SCHEDULE F – PROJECT COMPLETION REPORT TEMPLATE

VERY IMPORTANT:

Timing: You need to email a report, to your GMF project officer (contact info is in Schedule C), on the dates indicated in Schedule C or whenever FCM asks for such a report.

Copyright: Before you submit a report to FCM, make sure you hold the copyright for the report. If you're hiring a consultant to prepare the report, please make sure to get the copyright (see FCM's copyright tips document), or else FCM will not be able to disburse the Grant Amount.

Accessibility for people with disabilities: Please do not change the format, font, layout, etc. of this report. This template has been specially designed, following FCM's Accessibility Guidelines, in order to be accessible to people with disabilities.

Confidentiality: If your report contains any Confidential Information that you would prefer not be made available to the public (e.g. through a case study or other materials produced by FCM that relate to your Project), please submit two versions of the report:

1. **Complete report including Confidential Information:** Please clearly label this report with the word "**Confidential**" or similar wording and FCM will treat it as confidential.

2. **Abridged report excluding Confidential Information:** This report may be posted on the FCM website and otherwise made available to interested third parties, to help FCM meet its knowledge sharing objectives.

Please contact your project officer to receive an electronic copy of the Completion Report Template.

Upon completion of the project, a copy of the Final Deliverable must be submitted along with this Completion Report.

FCM will post your report on the Green Municipal Fund™ (GMF) website. This is because one of FCM's mandates is to help municipal governments share their knowledge and expertise regarding municipal environmental projects, plans and studies.

How to complete the Completion Report

The purpose of the Completion Report is to share the story of your community's experience in undertaking your project with others seeking to address similar issues in their own communities.

Please write the report in plain language that can be understood by people who are not specialists on the subject. A Completion Report is typically in the range of 5–10 pages, but may be longer or shorter, depending on the complexity of the project.

GMF grant recipients must enclose **final** copies of the Completion Report and the Final Deliverable with their final Request for Contribution. The reports, including all attachments and appendices, must be submitted in PDF format with searchable text functionality. Reports that are not clearly identifiable as final reports, such as those displaying headers, footers, titles or watermarks containing terms like "draft" or "for internal use only," will not be accepted by GMF. Additionally, reports must be dated. If you have questions about completing this report, please consult GMF staff.

GMF number	16840
Name of lead applicant (municipality or other partner)	City of Toronto
Name, title, full address, phone, fax and e-mail address of lead technical contact for this study	**Mabruck Mengele** Senior Project Coordinator, Capital Projects Section – PFR 416-809-8597 Mabruck.Mengele@toronto.ca
Date of the report	May 2020

1. Introduction

a) Who was involved in doing the Feasibility Study, and what are their affiliations? Please include name, title and contact information. Those involved could include municipal staff, engineers and other consultants, a representative from a non-governmental organization, and others.

Client Team:

Name	Title	Company	Contact
Mabruck Mengele	Senior Project Coordinator, Capital Projects Section - PFR	City of Toronto	Mabruck.Mengele@toronto.ca
Dejan Skoric	Senior Project Manager, Environment & Energy Division	City of Toronto	Dejan.Skoric@toronto.ca

Consulting Team:

Name	Title	Company	Contact
Zeina Elali	Senior Sustainability Advisor & Study Lead	Perkins&Will	Zeina.Elali@perkinswill.com
Christina Grimes	Project Architect	Perkins&Will	Christina.Grimes@perkinswill.com
Brad Bull	Mechanical Lead, Principal	Smith+Anderson	Brad.Bull@smithandanderson.com
James Back	Electrical Lead, Principal	Smith+Anderson	James.Back@smithandanderson.com
Lyle Scott		Footprint	Lyle.scott@sa-footprint.com
Xiangjin Yang	Project Manager	Footprint	Xiangjin.Yang@sa-footprint.com

2. The Feasibility Study

a) Describe the process that you undertook to make this feasibility study a reality, from concept, to council approval, to RFP, to final deliverable.

On October 2, 2019 the City of Toronto Council voted unanimously to declare a climate emergency and accelerate efforts to mitigate and adapt to climate change. Council has unanimously approved the following Greenhouse Gas (GHG) emissions reduction targets, based on 1990 levels, to:

1) 30 per cent by 2020

2) 65 percent by 2030

3) Net zero carbon by 2050, or sooner

New construction will need to evaluate and introduce significant measures to aid the reduction of GHG in order to achieve the 2050 net zero carbon target, including how we are building the new North East Scarborough Community Centre. The City of Toronto engaged the North East Scarborough consulting team to carry out a Net Zero Energy and Emissions feasibility study. The team met at the initiation of the study with the City of Toronto staff to establish the study targets and again for a mid-point consultation to share progress and gather feedback which have led towards the recommendations made in this report.

The primary goal of this report is to provide a Net Zero Energy & Emissions (NZEE) design strategy that aligns with Council's Motion. The design measures incorporated into the NZEE design are to be considered additions or modifications to the current design to-date of the project, which is a TGS Compliant Base Design. The current TGS Compliant Base Design meets the requirements of Toronto Green Standards (TGS) Version 3 Tier 2, to achieve 25% better than OBC 2012 Supplementary Standards SB-10 2017.

Through an integrated design approach, this project involved a Net Zero Energy and Emissions Study for the Northeast Scarborough Community and Child Care Centre in Scarborough, Ontario.
The team included members of the Strategic Initiatives, Policy & Analysis, City Planning Division, as well as the City of Toronto Project Management team. The study began in February 2020

The North East Scarborough Community Centre (NESCC) was halfway through the design development phase when the NZEE discussions began and study initiated. It was not part of the original RFP for the project. It was therefore too far into the design process to allow for any changes to the building mass, site location & orientation, and building floor plans to be studied. Despite these constraints, opportunities to improve the design remained through parametric analysis.

The study concluded in May of 2020, shared with Toronto City Counsel shortly after with a favourable vote to proceed with advancing this community center to a Net Zero Energy and Emissions Design.

b) What were the objectives of the Feasibility Study (what was it seeking to determine)?

The Net Zero Energy and Emissions Study included development of following opportunities:

1. Baseline Design (Equivalent of TGS Tier 2)
2. Design which results in Net Zero Energy and Emissions
3. Option 1: Optimized design that provides a 20-year payback of incremental costs over the Baseline Design
4. Option 2: Optimized design that provides a 30-year payback of incremental costs over the Baseline Design

Investigation included exploration of various passive and active mechanical strategies, renewable energy, and presented operations and maintenance considerations as well as ROI of the various measures. This exploration informed what measures are to be included to develop each of the three above noted opportunities to help inform the City of Toronto decision on how they wish to proceed with the project.

c) What approach (or methodology) was used in the Feasibility Study to meet these objectives?

Challenges associated with achieving a Net Zero Energy and Emissions facility on community center facilities with aquatics programming are substantial, as Net Zero Energy and Emissions required a substantial departure from 'TGS Tier 2 design'. Close to 50% of the facility's energy use is process driven, associated with aquatics. Significant collaboration took place to iteratively evaluate the energy and carbon impact of architectural, envelope, mechanical, electrical systems and package this analysis into project opportunities to advance energy and sustainability reductions.

The process began with a Visioning Kick-off with the City of Toronto project team to:

- Establish a clear Project Vision for the NZEE study;
- Define the parameters of the outcome of this study;
- Determine energy and carbon reductions measures of interest that can be explored; and
- List limitations that the team is to consider.

The Vision established guided the design team's exploration of strategies. The Visioning Kick-off was followed by a series of design charrettes and explorations with a minimum of weekly touchpoints. Explorations were informed by energy and carbon to help focus the design options on elements that offer the greatest reductions at the lowest capital costs and greatest return on investment.

d) Please describe any public consultations conducted as part of the Feasibility Study and their impact on the Study.

Consultation process included other City of Toronto divisions outside of the direct City of Toronto project team.

3. Feasibility Study Findings and Recommendations

a) What were the environmental findings related to the options explored in the Feasibility Study? Please provide quantitative results and summary tables of these results (or the page numbers from the Feasibility Study report).

Design Options Summary Table

Designs	TEUI (kWh/m²)	GHGI* (kg/m²)	Annual Utility Cost + Carbon Cost ($)	Capital Cost Premium** ($, %)	Net Present Value *** 20 Years	Net Present Value*** 30 Years	Comments
TGS Compliant Base Design: Toronto Green Standard, Version 3 - Tier 2	306	37	$221,408	$52,065,000	Base Case		5% renewable energy policy for city facilities is met by solar PV
RESPONSE TO COUNCIL MOTION: Net Zero Energy & Emissions Design	0	0	$ 0	$6,238,217 12.0% *(Includes capital cost of all measures required for NZEE design + additional off-site PV)*	($2,088,400)	($211,173)	The cost of the additional PV module area of 1300m², required for the NZEE design and to be sourced off site by the City, is included in the capital cost and is estimated to be approximately $878,217.
OPTION 1: Design Optimized for 20 Year Payback	187	27.5	$103,610	$665,000 1.3% *(Includes capital cost of all measures required for Option 1 design)*	$745,588	$1,385,228	This design option is not a full Net Zero design. It is a more energy efficient option that allows for a favourable 20 year return on investment.
OPTION 2: Near Net Zero Design Optimized for 30 Year Payback	94.3	4.7	$122,557	$1,940,000 3.7% *(Includes capital cost of all measures required for Option 2 design)*	($840,691)	($342,203)	This design option is not a full Net Zero design. It is a **'Near Net Zero'** option that is close to a positive 30 year return on investment.

b) What were the financial findings related to the options explored in the Feasibility Study (for example, results of a cost-benefit analysis, financial savings identified, and so on)? Please provide quantitative results and summary tables of these results (or the page numbers from the Feasibility Study report).

Technologies & Measures Summary Matrix

Technologies & Measures	Energy Savings**	TEUI (kWh/m²)	GHGI*** (kg/m²)	Annual Utility Cost + Carbon Cost ($)	Capital Cost ($)	Net Present Value (20 y)	Net Present Value (30 y)	TGS BASE DESIGN	NZEE DESIGN	OPTION 1 DESIGN	OPTION 2 DESIGN
TGS Compliant Base Design	-	306	37	221,408	52,065,000	-	-	X			
A2.1: Envelope Improvement – Walls R25	0.3%	305	36.9	221,181	150,000	(145,755)	(143,829)		X		
A2.2: Envelope Improvement – Roofs R55	0.3%	305	36.9	221,181	105,000	(100,755)	(98,829)		X		
A2.3 : Envelope Improvement – Triple Glazing (U-0.2)	2.6%	298	35.8	219,283	465,000	(425,275)	(407,261)		X		
A2.4: Fins Shading	Included in A2.3								X		
A3: Airtightness Improvement by 50%	3.6%	295	35.8	214,583	15,000	112,604	170,466		X	X	X
M1.1: Geothermal Heat Pump*	30.4%	213	10.7	272,794	3,695,000	(4,655,807)	(5,091,492)				
M1.2: Geothermal Heat Pump with backup Electric Boiler	27%	223	11.2	285,600	2,765,000	(3,965,255)	(4,509,518)				
M2: Air Source Heat Pump	30.4%	213	10.7	269,748	1,275,000	(2,232,965)	(2,667,361)		X		X
M3: Hybrid Air Source & Geothermal Heat Pump	Explored but not feasible										
M4: Push and Pull System	-18%	361	53.3	187,000	Explored but not costed						
M5: Pool Covers	5%	291	36.8	200,287	25,000	359,916	538,993		X	X	X
M6: Earth Tubes	3%	293	36	206,700	Explored but not feasible						
M7: Bio Mass Boilers	-7%	340	7	-	Explored but not feasible						
M9: Improve Heat Recovery Efficiency to 85% (except pool)	1.6%	301	36.9	215,581	320,000	(211,048)	(161,642)		X		
M10: Drain Heat Recovery	8.2%	281	32.8	209,672	30,000	189,437	288,942		X	X	X
E1.1: Photovoltaic and Thermal (PVT) (Roof Area)	23%	245	28.5	177,939	585,000	83,632	386,827		X	X	X
E1.2a: Bifacial PV Panels (Roof Area)	6.2%	287	36.3	197,488	115,000	332,237	535,039				
E1.2b: Bifacial PV Panels (Parking Area)	14.3%	262	34.9	161,760	2,060,000	(944,719)	(438,988)		X		
E1.3 BIPV on South Façade Glazing	2%	300	36.9	214,581	330,000	(202,350)	(144,466)		X		

*For Measure M1, all of building's ventilation cooling, heating and domestic hot water load has been shifted to the geothermal system.

** The energy savings are compared to the TGS Compliant Base Design

*** Using Energy Star Portfolio Manager Greenhouse gas emission factors

**** Using $50/ton of CO2e

c) Based on the environmental and financial findings above, what does the Feasibility Study recommend?

The Feasibility provides recommendations for different scenarios, listed above in question 3. City of Toronto Council was to determine which option they wish to proceed with.

TGS COMPLIANT BASE DESIGN - Toronto's TGS, Version 3 - Tier 2:

- R18 Wall Assembly
- R43 Roof Assembly
- Double pane Glazing
- HVAC systems to be comprised of D/X rooftop air handling units with glycol heating sections fed from a central high efficiency condensing boiler plant. Air handling units serving the change rooms and pool to be equipped with air side heat recovery (energy recovery wheel for the change rooms, refrigerant-based run around loop for the pool dehumidifier) and the pool dehumidifier will reject its waste heat to the pool. Air handling systems for the daycare, gymnasium and multipurpose/admin/circulation will be variable air volume (single zone or multi-zone).
- Photovoltaic panels for electric power generation provided to meet the requirements of TGSv3, Tier 2. Rated DC Capacity 128kW (320 modules) for 5% annual energy generation of 138,900kWh

RESPONSE TO COUNCIL MOTION - Net Zero Energy & Emissions Building:

- R25 Wall Assembly
- R55 Roof Assembly
- Triple pane glazing with thermally broken frame
- Air leakage improvements to 1 l/s/m2
- Pool Cover
- Air side heat recovery devices added to the multipurpose/admin/circulation, daycare, and gymnasium air handling units. Heat recovery effectiveness for all systems (excluding the pool) to be 85% or higher.
- Air handling unit zoning and variable speed approach to remain as described in TGS Compliant Base Design, but convert the building heating and cooling plant/system to a hydronic system served by central air-source heat pump chillers. Remove D/X section from all air handlers in lieu of chilled glycol coils and provide chilled glycol distribution pumps, piping, etc. Central air-source heat pump chillers will be capable of simultaneous heating and cooling and will be sized for a peak load of 285 tons. Due to concerns with low ambient operation/performance a back-up boiler plant will be required to ensure heat is available. The back-up boilers will be electric and sized for a peak heating requirement of 650 kW.
- To reduce the pool heating requirements, provide a plate and frame heat exchanger for continual drain down of pool water and heat exchange/recovery with make-up water to suit code-driven bather make-up water requirement of 15 L/bather/day.
- Provide 320 photovoltaic thermal (PVT) hybrid panels on the building roof to derive 128kW of electric power and 445kW of thermal energy.
- Building Integrated photovoltaic panel on south facade opaque walls. Rated capacity is 45kW (655 m2 area coverage)
- Photovoltaic panels system in the parking lot, with a rated capacity of 311 kW (820 modules) mounted on custom canopy structure & racking system.
- Provide an additional 1300 m2 of photovoltaic panels for electric power generation off site. To be sourced and coordinated by the City (not included in the capital cost).

OPTION 1 - Optimized 20 Year Payback:

- Air leakage improvements to 1 l/s/m2
- Pool Cover
- Mechanical systems as described for TGS Compliant Base Design, but with the plate and frame heat exchanger for continual drain down of pool water and heat exchange/recovery with make-up water to suit code-driven bather make-up water requirement of 15 L/bather/day
- 320 photovoltaic thermal (PVT) hybrid panels on the building roof to derive 128kW of electric power and 445kW of thermal energy.
-

OPTION 2 - Optimized 30 Year Payback:

- Systems as described above in Option 1, but with the following mechanical modification:
- Air handling unit zoning and variable speed approach to remain as described in TGS Compliant Base Design but convert the building heating and cooling plant/system to a hydronic system served by central air-source heat pump chillers. Remove D/X section from all air handlers in lieu of chilled glycol coils and provide chilled glycol distribution pumps, piping, etc. Central air-source heat pump chillers will be capable of simultaneous heating and cooling and will be sized for a peak load of 285 tons. Due to concerns with low ambient operation/ performance a back-up boiler plant will be required to ensure heat is available. The back-up boilers will be electric and sized for a peak heating requirement of 650 kW.

4. Lead Applicant's Next Steps

a) Taking the Feasibility Study's recommendations into account, what next steps do you as the municipality plan to take? What potential benefits or internal municipal improvements would result from these next steps?

The Feasibility Study was taken to City of Toronto Council in spring 2020 to make a decision on which direction the project is to proceed.

A Terms of Reference document was also developed to help guide other City of Toronto projects on carrying out Net Zero Energy and Emissions feasibility studies, and now posted on City of Toronto Green Standards website.

5. Lessons Learned

In answering the questions in this section, please consider all aspects of undertaking the Study — from the initial planning through each essential task until the Final Study was prepared.

a) What would you recommend to other municipalities interested in doing a similar Feasibility Study? What would you do differently if you were to do this again?

- Carrying out this study from project onset to allow for greatest number of opportunities for the project, prior to the design being set.
- Ensure a true integrated approach to bring every opportunity forward at the start of the study.
- Utilize the Net Zero Energy and Emissions Terms of Reference document created by our team to provide a framework to studies.
- Analyse data from studies to ensure budget is suitable for any associated premiums of Net Zero Energy and Emissions.

b) What barriers or challenges (if any) did you encounter in doing this Feasibility Study? How did you overcome them?

- Beginning the study once design was already established limited opportunities on what measures can be explored to upgrade the project to a Net Zero Energy and Emissions building.
- Identify and engage specialists of new technologies into the study, and avoid applying rules of thumb as an approach.
- Allow sufficient time for the study within the overall project schedule.

6. Knowledge Sharing

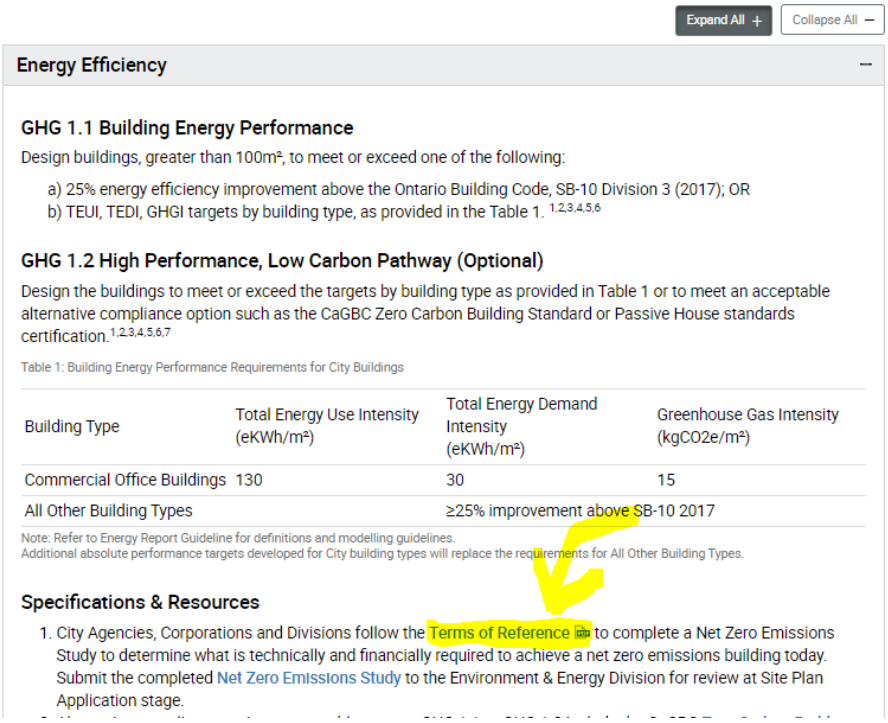
a) Is there a website where more information about the Feasibility Study can be found? If so, please provide the relevant URL.

We anticipate to post the final Feasibility Study report on the City of Toronto Green Standards website. It is also our understanding that the FCM will post our report on the Green Municipal Fund™ (GMF) website.

b) In addition to the Feasibility Study results, has your Feasibility Study led to other activities that could be of interest to another municipality (for example, a new policy for sustainable community development, a series of model by-laws, the design of a new operating practice, a manual on public consultation or a measurement tool to assess progress in moving toward greater sustainability)? If so, please list these outcomes, and include copies of the relevant documents (or website links).

A Terms of Reference for Net Zero Energy and Emission Studies was developed by the design team for the City of Toronto, to provide guidance to other Net Zero Energy and Emission Feasibility studies.

Link:
https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/toronto-green-standard-version-3/city-agency-corporation-division-owned-facilities-version-3/energy-ghg-resilience-for-city-agency-corporation-division-owned-facilities/



Expand All + Collapse All –

Energy Efficiency –

GHG 1.1 Building Energy Performance

Design buildings, greater than 100m², to meet or exceed one of the following:

a) 25% energy efficiency improvement above the Ontario Building Code, SB-10 Division 3 (2017); OR
b) TEUI, TEDI, GHGI targets by building type, as provided in the Table 1. [1,2,3,4,5,6]

GHG 1.2 High Performance, Low Carbon Pathway (Optional)

Design the buildings to meet or exceed the targets by building type as provided in Table 1 or to meet an acceptable alternative compliance option such as the CaGBC Zero Carbon Building Standard or Passive House standards certification.[1,2,3,4,5,6,7]

Table 1: Building Energy Performance Requirements for City Buildings

Building Type	Total Energy Use Intensity (eKWh/m²)	Total Energy Demand Intensity (eKWh/m²)	Greenhouse Gas Intensity (kgCO2e/m²)
Commercial Office Buildings	130	30	15
All Other Building Types		≥25% improvement above SB-10 2017	

Note: Refer to Energy Report Guideline for definitions and modelling guidelines.
Additional absolute performance targets developed for City building types will replace the requirements for All Other Building Types.

Specifications & Resources

1. City Agencies, Corporations and Divisions follow the Terms of Reference to complete a Net Zero Emissions Study to determine what is technically and financially required to achieve a net zero emissions building today. Submit the completed Net Zero Emissions Study to the Environment & Energy Division for review at Site Plan Application stage.

This project was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.