by more than 10%.

5.5.2. Fenestrations and Doors

The overall thermal transmittance of fenestration and doors shall be modelled according to their intended actual performance, including the impact of framing for the actual or anticipated window sizes used in the design. The general approach for determining performance shall be in accordance with NFRC 100, “Determining Fenestration Product U-factors”, with the following limitations:

- The thermal transmittance for fenestration shall be based on the actual area of the windows and not the standard NRFC 100 size for the applicable product type. It is acceptable to area-weight the modelled fenestration U-value based on the relative proportions of fixed and operable windows and window sizes. It is also acceptable to simplify the calculations by assuming the worst case by using the highest window U-value for all fenestration specified on the project.
- If the fenestration or door product is not covered by NFRC 100, the overall thermal transmittance shall be based on calculations carried out using the pro procedures described in the ASHRAE Handbook – Fundamentals, or Laboratory tests performed in accordance with ASTM C 1363, “Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus,” using an indoor air temperature of 21±1°C and an outdoor air temperature of -18±1°C measured at the mid-height of the fenestration or door.

5.6. Mixed-Use Buildings

Where the building consists of different use-types, each at least 10% of the total modelled floor area (MFA), it is considered a mixed-use building and shall be modelled as follows.

Mixed-use buildings with different absolute performance targets shall area-weight the TEUI, TEDI, and GHGI target requirements accordingly.

For mixed-use buildings that have different fundamental requirements (i.e. part of the building has absolute performance targets and part of the building has a relative performance target non-Archetype), the following methodology shall be used to determine the overall building requirements:

1. Develop a Reference building only for the portion of the building that has a relative performance target requirement. Note that the Reference building may use a de-rated R-value according to the methodology outlined in the white paper: “Accounting for thermal bridging at interface details – a methodology for de-rating prescriptive opaque envelope requirements in energy codes”[5].

[5] Accounting for Thermal Bridging at Interface Details: A Methodology for De-Rating Prescriptive Opaque Envelope Requirements in Energy Codes. Prepared by Morrison Hershfield. 2015. Accessed from the BC Hydro Resources Page.

2. Extract the Total Electrical and Natural Gas consumption in MBTU and Space heating load in MBTU as per the definition of TEDI for that reference building (Non-Archetype).
3. TEUI, TEDI, and GHGI targets shall be established based on calculated scales proportionally equivalent to the office building archetype in TGS v4.
4. The total building absolute TEUI, TEDI, and GHGI targets shall be based on an area-weighted average between the TEUI, TEDI and GHGI calculated in #3, and the absolute TEUI, TEDI, and GHGI targets for the rest of the building

Note: where the modelled floor area (MFA) of the portion of the building that has a relative performance target requirement (non-Archetype) is less than or equal to 10% of the MFA for the whole building, the reference building modelling for that portion is not required. In this case, the absolute performance target of the project archetype will be applied to the total MFA.

6.0 Relative Performance Targets Pathway Modelling Guidance

****This option is only available for projects with no building archetype defined. The energy savings percentage must be calculated based on the *total energy saved, not the total energy costs*. ****

Some variations in modelling from the OBC SB-10 requirements have been approved by the EED for the purposes of TGS compliance. This section of the guideline addresses these changes.

Energy savings from dwelling unit lighting in residential projects cannot be claimed under the relative performance target pathway.

6.1. Domestic Hot Water (DHW)

Reduction in DHW shall be determined using industry standard methods for hot water use estimates (e.g. LEED BD+C v4, Water Efficiency Prerequisite 1) with savings calculated relative to OBC requirements for maximum fixture flow rates.

6.2. District Energy & Combined Heat and Power

Contact the EED to discuss modelling requirements and documentation needed for projects proposing connection to a district energy system and/or use of a combined heat and power plant.

7.0 References and Resources

1. 2014 Building America House Simulation Protocols, NREL, 2014
2. ASHRAE Handbook of Fundamentals, ASHRAE, 2013
3. ASHARE Standard 90.1-2013 – Energy Standard for Buildings Except Low-Rise Residential Buildings,
4. National Energy Code of Canada for Buildings, NRCAN, 2015
5. Commercial Buildings Building Envelope Thermal Bridging Guide, Version 1.1, BC Hydro, 2016
6. Energy Modelling Guidelines and Procedures, CONMET, 2014

7. ENERGY STAR® Multifamily High Rise Program, Simulation Guidelines, Version 1.0, Revision 03, January 2015
8. Infiltration Modelling Guidelines for Commercial Building Energy Analysis, PNNL, 2009
9. The City of Toronto – Zero Emissions Buildings Framework, March 2017
10. Ontario Building Code, Supplementary Standard SB-10
11. Accounting for Thermal Bridging at Interface Details – a methodology for de-rating prescriptive opaque envelope requirements in energy codes, BC Hydro, 2015

8.0 Contact

Please contact Environment and Energy Division at EnergyReview@toronto.ca for further information about meeting the Toronto Green Standard energy performance measures, contents of Energy Report submissions, and information on the available incentive programs.

9.0 Appendices

Appendix A-1 and A-2 – Energy Efficiency Report (See Excel Workbook)

Appendix B-1 and B-2 – Energy Modelling Simulation Summary Report (See Excel Workbook)

Appendix C – Thermal Energy Demand Intensity (TEDI) Documentation (See Excel Workbook)

Appendix D – Performance Targets – All Buildings

Appendix E – DECLARATION: GHG 1.2: Advanced Buildings Energy Performance (Required with As-Constructed Stage Energy Report submission)