TORONTO

Net Zero Emissions Study for City-owned Buildings:

Terms of Reference

February 2021

Contents

1. Annotated Table of Contents: Net Zero Emissions Feasibility Study

This annotated sample Table of Contents is a collaboration between City of Toronto Planning Division, Environment & Energy Division and Perkins&Will, and is intended to provide guidance to project teams to carry out Net Zero Emissions (NZE) Feasibility Reports for all new city-owned buildings greater than 100 m^2, in order to report to Council on any additional costs needed to achieve net zero emissions.

Project teams may choose to add sections to this report to suit their specific project needs with approval by City of Toronto (CoT) Project Team but are required to follow the two-part format and maintain section headings as provided in order to maintain the consistency in reporting for all projects.

A single Net Zero Emissions Report is to be provided, presented into two parts. Part 1 will contain concise and relevant information to be submitted by CoT Project Team to Toronto City Council. Part 1 will be used by City Council to decide on whether the project is to proceed as a Net Zero Emissions building. Part 1 is to include summary and incremental capital costs of proposed measures over a baseline design that would achieve a Net Zero Emissions building.

Part 2 will provide further levels of detail intended for the CoT Project Team.

A draft report including both Part 1 and Part 2 is to be provided to the CoT Project Manager to circulate internally for comments. City comments are to be addressed by the design team prior to the issuance of the final report.

Part 1 – Net Zero Emissions Design – Response to Council Motion: Executive Summary
[Max 4 pages]

1. Purpose of NZE Feasibility Study

2. Description of Proposed Measures
   [Provide brief description of each NZE measure proposed]

3. Options Summary Table
   [Include Table 1]

Part 2 – Design Options Summary

Include an itemized summary of each of the three (3) Options noted below, complimented with 3D Architectural renderings to illustrate the visual impact of design modifications for each Option as deemed suitable by the consulting and CoT teams. Include calculations and tables, providing a sufficient level of detail of measures to aid CoT Project Team in understanding and making informed decisions.

All design options are required to integrate the TGS Renewable Energy Feasibility Terms of Reference, summarized in Renewable Energy Assessment Requirements in this document.

A) Baseline Building Design

- Design which meets all Toronto Green Standard V3 Tier 2 requirements for City building projects, including meeting TGS renewable energy requirements (minimum 5% renewable or 20% geothermal).
- If the proposed design uses any onsite combustion for space heating or hot water, a Zero Carbon Transition Plan must be prepared to demonstrate how the project will achieve net zero emissions by 2040. Zero Carbon Transition Plan requirements are established in the Canada Green Building Council's Zero Carbon Building Standard. For the purposes of this document, the relevant requirements are:
    - Describe mechanical HVAC strategy and how components of the system may be adapted to accommodate non-combustion-based technologies (such as operating temperature of the distribution system, space allocation for renewable or electrical-sourced heating technologies).
    - Identify required envelope improvements and natural intervention points before 2040 (such as the anticipated end of life of mechanical equipment) to achieve zero emissions should be identified and leveraged in the plan. The preliminary cost estimate of such a retrofit must be provided.
    - Referring to Mechanical System Design Guidelines for Low Carbon-Ready Buildings for additional guidance (link pending).

B) Net Zero Emissions – Response to Council Motion

Net Zero Emissions is defined as disconnecting from fuel sources with high greenhouse gas emissions, employing passive and active energy saving strategies, and installing renewable energy systems that generate renewable energy equal to the quantity of energy used on an annual basis.

- Meets Toronto Green Standard Tier 3 or 4 absolute performance pathway, combined with renewable energy offsets.
- Achieve Canada Green Building Council Zero Carbon Building Design and Performance Certification, or Passivehouse Certification combined with renewable energy offsets, or other equivalent high-performance building standard approved by City Planning Division.
- Prioritizes on-site strategies and considers carbon offsets as last resort requiring CoT Project Team approval.

C) 20 Year Optimized Design:

- Optimized design that provides a 20-year blended payback of all additional capital investment over Baseline Design option. Teams are to propose a grouping of measures which offer a combined blended payback of 20 years or less.
- Includes Zero Carbon Transition Plan to achieve net zero emission by 2040 by future-proofing design.

Headings for Study

1. Study Goals

   Provide a summary of the goals of this study.

2. Study Limitations and Project Constraints

   Provide a summary of limitations or constraints either provided by the CoT project team, are present on the site, or are due to the nature of the project.

3. Energy and GHG Modelling Software and Set-Up

   Include the name of software used, schedules, occupancy counts, plug load assumptions, utility rates, etc. The following tools are considered acceptable modelling tools for use:

   - IES-VE
   - eQUEST
   - Energy plus

   Design teams to determine tools for use based on advantages and limitations. Additional modelling software may be proposed by the design team, to be approved by CoT Energy Efficiency Division (EED).

4. Baseline Design Energy Profile

   Include window-to-wall ratios, mechanical and electrical system summaries, envelope description, glazing types, effective wall performance R value targets, TEDI, TEUI, GHG, annual utility cost, annual energy consumption by end use in kWh, and renewable energy systems which meet TGS minimum renewable energy requirements for City owned buildings. Include Table 2.

5. Technologies & Measures Summary

   Provide a summary for each measure explored in the study. Also include measures which have been explored but eliminated along with reasoning. Include Table 3.

   At a minimum, include the following passive design strategies using parametric modelling analysis. Parametric informed design will allow teams to specify the key parameters of a project and make changes interactively with automatic modelling updates and use the quantitative information as an aid in making key design decisions. Design teams are to employ new computational analysis methods to inform passive design strategies and present data visualization of results within the feasibility report. Parametric analysis for this study is to inform employment of passive measures, with analysis to include at minimum:

   - Massing and orientation
   - Harvest wind direction and speed
   - Incident solar radiation
   - Interior daylight and glare
   - Solar heat gain

Passive measures to consider:

- Insulation levels
- Varying glazing types such as double glazing vs. triple glazing, and electrochromic glazing. SHGC relative to the heating or cooling demand of specific areas within the building. Consider localizing higher performance glazing in areas which result in highest energy reduction based on.
- Optimizing window to wall ratios
- Solar shading strategies such as Overhangs, Exterior Solar Fins, Exterior or interior automated rolling shades.
- Natural ventilation
- Envelope air tightness levels and establish construction phase testing.

Active measures to be considered:

- Mechanical (HVAC)
- Lighting Controls
- Daylighting Controls
- Occupancy Controls
- Other beneficial smart building controls
- Demand Management & Peak Shaving
- Monitoring Schemes (Building Monitoring Systems and Intelligent Systems)

Renewable Energy to be considered:

- Solar system installation (both PV and thermal) on roof and walls as Building-Integrated solar PV, on grounds such as solar carports over parking areas and site shading structures.
- Ground Source Heat Pumps (open and closed geothermal loop)
- Air Source Heat Pumps
- Where the business case for a renewable energy system does not meet financial criteria, but solar system is technically practical, the building must be designed and built to accommodate a solar installation in the future as part of the baseline design.

Achievability of a Net Zero Emissions design is determined by four key factors:

1. Passive Energy Conservation
2. Active Energy Conservation
3. Renewable Energy
4. Optimized Operations & Maintenance

Once energy load reductions have been considered through passive and active systems, the balance of energy is to be offset by using renewable energy. Design teams are encouraged to prioritize passive design first to reduce overall energy loads, then explore active systems. On-site renewables are to be maximized prior to the proposal of green power and carbon offset purchases.

6. Analysis of Design Options
    - Baseline Building Design Summary
    - Net Zero Emissions Design Summary
    - 20 Year Optimized Design Summary

    Provide a narrative to describe the design team approach to each of the above listed.

7. Design Options Summary Table

    Include Table 4.

8. Net Zero Phasing Strategy and Matrix

    Include Table 5 'Net Zero Phasing Strategy and Matrix' if phasing is recommended by the design team, and approved by the CoT Project Team. Provide a phase-in strategy of measures to reach Net Zero Emissions prior to 2040. Design measures incorporated into the NZE are phased to reduce initial project capital cost, while still allowing project to reach NZE in the future, but prior to 2040. Provide an explanatory narrative and include Table 5.

9. Additional Design Scope Soft Costs

    Advise City of Toronto Project Team of any additional design fees associated with proposed options.

10. Project Schedule Impact

    Advise City of Toronto Project Team of any project schedule impacts associated with proposed options.

11. NZE Decision Timeline

    Advise City of Toronto Project Team timeline of critical decisions in order to not considerably impact established project schedule.

12. Embodied Carbon Summary of Design Options

    Conduct a Life Cycle Assessment (LCA) to provide an embodied carbon emissions summary for each of the Design Options in Part 2 reported in kilograms of carbon dioxide equivalent (kg CO2e) as a total value per Option. Analysis is to include manufacturing, transport, installation, use, and end-of-life of building materials. Identify embodied carbon of new building materials, as well as embodied carbon saved through reuse of architectural or structural elements when applicable to the project.

    Assessment is to assume a service life of 60 years, and to include all envelope and sub structure such as foundations, and all super structural elements such as structural wall assemblies. Interior finishes, mechanical, and electrical elements are to be excluded, however teams are encouraged to consider the impact on embodied carbon during finish selections later in the project. Provide a graph indicating the contribution analysis by either material type or by building assembly.

Design teams may select one of the City of Toronto currently approved LCA tools listed below. Contact City of Toronto Planning Division for written approval of any alternative LCA tools at sustainablecity@toronto.ca

- Athena Impact Estimator (athenasmi.org)
- Tally (choosetally.com)
- OneClick LCA (oneclicklca.com)

Appendices:

A: NZE Cost Report

B: Energy Modelling Detailed Report for each Option

C: Life Cycle Assessment Software Detailed Report for Each Option

D: … [Include additional materials which supported reaching the outcomes of this study.]

2. Renewable Energy Assessment Requirements

At a minimum, the feasibility study shall incorporate the following components:

A. Ground Source and Air Source Heat Pump Feasibility Assessment

1. Building and Site Assessment

- Consultant shall review drawings, design parameters, BAS capabilities, proposed HVAC systems and proposed borefield location to verify that ground source (GSHP) is appropriate for the site.
- Consultant shall evaluate project for geothermal systems supplied by open loop water wells, as well as closed loop vertical boreholes. The open loop water well option requires the presence of a major groundwater aquifer beneath the property and a system of supply and injection wells. Assess if an open loop is possible by providing:
  - Research pertaining to the presence of any major groundwater aquifer beneath the property. If open loop geothermal wells have been installed in the area near the Project, provide yield of the aquifer in L/s or gpm available from a single well.
  - Estimate of the required open loop well flow is required for the Project based on the hourly heating and cooling loads.
  - Estimate of the total number of open loop wells required to satisfy the building loads, based on groundwater conditions.
  - Proposed test drilling program required to determine the potential capacity of the aquifers beneath the Project if no known deep wells are in the area.
- Consultant shall work with a local driller and review the Ontario Geological Survey (OGS) data to estimate the ground thermal conductivity. A test borehole is not required

at the feasibility stage; however Thermal Conductivity Test is mandatory during detailed design if the decision has been made to move forward with the system.

- The consultant shall make a reasonable effort to identify any issues with drilling at the proposed location.

2. Building Energy Model

- Create an 8760-hour energy model.
- Use the building energy model and GHX model to directly inform design and consider all relevant opportunities that may promote system balancing. This may include incorporating DHW load, ventilation loads, fluid cooler, snow melting, other building exterior or interior changes, hybrid system, etc. The report shall clearly indicate which options were considered and the corresponding results.
- Relevant screen shots illustrating results from the building energy model are to be included in the report.
- Consultants are to indicate a preferred system configuration, discuss the relative energy balance, and efforts made to optimize the design through adjustments to the HVAC design.

3. GHX model, design, and sizing

- Consultants are to describe the proposed system, including the system size, location and sizing of vertical/horizontal geoexchange field, building connection point, heat pump configuration, and sequence of controls.
- Consultants are to evaluate both open and closed loop systems and identify pros and cons of each system and make a recommendation of the two systems.
- GHX sizing is not be based on rules of thumb.
- GHX sizing is to be done with GLD, Earth Energy Designer (EED), GHLE Pro or Looplink.
- Include a plot illustrating a 20-year fluid temperature projection.
- Explicitly state annual heat flows to and from the ground.
- Provide a layout for the proposed borefield.
- Relevant screen shots illustrating results from GHX model are to be included in the report.

4. Energy, Financial, and GHG Analysis

- The Consultant shall evaluate the energy, cost, and GHG savings of a Ground Source Heat Pump (GSHP) and compare them with an Air Source Heat Pump (ASHP) or other reasonable low to no carbon conventional system.

- Financial analysis shall include net present value (NPV), return on investment (ROI), and simple payback calculations for GSHP and ASHP over the conventional system. Identify and run an analysis of the incremental costs of using GSHP or ASHP over a conventional system.
- Incremental cost should be detailed, indicating estimated cost of GHX, but also savings for all mechanical equipment and systems removed from the building. No redundant systems or hybrid configurations should be used unless justified as the best value through the financial analysis or determined by the CoT Project Team as required or good value based on internal risk analysis.
- Identify applicable utility and any available government incentives.
- Use utility rates provided by the City in the financial analysis but also evaluate other possible scenarios that may occur as part of a sensitivity analysis, for example, financial performance using the highest historical gas rate in the past 10 years.
- As separate line items, the consultant is to consider savings from the following, as applicable:
    - Cooling season energy costs
    - Heating season energy costs
    - Saved person-hours for operation and maintenance of mechanicals
    - Saved person-hours and materials for other building operations (snow-melting)
    - Saved water usage and chemical treatment (cooling towers)
    - Saved infrastructure cost (new builds)
    - Capital reserve savings due to longer component lifetimes (based on ASHRAE life expectancy)
    - Consultant shall refer to AHRI-rated specifications of proposed equipment to estimate equipment efficiencies. Efficiency values shall be adjusted to represent expected operating conditions (for example, entering or leaving water temperatures that deviate significantly from rated performance points) and the adjustment should be justified within the report.
- Components' costs should be traceable and included as separate line items; acceptable sources include either RS means mechanical data, actual equipment quotes for this project, or from recent previous projects.
- Estimate GHG savings for both GSHP and ASHP options based on current emission factors provided by the CoT EED. If not provided, consultant is to use emission factors for Ontario as reported in the National Inventory Report.

5. Environmental Impact

- Identify any potential ground loop impact on the local water source and the environment.
- Identify whether approvals or coordination is required with nearby properties or agencies or relating to environmentally sensitive areas or waterways.

B. Solar PV and Solar Thermal Analysis

- Assess the feasibility of solar system installation, both PV and thermal PV, on the roof and walls of the building as Building Integrated solar PV, or on the site such as solar carport over parking areas. Use a minimum of 400W solar PV panels placed at a 10-degree angle on a rooftop, or site installations.
- Conduct a long-term shading study incorporating existing and permitted building heights and other obstructions to the south-east, south and south-west of the site.
- Provide an estimate of the maximum PV system size, and system production using accepted industry solar PV design software (PVSyst and Helioscope are preferred) and provide that software report as an attachment to this study.
- Provide preliminary layout of the potential system considering the set-back from the property edge and shading, roof edges, mechanical equipment, and green roof requirements for roof installations.
- Conduct GHG savings analysis.
- Provide financial analysis including net present value (NPV), return on investment (ROI), and payback calculations (including costs based on current hydro rates for net metering. The City EED staff will provide the necessary electricity rates and discount rates to be used for calculations. Results are to be provide in a spreadsheet with the analysis and appended within the NZE Feasibility study.

C. Solar Ready

Where the business case for a renewable energy system does not meet financial criteria, but solar system is technically practical, the building must be designed and built to accommodate a solar installation in the future as part of the baseline design.

The roof should be designed to be structurally capable of accommodating additional dead and live loads of a solar PV system along the full extent of the roof. It should be free of obstructions such as self-shading on the south facing portion, or from rooftop units, to maximize sun exposure. The designer should include roof loads, and potential location of solar PV system in roof plan tender drawings. Consult NREL’s Solar Ready Buildings Planning Guide.

At a minimum:

- Designate area of roof for future solar PV and making it structurally sound to support it
- Place HVAC or other rooftop equipment on the north side of the roof, to prevent future shading
- Provide a conduit from the roof to the rough in for the location of the external disconnect (exact location to be determined in discussions with Toronto Hydro) and then to closest electrical panel that the solar system can connect to. Size of conduit to be determined based on maximum potential PV system size.

- Provide one-inch conduit for communications from the roof to building electrical connection point or to the network hub (exact location to be determined based on monitoring requirements during design stage)

3. Study Timeline

The optimum timing to conduct the Net Zero Emissions study for a new building project is during the Schematic Design phase (SD), and prior to Site Plan application (SPA). The completed study and approved strategy will inform Detailed Design.

Begin the NZE feasibility study within 1 month of project award. Complete the study within 8 weeks from NZE Feasibility study start.

4. Meetings

A minimum of three (3) meetings between the City and the project team are recommended for the Net Zero Emissions feasibility study. An additional meeting may be proposed as requested by the consulting team or City of Toronto project team. City Planning and Energy Efficiency divisions are to be included in the meetings.

- **Meeting 1:** NZE Feasibility Study Kick-off and Visioning Workshop (2-3 hours): This meeting is to take place within one week of the initiation of the NZE Feasibility Study. Discussions to include the scope of the feasibility study, inclusions and exclusions, potential limitations, study timeline including milestone dates, scheduling of upcoming meetings, and a minimum 2-hour Integrated Design visioning workshop.

- **Meeting 2:** Mid-Point Consultation (2 hours): Presentation of design team progress to-date, measures investigated or under investigation. The purpose of the meeting is to provide CoT staff feedback.

- **Meeting 3: Final** Presentation (1 to 1.5 hours): Sharing of study outcomes, results of each measure as relating to energy and emissions reductions, cost premiums, maintenance requirements, and payback analysis.

5. Team Expertise

Projects are to engage the expertise noted below for the Net Zero Emissions feasibility study as applicable. One individual can serve multiple roles if experience can be demonstrated for each specialty.

- **Architect** - Minimum 10 years' experience, serving on a minimum of 2 projects with similar complexity in a similar role.

- **Parametric Analyst** - Minimum 5 years' experience, conducting analysis on a minimum of 2 projects with similar complexity in a similar role.
- **Mechanical Engineer** - Minimum 10 years' experience, serving on a minimum of 2 projects with similar complexity in a similar role.
- **Electrical Engineer** - Minimum 10 years' experience, serving on a minimum of 2 projects with a similar complexity in a similar role.
- **Renewable Energy Specialist** Minimum 5 years' experience on Solar PV, PVT, and BIPV, serving on a minimum of 2 projects with a similar complexity in a similar role. If Geothermal is possible on project, then dedicated geothermal specialist to be engaged with minimum 10 years' experience on minimum 5 projects with similar complexity.
- **Building Envelope Specialist** Minimum 5 years' experience, serving on a minimum of 2 projects with a similar complexity in a similar role.
- **Energy and GHG Modeller** - Minimum 5 years' experience, serving on a minimum of 2 projects with similar complexity in a similar role.
- **Cost Consultant** - Minimum 10 years' experience, serving on a minimum of 2 projects with a similar complexity in a similar role.

6. Third Party Green Building Certification

Should the project proceed with Net Zero Emissions design, the project team will pursue and achieve the current version of either the Canada Green Building Council Zero Carbon Building (ZCB) certification, or Passivehouse Canada Certification. Project team will be required to register and coordinate the certification process. If the project is not suited for ZCB certification or Passivehouse certification, project team is to advise City of Toronto project team during the NZE feasibility study period.

NZE Report Tables:

Table 1 - NZE Summary Table

Design Option	TEUI (kWh/m²)	GHGI (kg/m²)	TEDI (kWh/m²)	Annual Utility Cost ($)	Carbon Tax in 2030 ($)	Capital Cost Premium ($, % premium)
TGS Compliant Base Design Toronto Green Standard, Version 3 – Tier 2						Capital Cost: $__________
Response to Council Motion: Net Zero Emissions Design (NZE)	0	0				Additional Capital Costs over TGS Compliant Base Design: $______________ % Over TGS Compliant Base Design: __% NPV, Payback for additional capital cost

Contact the Dejan Skoric, Senior Project Manager, Environment & Energy Division (Dejan.Skoric@toronto.ca) for study assumptions regarding utility rates, carbon tax and discount rates for Net Present Value and payback calculations, and acceptable renewable energy assumptions.

Table 2 – Heating and Cooling Peak Loads

	Heating Peak (kBtu)	Cooling Peak (kBtu)
TGS Compliant Base Design		
Response to Council Motion: Net Zero Emissions (NZE)		
20 Year Optimized Design		

Table 3 – Technologies and Measures Summary Matrix

[Add/Delete rows as needed.]

Technologies & Measures	Energy Savings	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kg/m2)	Annual Utility Cost	Carbon Tax in 2030	Capital Cost	Net Present Value (20 y)	Insert 'X'		
									TGS BASE DESIGN	NZE DESIGN	20 YR OPTIMIZED
TGS Compliant Base Design								-	X		
A 1.1:											
A 1.2:											
A 1.3:											
M 1.1:											
M 1.2:											
M 1.3:											
E 1.1:											
E 1.2:											
E 1.3:											
R 1.1:											
R 1.2:											
R 1.3											

[Each measure in table above to be compared to TGS Compliant Base Design, as an increase or decrease in units specified for the column.]

Table 4 – Design Options Summary

	TEUI (kWh/ m^2)	**TEDI** (kWh/m2)	**GHGI*** (kg/m^2)	**Annual Utility Cost**	**Carbon tax in 2030**	**Capital Cost Premium** ($, %)	**Net Present Value***** 20 Years	Comments
Base Design: Toronto Green Standard, Version 3 - Tier 2						$ x		
RESPONSE TO COUNCIL MOTION: Net Zero Emissions Design	0					$ x X % over Base Design		
OPTION 2: Near Net Zero Design Optimized for 20 Year Payback								

Table 5 – Net Zero Emissions Phasing Strategy and Matrix

[Add/delete rows as needed. Add/delete phasing as needed]

Technologies & Measures		Annual Utility Cost	Carbon tax in 2030	Capital Cost ($)	TGS Base Design	NZE Design	20 year optimized	NZE Phased Design Legend: Phase 1: … Phase 2: …
TGS Compliant Base Design					X			
	Architectural Measures							
A1.1:								
A1.2:								
A1.3:								
	Mechanical Measures							
M1.1:								
M1.2								
M1.3:								
	Electrical Measures							
E1.1:								
E1.2:								
E1.3:								
	Renewable Energy Measures							
R1.1:								
R1.2:								
R1.3								
	Phase 1							
	Phase 2							
	TOTAL NZE Capital Cost							