Bluffer's Park Pavilion

Sustainability Report

September 12, 2023

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Ross & Baruzzini

Issue	Description	Date	Prepared By	Signed Off
1	Issued for 50% CD	2023-01-31	HM, TG	EC
2	R1 Issued for 50% CD	2023-09-12	GC	EC

Project Number: 2020.0010052.000

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1 Executive Summary

1.1 Introduction

Bluffer's Park Pavilion is comprised of two single-storey buildings. The West building is a 360 m^2 proposed building containing offices, a meeting room, and a breakroom for City of Toronto Parks, Forestry, and Recreation staff as well as public washrooms. The east building is a 136 m^2 structure with changerooms and seasonal storage. The east building is unheated and naturally ventilated while the West building is fully conditioned. The project has high sustainability requirements, targeting TGS for City owned buildings.

This report intends to provide insight into the design strategies and provide opportunity for feedback and costing. For this 50% CD submission, an analysis of preliminary energy performance, renewable energy potential, and life cycle assessment (LCA) of embodied carbon have been provided,

The pathway to compliance with TGS GHG 1.1 for City-Owned buildings includes either:

- Maximum TEUI of 100 kWh/m^2/yr and TEDI of 30 kWh/m^2/yr;
- Energy efficiency at a minimum 50% better than Ontario Building Code compliant building (Ontario Building Code, SB-10 Division 3 2017);
- Passive House levels of energy performance including registration and certification; OR
- CaGBC Zero Carbon Building Standard v2 (Net Zero) design or performance standard including registration and certification.

In all cases, the GHGI must be 0 $kgCO_2e/m^2$/yr which requires either sufficient on site renewable energy generation to export green power to offset grid emissions or the purchase of carbon offsets.

The identified strategy with the most flexbility for this building is to follow the CaGBC Zero Carbon Design standard. Since v2 is no longer available for registration, the project will be evaluated to v3.

A separate TGS checklist for other portions of TGS will be provided at a later date.

1.2 Energy Analysis

A preliminary energy model was created to provide feedback on the performance of the building prior to 100% design in the event that performance needs to be increased. Inputs were based on discussion with the mechanical designer and review of the available architectural and mechanical drawings.

In order to achieve the energy performance requirements of version 3, there are numerous paths available. These are summarized in greater detail in the Zero Carbon Building Strategy section of the report. However, of note is that the building must have a TEDI of 32 kWh/m^2/year unless the seasonal heating COP is greater than 2 or if a detailed analysis of building loads and explored mitigation strategies shows that the target TEDI is not achievable, in which case the TEDI resulting from an NECB reference design will apply to those specific spaces. This detailed TEDI analysis is outside of the current scope.

1.2.1 Proposed Performance

Following are the proposed performance metrics for the project:

- TEUI: 193 kWh/m^2/year
- TEDI: 136 kWh/m^2/year
- GHGI: 4.9 kgCO2e/m2/year (using ZCB factors)
- Overall heating COP: 1.4

1.2.2 Sensitivity Analysis

A sensitivity analysis has been conducted to determine the effect of various energy conservation measures (ECMs) on TEUI and TEDI. The analysis included six energy model variations, inclusive of the proposed project. Starting with the proposed project, each consecutive model included an additional ECM. The results demonstrate that every additional energy conservation measure improves the overall building performance.

The energy conservation measures included in the analysis are, as follows:

1. Add 100mm subgrade insulation
2. Increase wall R Value to R30 eff.
3. Decrease infiltration by 20%
4. Replace spandrel with wall assembly
5. Upgrade to Triple Glazed Windows

Incorporation of all five energy conservation measures improves the performance metrics to the following:

- TEUI: 162 kWh/m^2/year, 16% decrease
- TEDI: 94 kWh/m^2/year, 30% decrease

1.2.3 Recommendations

With high heat loss through the envelope, strategies can be included to improve the effective resistance of the envelope and minimize any linear or point transmittances. The sensitivity analysis includes some of these measures, however, full application of Passive House level measures should help to improve performance further.

Any refinements in building operation strategy that can reduce the hours when public washroom exhaust runs or strategies that allow the building exhaust to be set back should help reduce building TEDI, EUI, and utility cost.

Due to mechanical equipment limitations associated with small projects, it is challenging to provide heat to the building using systems other than electric resistance heat. The low overall heating COP (evaluated by dividing the building TEDI by the building heating energy) means that strategies to reduce heat loss can have a significant impact on reducing building operational cost.

More details on the energy analysis are available in Appendix A.

1.3 Renewable Energy Assessment

A renewable energy system is one strategy to achieve the project target GHGI of 0. Under ZCB, building emissions associated with grid electricity can be offset by exporting green power using the marginal emissions factor of the grid instead of the average emissions factor. Exporting green power is possible when the renewable energy system produces in excess of what the building requires, as evaluated on an hourly basis using the energy model. Usually, this amounts to 30-40% of total building energy use. Based on the preliminary energy modelling results, this means the PV system needs to supply about 25 MWh/yr.

Maximizing the installation of PV panels on the available roof area (36 kWp PV array) allows for production of 40.9 MWh/year. This can offset TEUI by 133 kWh/m²/year, or 69%.

More details are available in Appendix B.

1.4 Lifecycle Assessment

The baseline embodied carbon performance of the West building is 680 kg CO_2e/m^2 and for the East building it is 742 kg CO_2e/m^2. The target for ZCB certification is a maximum of 500 kg CO_2e/m^2 or a reduction of 10% from the baseline while TGS compliance requires a 20% reduction from baseline. As of May 1, 2022, TGS compliance requires an upfront carbon emissions of less than 350 kg CO_2e/m^2.

Life Cycle Stage	Proposed: West	Proposed: West	Proposed: Both Buildings
Upfront Carbon (A1-A5) (t CO2e)	223	86	318
Upfront Carbon Intensity* (A1-A5) (kg CO2e/m²)	606	672	623
Embodied Carbon (A-C)	250	95	318
Embodied Carbon Intensity* (A-C)	680	742	641

*With a West Building GFA of 368m² and East Building GFA of 128m².

Low carbon concrete and specific requirements on XPS and PIR insulation should allow both of these targets to be met. In addition, by achieving a 20% reduction in embodied carbon from baseline, an impact and innovation point can be achieved, of which two are necessary for ZCB certification.

These embodied carbon values are expected to change slightly as more data becomes available in future stages of design.

More details about how the project is performing and areas for improvement are available in Appendix C.

1.5 Zero Carbon Building Strategy

The ultimate goal of this certification is for a project design to demonstrate that it can achieve zero carbon emissions by calculating embodied and operational carbon emissions, working to minimize these and offset them using onsite means, and then lastly by obtaining quotes for the purchase of carbon offsets and renewable energy credits. The project has not yet been registered.

Details are provided in Appendix D.

1.5.1 Carbon

The project must estimate the carbon emissions associated with the manufacture, transport, assembly, use, disassembly, and end-of-life (i.e. embodied carbon) of the structure and envelope. The preliminary estimate carried out based on the 50% CD drawings is **680 kg CO_2e/m^2** for the West building and **742**

kg CO_2e/m^2 for the East building, which are above the limit for ZCB certification. Therefore, a 10% reduction from this baseline is required. Refer to the LCA report for strategies to achieve this required reduction.

The project intends to use an all-electric heating and cooling system, which means that there will be no on-site combustion equipment. Based on preliminary estimates of energy use prior to any reduction from onsite renewable energy, the carbon emissions associated with grid electricity usage is 1.5 tonnes of carbon dioxide equivalent per year, or 4.9 kg CO_2e/m^2 of building area per year.

1.5.2 Energy

The project must comply with one of three energy paths for the design certification. Due to the high TEDI performance, the Renewable and Passive Approaches are unlikely to apply to the project. The Flexible approach is therefore the likely path to compliance, and therefore the following requirements apply:

- Overall energy performance is 25% better than the NECB 2017 reference building
- Seasonal heating COP is 2.0 or greater
- If the seasonal COP is lower than 2.0 the following two options may apply:
- TEDI is 32 kWh/m^2/year
- Perform detailed analysis of heating loads to explain why reduction of TEDI is not possible, including financial analysis, in which case an adjusted TEDI value based on the NECB 2017 reference TEDI may apply, pending review by CaGBC

Based on preliminary modelling, the project is not on track to achieve the energy performance for ZCB-Design. Refer to the Energy Analysis section for more information about current performance and strategies to achieve compliance.

1.5.3 Impact and Innovation

Two impact and innovation credits must be selected from a pre-approved list. For this building, the following may apply:

- No combustion for space heating
- Embodied carbon reduction baseline of 20% or max embodied carbon intensity of 350 kg CO_2e/m^2 (this aligns with a TGS embodied carbon requirement and should be targeted)
- On-site renewable energy systems providing 5% of yearly energy requirements or covering 75% of available roof space.

Due to significant overlap with TGS requirements, there should be no issue achieving these points.

Appendix A: Energy Analysis Report

Bluffer's Park Pavilion

Energy Analysis Report

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1 Limiting Conditions

This report has been prepared to provide estimated energy performance of the proposed building design for feedback prior to 100% design, in the event performance needs to be increased. Inputs were based on discussion with the mechanical designer and review of the available architectural and mechanical drawings.

The analysis and the results present the annual energy performance for the proposed building design in comparison to designs incorporating energy conservation measures (ECMs). The proposed and alternative design calculations are applicable only for comparison. The results contained in this report are intended to demonstrate relative energy use reductions based on the current proposed envelope and system design. They are not predictions of actual energy use or costs of the proposed design after construction. Actual experience will differ from these calculations due to the variations such as occupancy, building operation and maintenance, weather, energy use not covered by this analysis, and precision of the calculation tool.

2 Project Narrative

Bluffer's Park Pavilion located in Scarborough, Toronto is comprised of two single-storey buildings. The west building is a 360 m^2 proposed building containing offices, a meeting room, and a breakroom for City of Toronto Parks, Forestry, and Recreation staff as well as public washrooms. The east building is a 136 m^2 structure with changerooms and seasonal storage. The east building is unheated and naturally ventilated while the west building is fully conditioned. The project has high sustainability requirements, targeting Toronto Green Standard for City owned buildings.

Ventilation for the entire west building is provided by two energy recovery ventilators (ERVs) with hydronic heating and cooling coils. There is one air source heat pump outdoor unit located on the roof that is connected to multiple indoor wall-mount ductless indoor units to provide conditioning for all different staff access areas. Additionally, electric resistance heat is provided for corridor spaces, garage, and utility room. Electric forced flow heaters and baseboard heaters will be also provided for the washroom facility with public access in order to be more vandal-resistant than other mechanical heating solutions such as a heat pump. The DHW heating is provided by a central electric hot water tank.

For reference purposes, a 3D rendering of the building in the IESVE software is shown in the figure below.

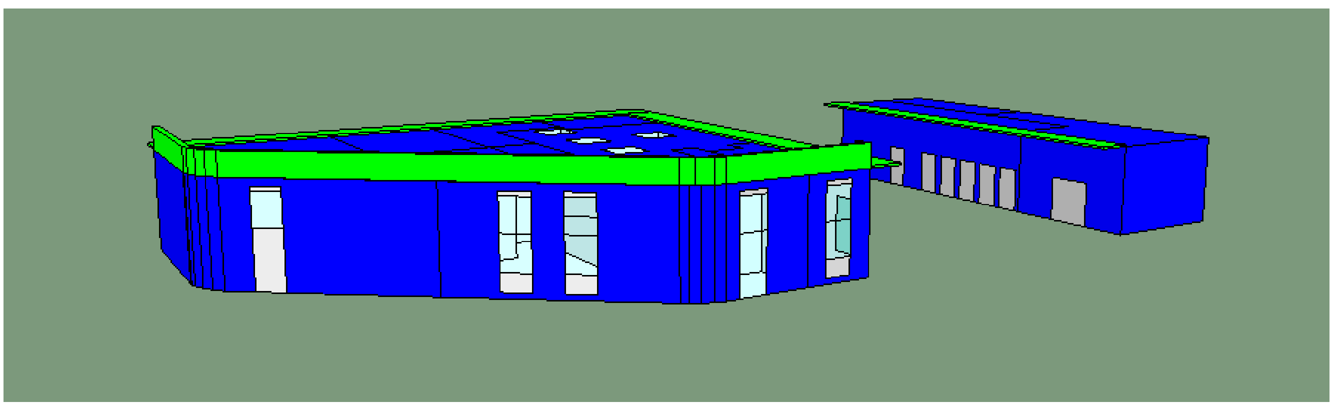

Figure 2.1: 3D Rendering of Energy Model

3 Energy Modelling Results

The energy model was developed using IESVE 2022 which conducts hourly building thermal and energy use calculations using 3D model inputs, detailed envelope constructions, internal thermal gains, infiltration air flow, detailed HVAC network inputs, and industry standard hourly weather files.

3.1 Current Performance

Following are the current performance metrics for the project:

- TEUI: 195 kWh/m^2/year
- TEDI: 138 kWh/m^2/year
- GHGI: 4.9 kgCO2e/m2/year (using ZCB factors)
- Overall heating COP: 1.3

The energy model includes values for the east building although these are not substantial since the building is mostly unoccupied and unconditioned. Below is the breakdown on energy end use:

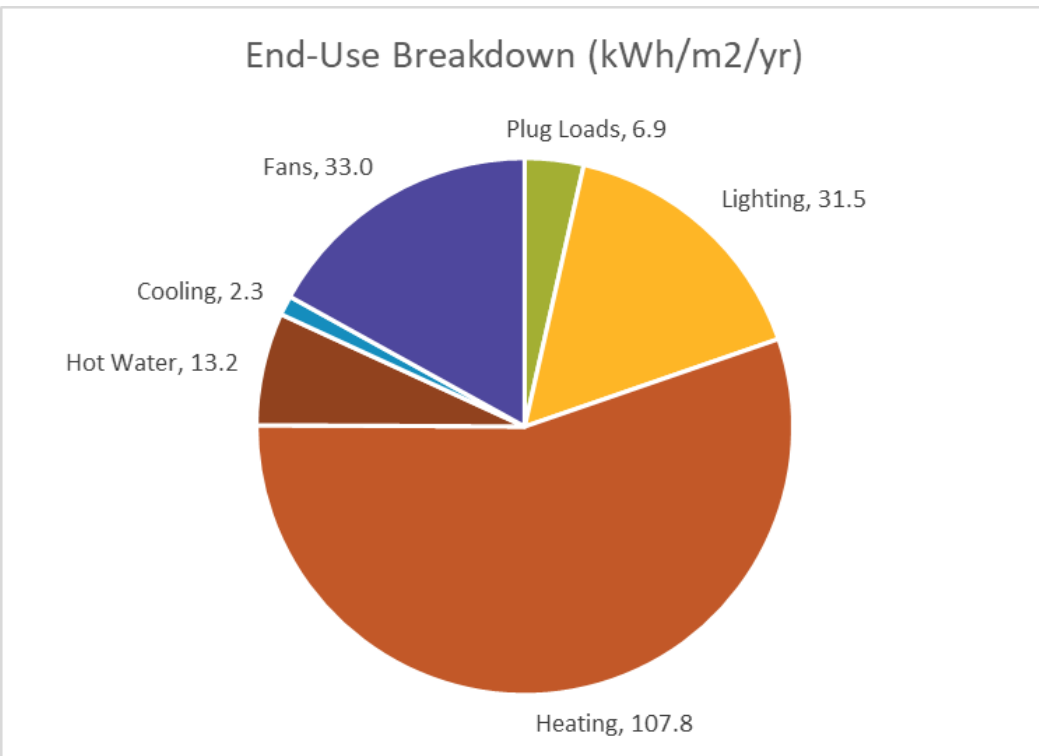

Figure 3.1.1: Energy End-Use Breakdown

Due to the high heating energy end-use, a separate heating energy breakdown has been provided, and the ventilation has been turned off to see the impact of the envelope alone.

Table 3.1.1: Heating Energy Breakdown by Source

Heating Source	Proposed (kWh/m2/yr)	Without Ventilation (kWh/m2/yr)
All Heat Pumps	18.8	16.1
Back up Heat for HPs	3.0	2.0
Elec Heat Washroom	39.7	12.0
Elec Heat Garage	2.2	2.4
Elec Heat Lobby S	14.0	8.1
Elec Heat Lobby N	12.3	10.8
Elec Heat Utility Rm	17.8	15.6
Total	**107.8**	**66.9**

Energy use is not particularly sensitive to ventilation in most areas with the major exception being the washroom, where high airflows contribute to high heating loads on an electric resistance heater.

The TEDI with building ventilation turned off is reduced to 92 kWh/m2/year which is still high and indicates that reductions in envelope heat loss can improve building performance. This makes sense as the project is a single level building with relatively high envelope surface area to floor ratio.

3.2 Sensitivity Analysis

A sensitivity analysis has been conducted to determine the effect of energy conservation measures (ECM) on reducing envelope heat loss. Table 3.2.1 compares the annual energy use intensity and the thermal energy demand intensity for the current proposed design and the ECMs.

Table 3.2.1 Energy Model Sensitivity Analysis Results

Measures	Scenario Number	TEUI [kWh/m²]	% Reduction	TEDI [kWh/m²]	% Reduction
Proposed (Baseline)	1	193.1	-	135.6	-
Add 100mm subgrade insulation	2	179.3	7%	118.0	13%
Add 100mm subgrade insulation, **Increase wall R Value to R30 eff**	3	172.2	11%	118.0	13%
Add 100mm subgrade insulation, Increase wall R Value to R30 eff, **Decrease infiltration by 20%**	4	167.3	13%	102.1	25%
Add 100mm subgrade insulation, Increase wall R Value to R30 eff, Decrease infiltration by 20%, **Remove Spandrel**	5	166.3	14%	100.5	26%
Add 100mm subgrade insulation, Increase wall R Value to R30 eff, Decrease infil by 20%, Remove Spandrel, **Add Triple Glazed Windows**	6	161.6	16%	94.2	31%

While the overall efficiency of the system improves as envelope performance improves, the heating overall COP does not improve due to the increasing contribution of electric heat in the washroom which is not improved with improved envelope.

Reducing the load on that washroom electric heat will have a significant impact on building performance and can occur at minimal cost to the project. This could look like:

- reducing the hours of operation of the ventilation and makeup air in the washroom (subject to the needs of the building),
- reducing the exhaust air flow by reducing access to washrooms during periods of low usage (e.g. blocking access to 50% of washrooms would mean reducing the exhaust requirements by approximately 50%),
- or to a lesser extent by refocusing the intent of the washroom heating system towards occupant comfort (e.g. high temperature radiant or warmed surfaces) rather than attempting to heat the entire air volume of the space.
    - A lower temperature setpoint should be used in this scenario

3.3 Recommendations

With high heat loss through the envelope, strategies can be included to improve the effective resistance of the envelope and minimize any linear or point transmittances. The sensitivity analysis includes some of these measures, however, full application of Passive House level measures should help to improve performance further.

Any refinements in building operation strategy that can reduce the hours when public washroom exhaust runs or strategies that allow the building exhaust to be set back should help reduce building TEDI, EUI, and utility cost.

Due to mechanical equipment limitations associated with small projects, it is challenging to provide heat to the building using systems other than electric resistance heat. The low overall heating COP (evaluated by dividing the building TEDI by the building heating energy) means that strategies to reduce heat loss can have a significant impact on reducing building operational cost.

4 Conclusion

In order to achieve the energy performance requirements of TGS version 3, there are numerous paths available. These are summarized in greater detail in the Zero Carbon Building Strategy section of the Sustainability Report. However, as neither the TEUI, TEDI, or heating COP performance metrics for the CaGBC ZCB v3 standard or TGS GHG 1.1 are expected to be met, it is recommended that the the targets be adjusted for this building, or that investment in building envelope and mechanical systems in increased. Changes to the mechanical system selection may have impacts on vandal-resistance intent of the current design, which could affect the operations and maintenance cost of this building and may not be feasible, but modifications to the operation of the system may be more easily achievable and should be explored.

Please note the energy results presented in this report are strictly based on the assumptions and inputs in Appendix A of this report. Any changes in these assumptions and inputs in the final design, building geometry, etc. will have an impact on the results.

We trust the foregoing provides the information required at this time. Please do not hesitate to contact the undersigned with any questions or comments.

5 Input Summary Table

<table>
<tr><th colspan="2">Proposed Model</th></tr>
<tr><td colspan="2">General</td></tr>
<tr><td>Location</td><td>Scarborough, ON</td></tr>
<tr><td>Simulation Weather File</td><td>Toronto 2016 CWEC</td></tr>
<tr><td>Climate Zone</td><td>ASHRAE 90.1 - 2013 Climate Zone 5</td></tr>
<tr><td>Modeling Software</td><td>IESVE 2022.2</td></tr>
<tr><td>Building Area</td><td>West MFA: 308 m^2, East MFA: 162 m^2</td></tr>
<tr><td>Hours of Operation</td><td>As per NECB 2017 Schedule A</td></tr>
<tr><td>References</td><td>RJC Structural Sketches SK-1 to 4 (2022-11-28)
DTAH Architectural Drawings A001,201,400,401 (2022-12-16)</td></tr>
<tr><td colspan="2">Envelope Performance</td></tr>
<tr><td>Overall Roof U-Value</td><td>U- 0.11 (RIP-50.8)</td></tr>
<tr><td>Overall Wall U-Value</td><td>U- 0.33 (RIP-17) (estimate for degradation due to thermal bridges included)</td></tr>
<tr><td>Overall Floor U-Value</td><td>U- 0.34 (RIP-17)</td></tr>
<tr><td>Window to Wall Ratio</td><td></td></tr>
<tr><td>Overall Glass U-Value including frame and SHGC</td><td>U- 1.68 (RIP-3.38) / SHGC-0.40</td></tr>
<tr><td>Infiltration</td><td>0.25 L/s-m^2 at operating pressure applied to above ground wall and window area (per Zero Carbon Building energy modelling guidelines v3)</td></tr>
<tr><td colspan="2">Internal Loads</td></tr>
<tr><td>Occupancy</td><td>As per NECB 2017 Space References:
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<tr><td>Space Type</td><td>Occ. m^2/person</td></tr>
<tr><td>Meeting Rm</td><td>5</td></tr>
<tr><td>Enclosed Office</td><td>20</td></tr>
<tr><td>Garage</td><td>1000</td></tr>
<tr><td>Washroom</td><td>30</td></tr>
<tr><td>Small Storage Room</td><td>100</td></tr>
<tr><td>Lobby</td><td>100</td></tr>
<tr><td>Seasonal Vehicle Storage</td><td>1000</td></tr>
<tr><td>Lounge/ Break Room</td><td>10</td></tr>
<tr><td>Changeroom</td><td>30</td></tr>
<tr><td>Storage</td><td>100</td></tr>
<tr><td>Utility</td><td>200</td></tr>
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<table>
<tr><th colspan="2">Proposed Model</th></tr>
<tr><td>Interior Lighting Power Density (LPD)</td><td>As per NECB 2017 Space References:
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<tr><td>Space Type</td><td>LPD W/m²</td></tr>
<tr><td>Meeting Rm</td><td>5</td></tr>
<tr><td>Enclosed Office</td><td>6.15</td></tr>
<tr><td>Garage</td><td>4.2</td></tr>
<tr><td>Washroom</td><td>3.5</td></tr>
<tr><td>Small Storage Room</td><td>3.5</td></tr>
<tr><td>Lobby</td><td>4.5</td></tr>
<tr><td>Seasonal Vehicle Storage</td><td>5</td></tr>
<tr><td>Lounge/ Break Room</td><td>4.5</td></tr>
<tr><td>Changeroom</td><td>3</td></tr>
<tr><td>Storage</td><td>5</td></tr>
<tr><td>Utility</td><td>5</td></tr>
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<tr><td>Lighting Control</td><td>NECB A Lighting: Changerooms, Lobby, Office, Washroom, Utility
NECB C Lighting: Conference
NECB K Lighting: Garage, Janitorial, Seasonal Vehicle Storage, Storage
No Automatic Daylight Controls</td></tr>
<tr><td>Receptacle Loads</td><td>As per NECB 2017:
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<tr><td>Space Type</td><td>EPD W/m²</td></tr>
<tr><td>Washroom</td><td>1</td></tr>
<tr><td>Meeting Rm</td><td>1</td></tr>
<tr><td>Office</td><td>7.5</td></tr>
<tr><td>Lounge/ Break Room</td><td>1</td></tr>
<tr><td>Washroom</td><td>1</td></tr>
<tr><td>Storage</td><td>1</td></tr>
<tr><td>Utility</td><td>1</td></tr>
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<tr><td>Process Loads</td><td></td></tr>
<tr><td>Domestic Hot Water</td><td>Demand from spaces using NECB profiles.</td></tr>
<tr><td colspan="2">Mechanical Systems</td></tr>
<tr><td>Indoor Design Temperature for Conditioned Areas</td><td>Occupied Space: Cooling (NECB A Cooling and NECB C Cooling (Conference)), Heating (NECB A Heating and NECB C Heating (Conference))
Electrical rooms: Cooling (NECB K Cooling), Heating (NECB K Heating)</td></tr>
<tr><td>System Description</td><td>One ASHP with auxiliary electric heating</td></tr>
<tr><td>Fan Power and Efficiency</td><td>Fan powers per mechanical selections:
ERV-1 - FCU Fan: 0.054 kW, 48%
ERV-1 - SA Fan: 0.243 kW, 82%
ERV-1 - RA Fan: 0.142 kW, 82%
ERV-1 - EA Fan: 0.098 kW, 70%
ERV-2 - SA Fan: 0.25 kW, 82%
ERV-2 - Washroom Fan: 0.15 kW, 80%
ERV-2 - RA Fan: 0.045 kW, 82%
ERV-2 - EA Fan: 0.098 kW, 70%</td></tr>
</table>

Proposed Model	
Total Ventilation Rates	ERV-1: 300 CFM ERV-2: 925 CFM
Ventilation Control	Constant rate based on ASHRAE 62.1 for occupied hours.
Energy Recovery	ERV-1: HE3XINV - 86.4% SHE, 85.9% LHE ERV-2: HE1XINV - 82% SHE, 81% LHE
Humidity Control	ERV
Central Plant	
Domestic Hot Water Loop	Domestic Hot Water Loop - LWT: 140°F / Δ: 100°F - Electric Boiler - 100% Thermal Efficiency

Appendix B: Renewable Energy Analysis

Bluffer's Park Pavilion

Renewable Energy Analysis

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1 Rooftop Photovoltaics (PV)

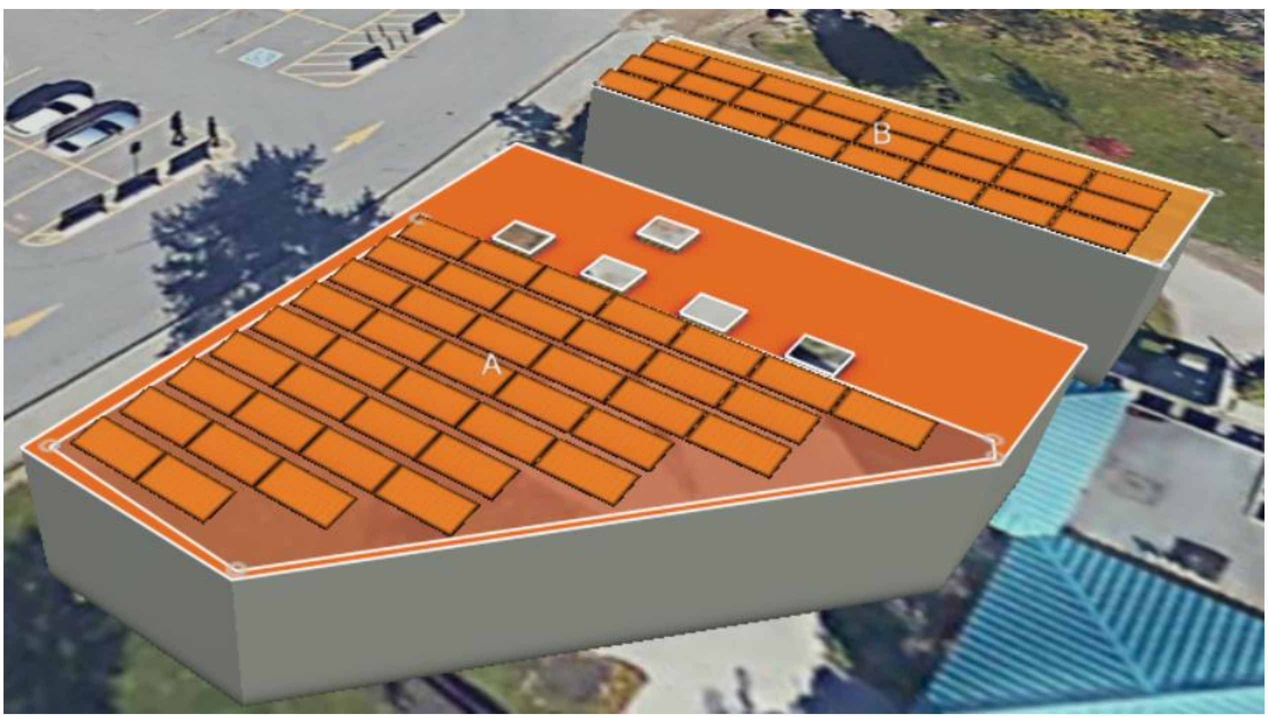
1.1 Inputs

The rooftop panel array was developed with the Aurora Solar program. The panels were modeled using Canadian Solar CS6W-545MS and with a solar access percentage (SAP) set at 100%. The inverter was modeled with the Canadian Solar CSI-25KTL-GS-FLB, with a DC/AC ratio of 1.5 and a string length of 10-18. Assuming about 60% roof area will have multiple rectangular PV bundles.

1.2 Results

The renewable energy estimates the rooftop PV panels will generate 40.9 MWh/yr. In total, the offset will reduce EUI by 133 kWh/m^2/yr, or at least 69%, based on a MFA of 308m^2.

System Description	Installed Capacity (kWp)	Roof Area for PV (m^2)	System Generation (MWh/yr)	EUI reduction (kWh/m^2/yr)
10° tilt, SW facing, 500mm row spacing	36	260	40.9	133



Rooftop PV

Appendix C: Lifecycle Assessment

Bluffer's Park Pavilion

January 31, 2023

Lifecycle Assessment Results at 50% CD

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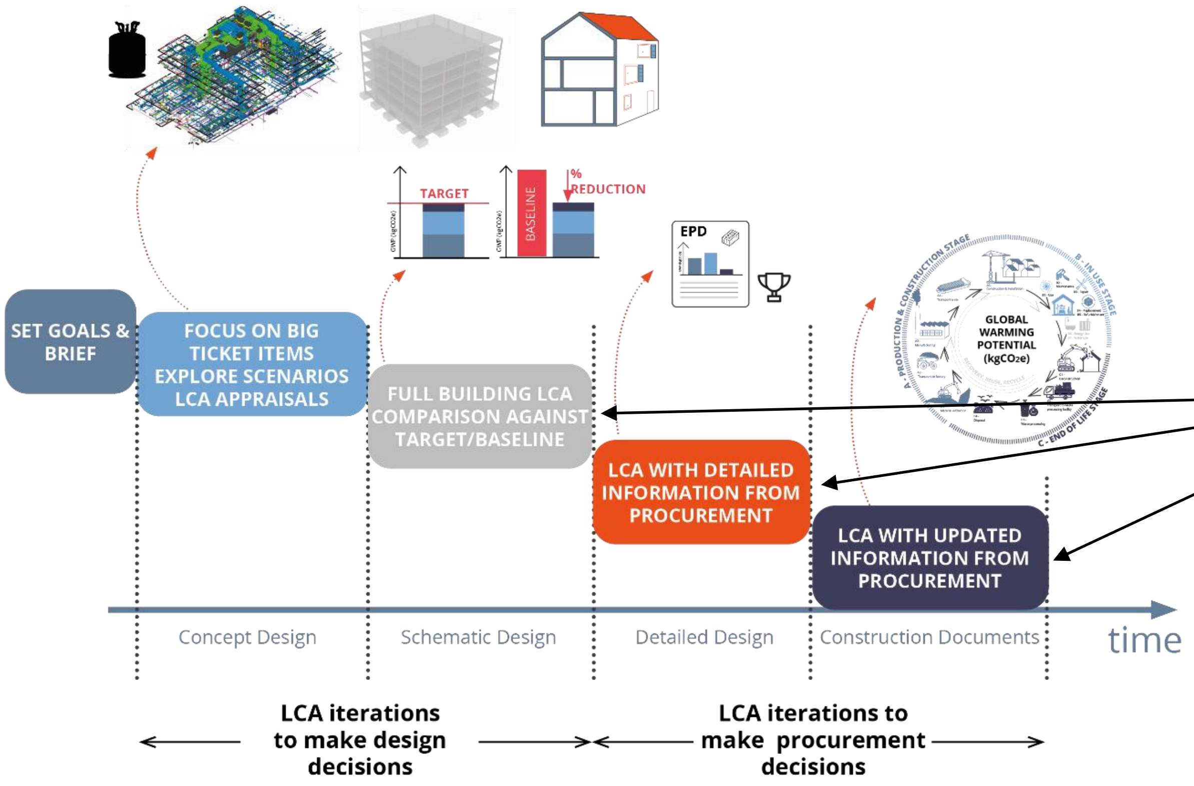
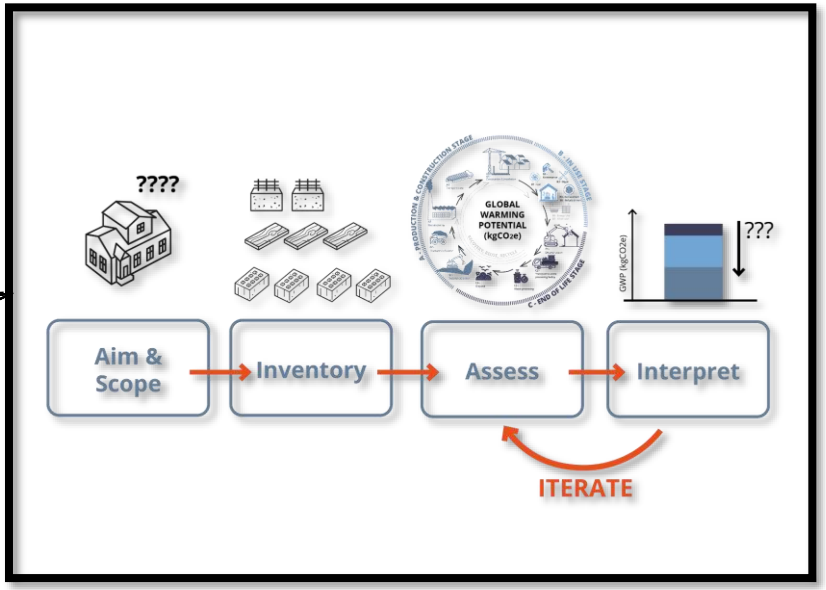
Process Overview

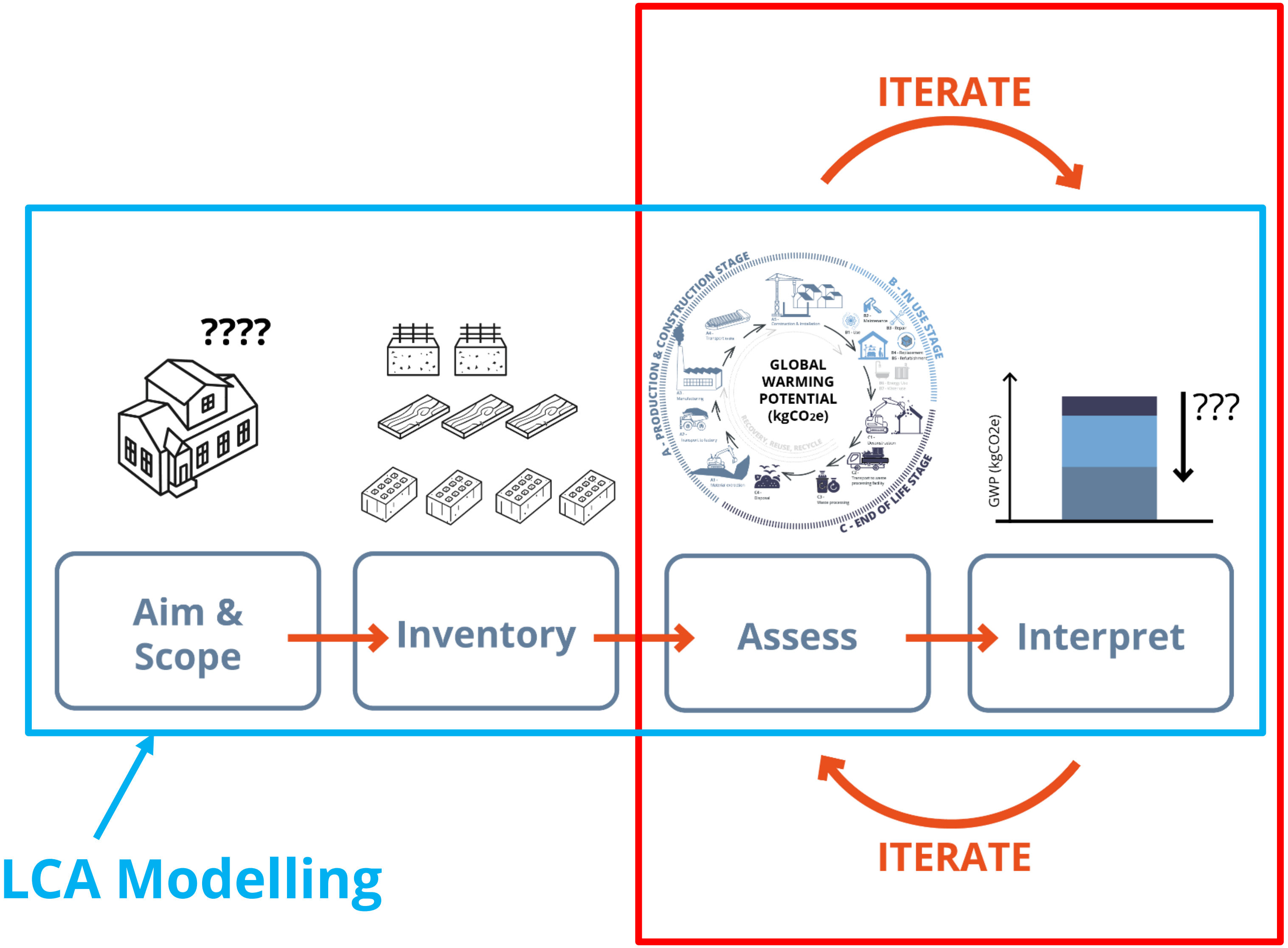
Typical Steps of an LCA Through Design & Construction





Process Overview

LCA Process

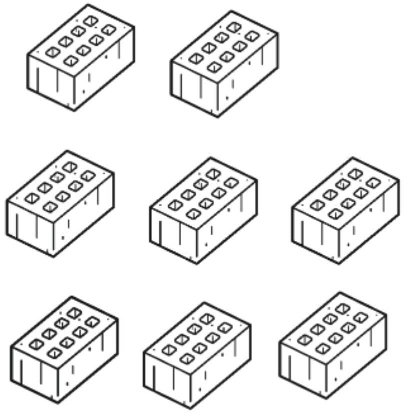


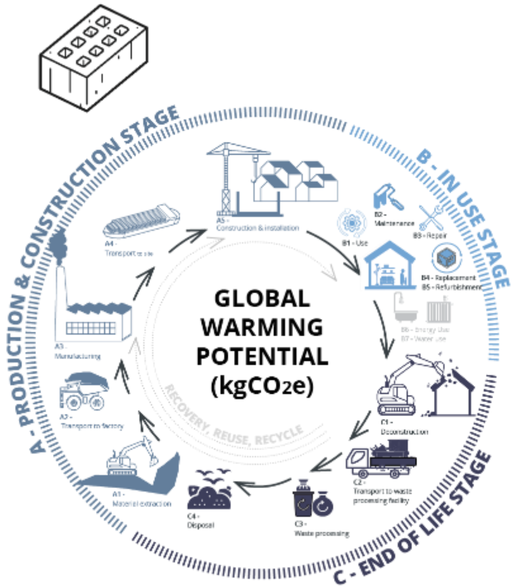
Step 1: LCA Modelling

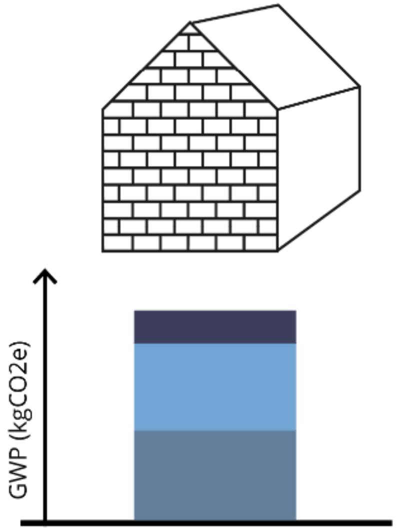
Step 2: Sensitivity Analysis

Modelling Process

Basic LCA Calculation Methodology





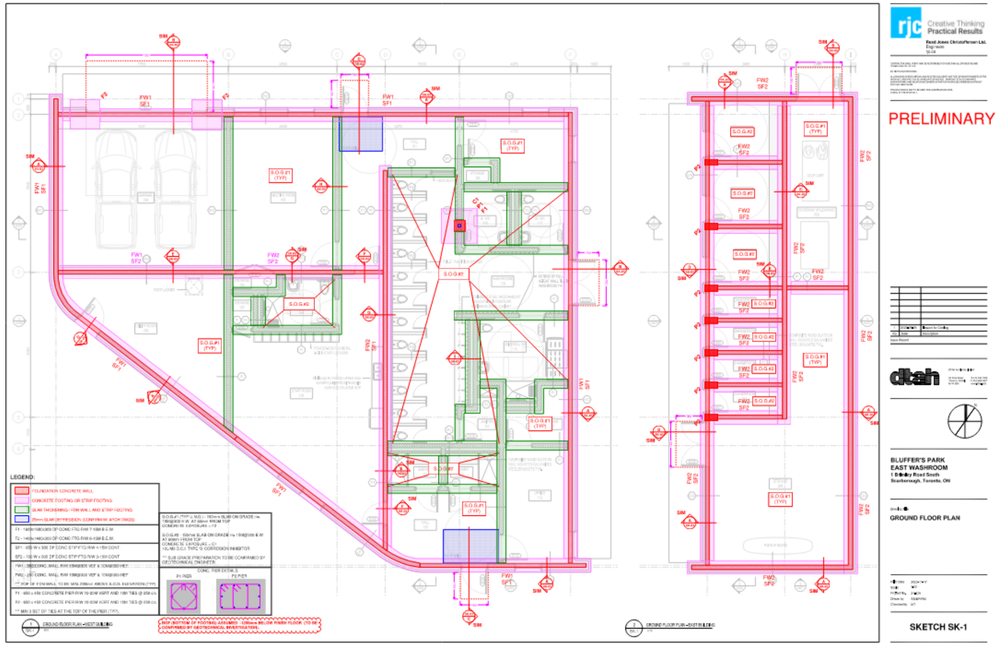


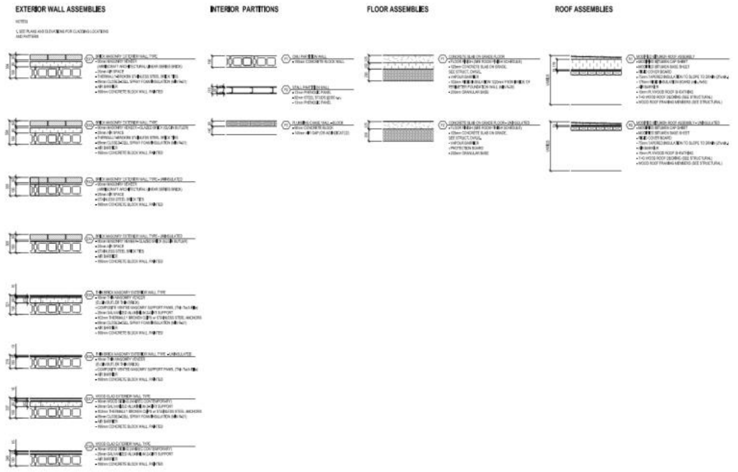
Material Quantity Estimate X **Embodied Carbon per unit material** = **Building Embodied Carbon estimate**

Modelling Process

Estimating Material Quantity – Manual Takeoffs

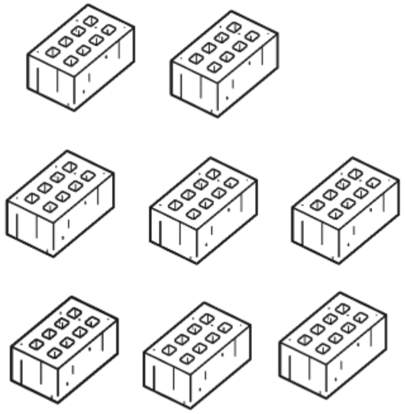
- RJC Structural Sketches SK-1 to 4 (2022-11-28)
- dtah Architectural Drawings A001, 201, 400, 401 (2022-12-16)

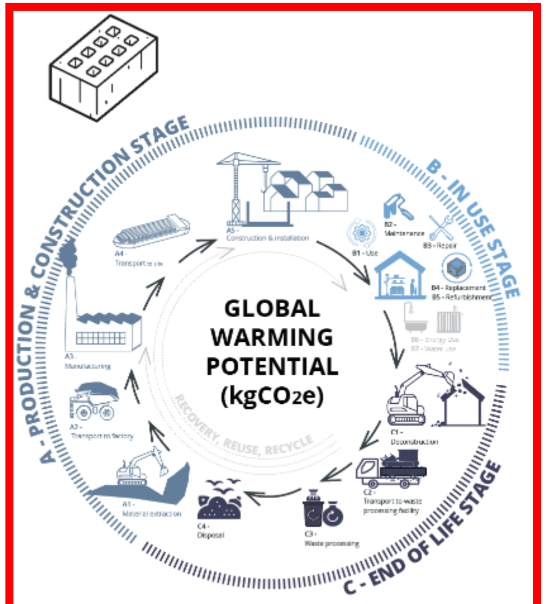


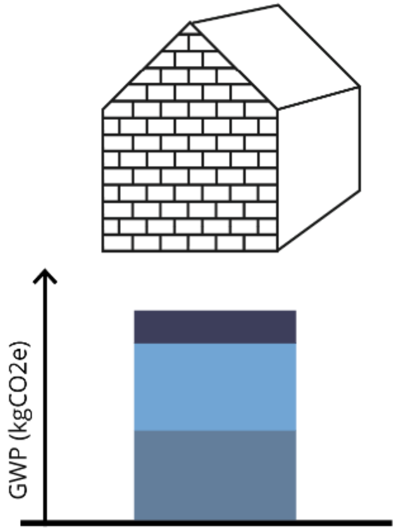


Modelling Process

Basic LCA Calculation Methodology



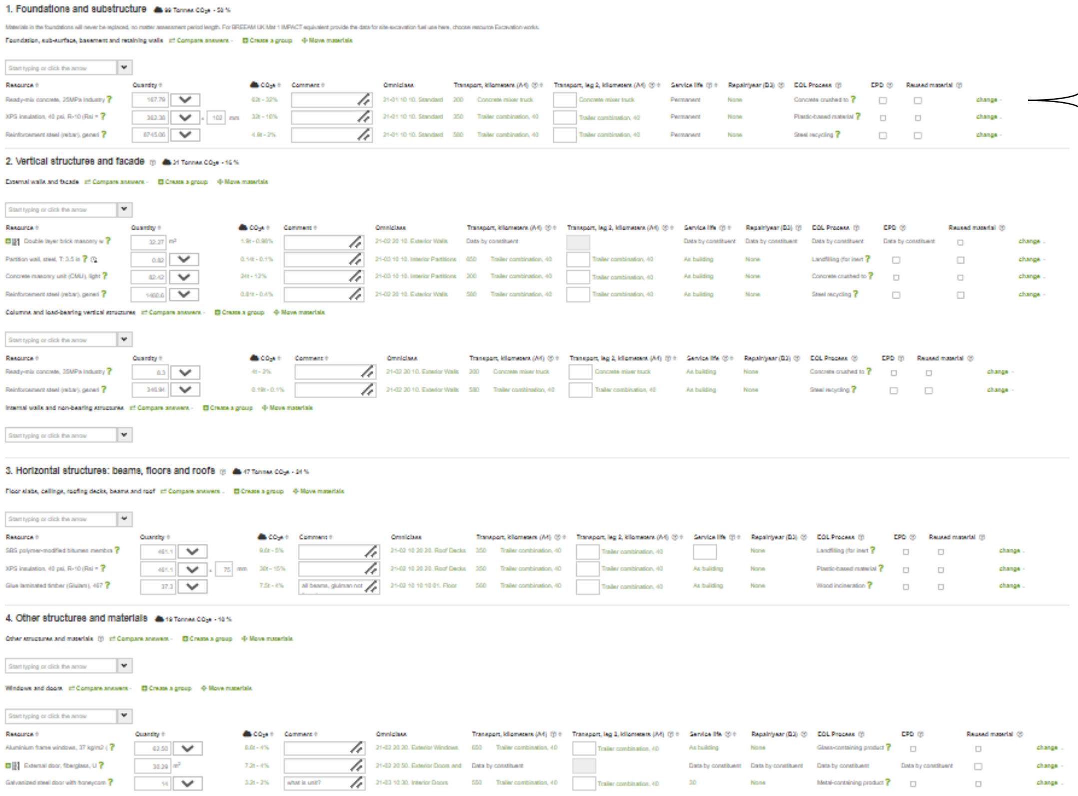


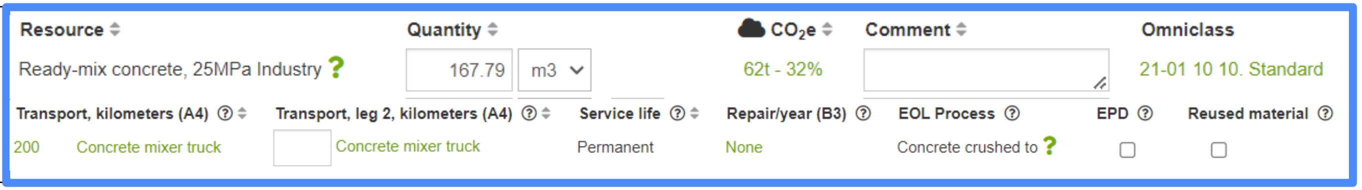


Material Quantity Estimate X **Embodied Carbon per unit material** = **Building Embodied Carbon estimate**

Modelling Process

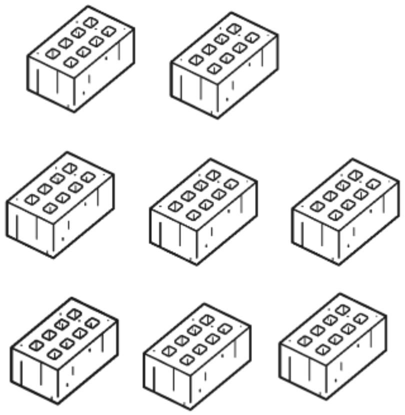
Embodied Carbon Per Material + Modelled Scenarios in OneClick LCA

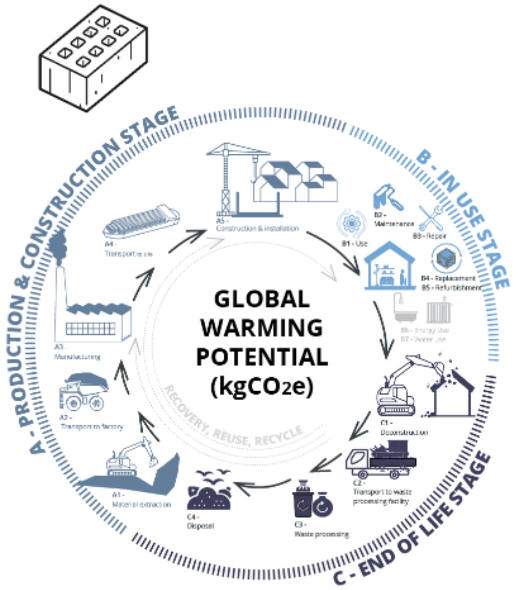


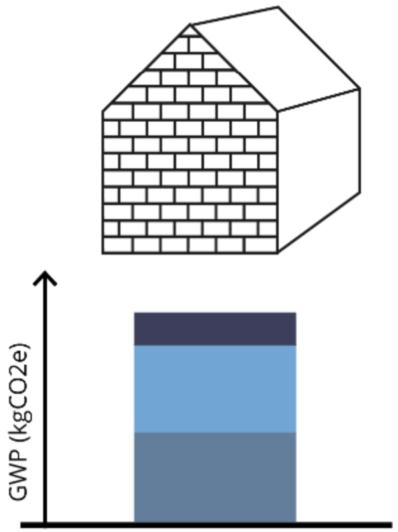


Baseline Result

Reminder: Basic LCA Calculation Methodology



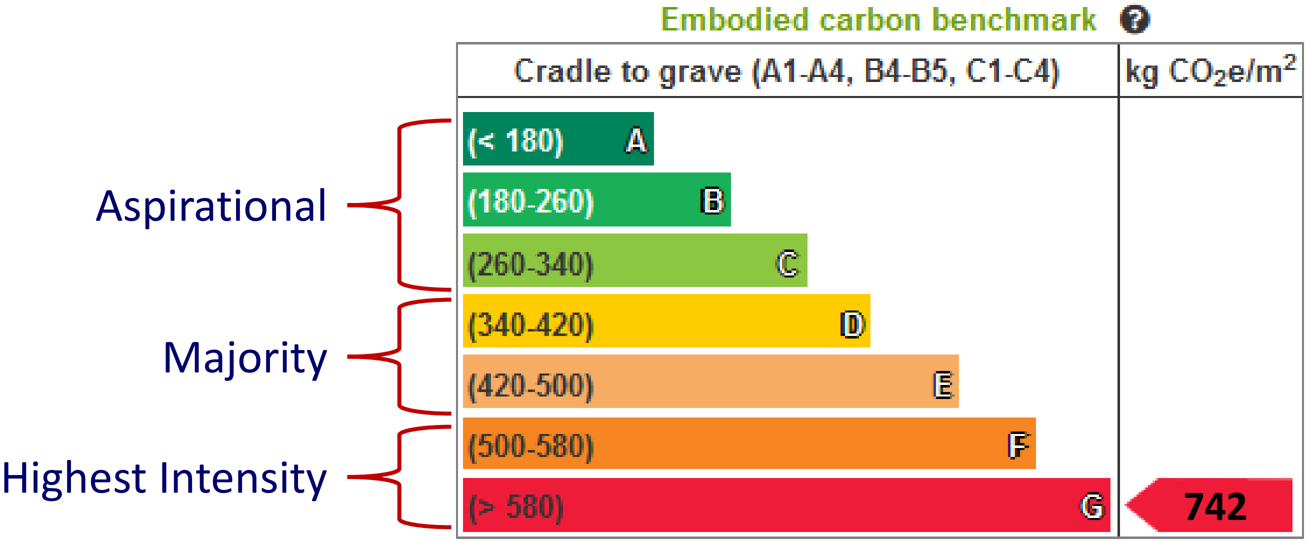




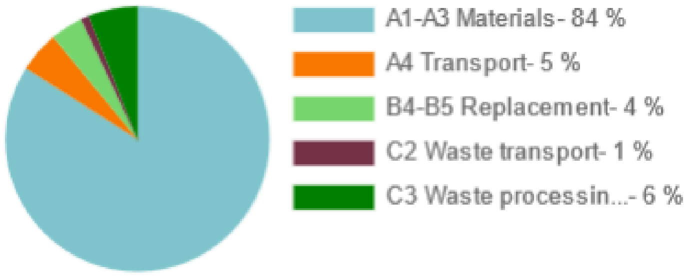
Material Quantity Estimate X **Embodied Carbon per unit material** = **Building Embodied Carbon estimate**

Baseline Results

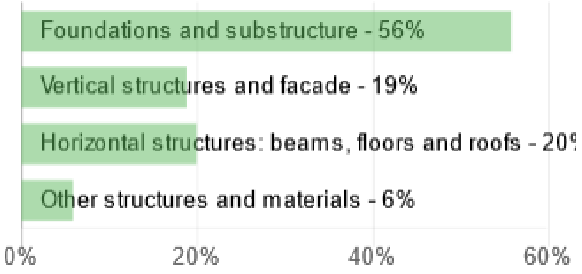
West Building



Embodied carbon by life-cycle stage



Embodied carbon by structure - A1-A3



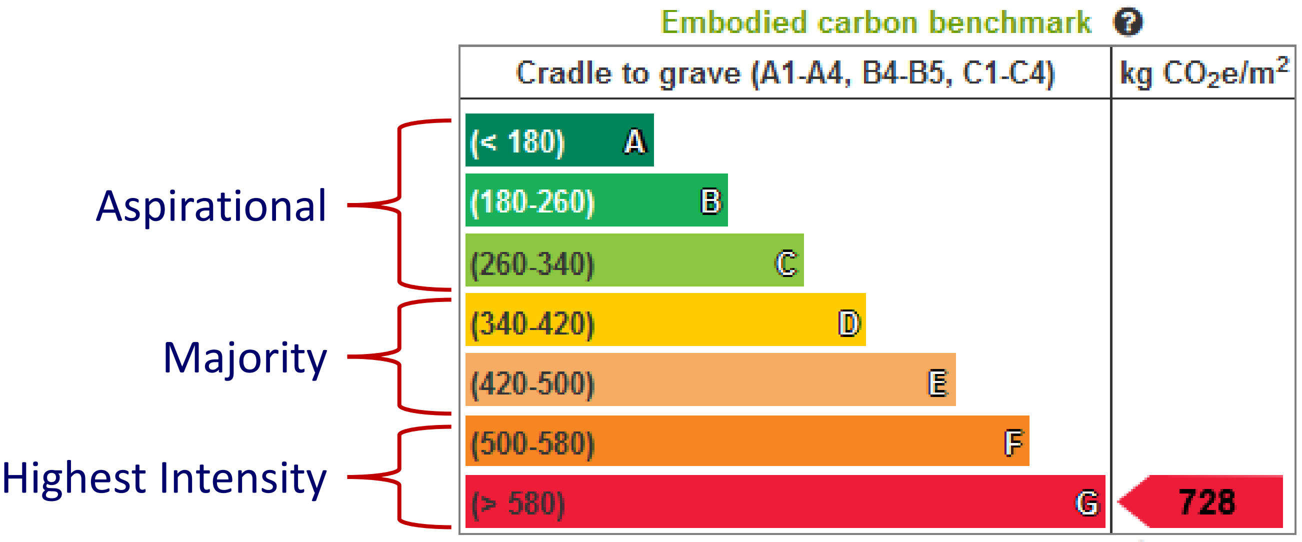
250 Tonnes CO_2e

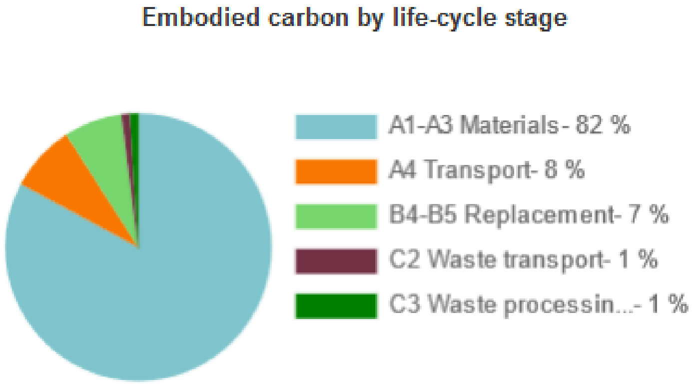
11.5 kg CO_2e / m^2 / year

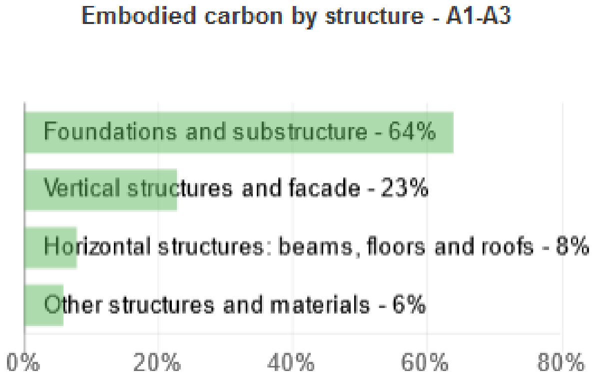
Compared to all types of buildings – Not only this type

Baseline Results

East Building







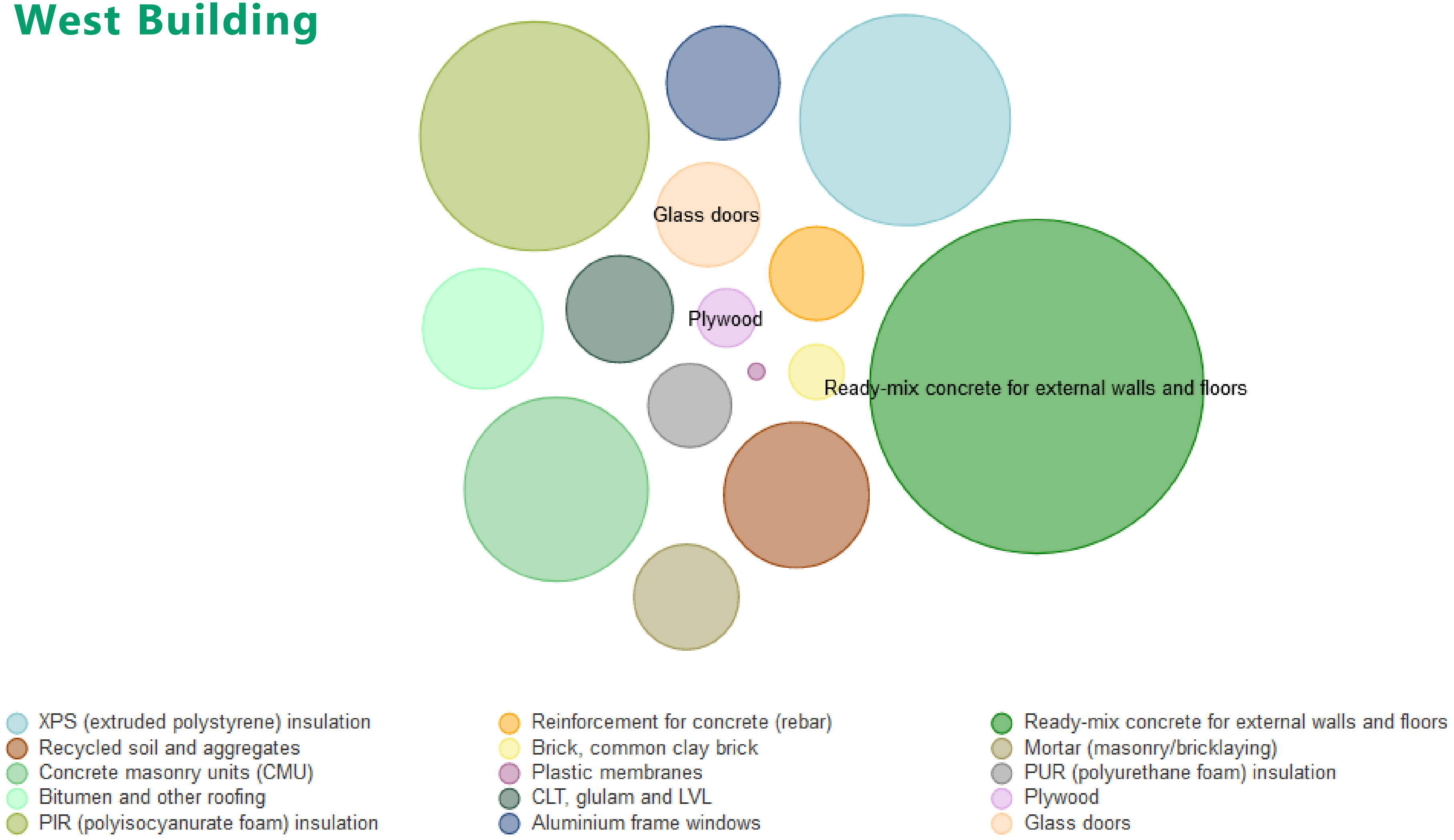
95 Tonnes CO_2e

12.32 kg CO_2e / m^2 / year

Compared to all types of buildings – Not only this type

Baseline Results

Per Material – West Building



Bubble chart, total life-cycle impact by resource type and subtype, Global warming

Sensitivity Analysis

Focus on Highest-Impact Materials

West Building

No.	Resource	Cradle to gate impacts (A1-A3)	Of cradle to gate (A1-A3)
1.	Ready-mix concrete, 35MPa Industry Average Benchmark ?	73 tonnes CO_2e	35.7 %
2.	XPS insulation, 40 psi, R-10 (Rsi = 1.76 m2K/W), 2 in (50.8 mm), 1.47 kg/m2, 28.9 kg/m3 ?	30 tonnes CO_2e	14.5 %
3.	PIR (polyisocyanurate foam) insulation panels, unfaced, generic, L = 0.022 W/mK, R = 4.55 m2K/W (26.7 ft2°Fh/BTU), 100 mm (3.94 in), 45 kg/m3 (2.81 lbs/ft3), Lambda=0.022 W/(m.K) ?	28 tonnes CO_2e	13.7 %
4.	Concrete masonry unit (CMU), light weight, 1825 kg/m3 ?	22 tonnes CO_2e	10.9 %
5.	Granular fill, ?	10 tonnes CO_2e	5.0 %
6.	Aluminium frame windows, 37 kg/m2 ?	8.5 tonnes CO_2e	4.1 %
7.	Cement mortar, 0.834 lb/ft2, 80.03 lb/ft3 ?	7.1 tonnes CO_2e	3.5 %
8.	Glue laminated timber (Glulam), 467.3 kg/m3 ?	6.9 tonnes CO_2e	3.3 %
9.	Reinforcement steel (rebar), generic, 90% recycled content, A615 ?	5.2 tonnes CO_2e	2.5 %
10.	Fiberglass reinforced polyester (FRP) door, per m2, 0.375-1.125 in / 9.5-28.6 mm glass pocket thickness ?	3.6 tonnes CO_2e	1.7 %

East Building

No.	Resource	Cradle to gate impacts (A1-A3)	Of cradle to gate (A1-A3)
1.	Ready-mix concrete, 35MPa Industry Average Benchmark ?	43 tonnes CO_2e	56.6 %
2.	Concrete masonry unit (CMU), light weight, 1825 kg/m3 ?	10 tonnes CO_2e	13.7 %
3.	Cement mortar, 0.834 lb/ft2, 80.03 lb/ft3 ?	5.3 tonnes CO_2e	6.9 %
4.	Fiberglass reinforced polyester (FRP) door, per m2, 0.375-1.125 in / 9.5-28.6 mm glass pocket thickness ?	4.3 tonnes CO_2e	5.6 %
5.	Granular fill, ?	3.6 tonnes CO_2e	4.7 %
6.	Reinforcement steel (rebar), generic, 90% recycled content, A615 ?	2.5 tonnes CO_2e	3.2 %
7.	PIR (polyisocyanurate foam) insulation panels, unfaced, generic, L = 0.022 W/mK, R = 4.55 m2K/W (26.7 ft2°Fh/BTU), 100 mm (3.94 in), 45 kg/m3 (2.81 lbs/ft3), Lambda=0.022 W/(m.K) ?	2.4 tonnes CO_2e	3.1 %
8.	Glue laminated timber, ?	1.3 tonnes CO_2e	1.8 %
9.	Clay brick, 3.625 x 2.25 x 7.625 in, 37.1% fly-ash ?	1.2 tonnes CO_2e	1.6 %
10.	SBS polymer-modified bitumen membrane roofing, self-adhered, 6.69 kg/m2 ?	1.2 tonnes CO_2e	1.6 %

Sensitivity Analysis focuses on:

Concrete (35.7%)

XPS (14.5%)

PIR (13.7%)

Sensitivity Analysis

Concrete

35 MPa – Assumed all concrete is 35 MPa. To be updated in future.

30 MPa – Assumed 0%

25 MPa – Assumed 0%

Modeled GWP in Baseline (35MPa):
417.05 kg CO_2e / m^3 (based on CRMCA Baseline)

Proposed (35MPa AIR):
298.76 kg CO_2e / m^3 (Based Pickering Innocon ECOPact Entry Level)
Other values and mixes are available locally, with reduced GWP

Overall project GWP impact of the best option:
West: -20 tCO2e, 8% decrease
East: -13 tCO2e, 13% decrease

Note: The products released recently may have lower GWP than the products available in the modeling tool

Sensitivity Analysis

Insulation

XPS Insulation – For foundation insulation

Modeled GWP in Baseline:
810.47 kg CO_2e / m^3 (based on Owens-Corning Foamular)

Proposed:
62.11 kg CO_2e / m^3 (based on Soprema Closed Cell XPS)

Overall project GWP impact of the best option:
West: -28 tCO2e, 30% decrease

PIR Insulation – For roof insulation

Modeled GWP in Baseline:
34.76 kg CO_2e / 1-m^2 RSI (based on Generic OneClick LCA)

Proposed:
2.75 kg CO_2e / 1-m^2 RSI (based on best available PIR)

Overall project GWP impact of the best option:
West: -25 tCO2e, 10% decrease
East: -2 tCO2e, 2% decrease

Sensitivity Analysis

Potential Drop in Embodied Carbon vs Baseline

	Baseline Design		Proposed Design
West Building	250 tonne CO2e 690 $kgCO_2e/m^2$	-29%	177 tonne CO2e 490 $kgCO_2e/m^2$
East Building	95 tonne CO2e 742 $kgCO_2e/m^2$	-16%	80 tonne CO_2e 623 $kgCO_2e/m^2$
Both Buildings	345 tonne CO2e	-25%	257 tonne CO_2e

20% reduction versus baseline is required for TGS. This should also be sufficient for an impact and innovation point in ZCB.

Appendix D: Zero Carbon Building Strategy

Appendix D

BLUFFER'S PARK - ZERO CARBON BUILDING STRATEGY

January 31, 2023

Table of Contents

1 Summary

To mitigate the worst effects of climate change, the UN Intergovernmental Panel on Climate Change (IPCC) has set a fixed carbon budget design to limit global temperature increase to 1.5°C. To support this effort, the Canadian Green Building Council (CaGBC) has developed the Zero Carbon Building (ZCB) Standard to assist the building construction and operations industry in the transition to zero carbon by 2050.

Two versions of the standard are currently in effect, both mandating whole life carbon neutrality through a combination of design, construction, and off-site measures. The ZCB – Design Standard applies to new construction and major renovations and focuses on low-carbon design, while the ZCB – Performance Standard applies to existing buildings and is an annual verification of zero carbon operations. New construction projects that have achieved ZCB – Design certification may go on to pursue ZCB – Performance certification to verify their operational performance.

1.1 Target

The Zero Carbon Building certification target for this project is ZCB – Design v2 or v3.

1.2 Summary of 50%CD Performance

- Embodied Carbon: 345 tonne CO2e
- Energy Performance:
    - TEDI: 138 kWh/m^2/yr
    - EUI: 195 kWh/m^2/yr
    - GHGI: 4.9 kgCO2e/m2/year
    - Note: the impact of PV has not yet been incorporated into these results.
- Impact and Innovation Credits:
    - 100% of space heating designed to operate without combustion.
    - Embodied carbon performance>= 20% vs baseline = 276 tonne CO2e
    - PV to provide <5% of building energy: >3 MWh/yr

The project requires some attention in order to achieve compliance. Due to the high heat loss and low building heating COP, the project does not comply with the energy requirements of ZCB.

2 Project Boundaries and Metrics

Similar to a LEED Project Boundary, the ZCB Boundary must include the entirety of the project building and site. While the site has two separate buildings, all energy and carbon calculations will be conducted for both buildings.

3 ZCB Certification Overview

The project is targeting certification under the ZCB-Design Standard. Unlike LEED, ZCB is not comprised of optional credits and compliance pathways; projects must comply with all requirements noted to achieve certification. An overview of the requirements of the ZCB Standards is included below:

		ZCB-Design One-time certification for new buildings and major renovations	ZCB-Performance Annual certification for existing buildings
Carbon	Zero carbon balance	Model zero carbon balance	Achieve zero carbon balance
	Embodied carbon	Report embodied carbon	Offset embodied carbon
	Refrigerants	Report total quantity	Offset any leaks
	RECs and carbon offsets	Provide quote	Provide proof of purchase
	Onsite combustion	Provide transition plan	Update plan every 5 years
Energy	Energy efficiency	Meet one of three approaches	Report EUI
	Peak demand	Report seasonal peaks	Report seasonal peaks
	Airtightness	Report and justify modelled value	Conduct testing if ZCB-Design v2 certified
Impact and Innovation		Apply two strategies	No requirement

Figure 1 Minimum requirements of ZCB-Design and Construction Certification

3.1 Carbon

The primary focus of the Carbon section of the ZCB Standard is the modelling and achieving of a net zero carbon balance, as shown below. Essentially, the project must demonstrate that all carbon generated as a result of building construction, maintenance, operation, and demolition is offset through either green power generation or the purchase of high-quality carbon offsets.

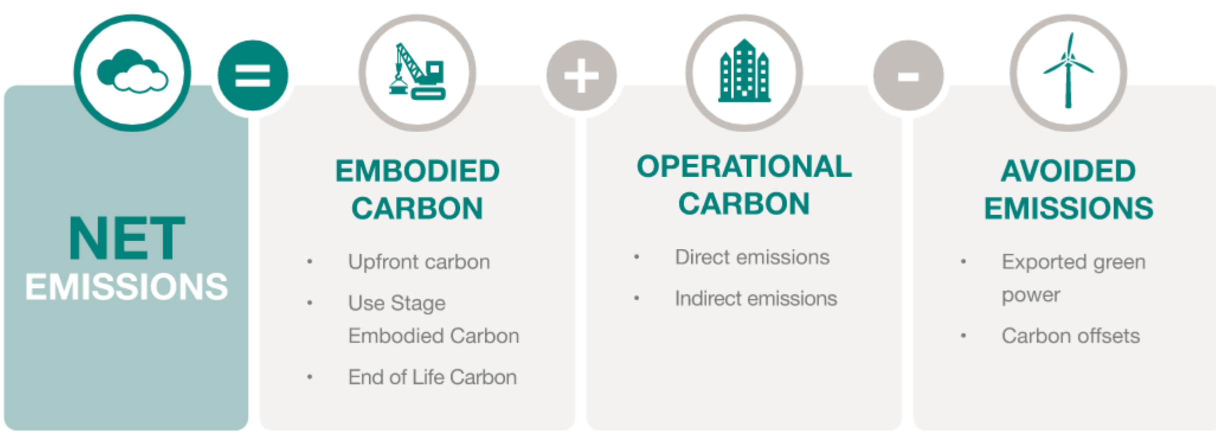


Figure 2 Net-zero carbon balance

Throughout the standard, greenhouse gas emissions are reported as carbon dioxide equivalents (CO_2e), normalized to the volume of CO_2 that would have equivalent 100-year global warming potential (GWP).

3.1.1 Embodied Carbon

Embodied carbon refers to the greenhouse gases associated with the materials, products, and processes required throughout the whole life of a building. Embodied carbon is often split into the following phases:

- Upfront Carbon (stages A1-5), which includes greenhouse gas emissions from raw material supply, manufacturing, transportation, and building construction
- Use Stage Carbon (stages B1-5), which includes greenhouse gas emissions from maintenance, repair, refurbishment, and replacement of components
- End of Life Carbon (stages C1-4), which includes greenhouse gas emissions from demolition, waste processing, and disposal
- Beyond the Life-Cycle Carbon (stage 5), which includes effects of reuse, recovery, and recycling

ZCB v2 and v3 Design Standard require new construction projects to conduct a whole building carbon life cycle assessment (LCA) across life-cycle stages A through C. The LCA will assess the impact of all building structure and envelope elements, including foundations, wall assemblies, floors, ceilings, roof assemblies, and stairs, over a 60-year cycle. Materials beyond the structure and envelope, such as MEP systems and interior fit-outs, are known to have significant impacts on embodied carbon and may be reported, but are outside the formal scope of the ZCB LCA. The targets are identified in Table 1.

3.1.2 Operational Carbon

Operational carbon refers to emissions caused either as a result of energy usage or refrigerant leakage during the operation of the building. Emissions may be classified as either direct (i.e. emissions occurring at the project site, such as those associated with fossil-fuel combustion or refrigerant leakage) or indirect (i.e. emissions that do not occur directly within the project site, such as those associated with purchased energy).

ZCB requires the reporting of refrigerant quantities and, for Performance certification, reporting and offsetting of any major leaks. Typical refrigerants have a global warming potential many thousands of times greater than CO_2 and inevitable leakages, although difficult to track, have a serious detrimental impact on meeting global carbon reduction targets.

ZCB also requires all emissions associated with energy use to be offset. On-site combustion is allowed provided the project submits a transition plan detailing how it will eliminate the use of fossil fuels in the future; however, use of fossil fuels is not anticipated on this project. As such, the scope of operational carbon for this project will be limited to indirect emissions from grid-based electricity use, which can be offset through on-site or off-site owned renewable energy systems or through the purchase of green power products. Location-based grid factors, representing average grid emissions in a province, are provided by CaGBC and periodically updated.

3.1.3 Avoided Emissions

Emissions may be offset either through the use of project-owned renewable energy systems, or through the purchase of bundled green power and green power environmental attributes. As a synergy with LEED certification, the project is expected to install a PV array sized to provide at least 5% of the project's annual energy use; this will also benefit the project by reducing the EUI.

Green power products may be purchased from anywhere in Canada, though ZCB recommends that projects pursue local options first. Estimated costs for green power products range widely depending on where the reduction in fossil fuel-based electricity generation is intended; and options available in Ontario tend to carry a premium since the local electricity grid is relatively difficult to further decarbonise. A price range of \$5/tCO_2e to \$62/tCO_2e is expected.

3.2 Energy

In addition to setting carbon targets, ZCB requires projects to demonstrate improved energy efficiency and resiliency. For ZCB-Design projects, three different approaches are available and described in Table 1:

1. Flexible Approach
2. Passive Design Approach
3. Renewable energy approach

For this project, the specific approach is still be evaluated, but the flexible and passive approaches could both apply. The preliminary energy model indicates that only the flexible approach will apply due to the high TEDI.

Projects are also required to report modelled or operational EUI and seasonal peak demand values, and are encouraged to consider measures to reduce these values, including onsite renewable energy, energy storage, heat pump technology, or demand-response capabilities. Lastly, ZCB-Design projects applying for their first ZCB-Performance certification are required to perform air tightness testing to validate their energy modelling results.

3.3 Impact and Innovation Credits

A minimum of two impact and innovation credits are required for ZCB-Design certification. See Table 1 for a list of pre-approved strategies by CaGBC.

Table 1. ZCB Certification requirements v2 vs v3

Sections	ZCB v3	Current Performance	Comply
Embodied Carbon Performance	- Project must demonstrate that all carbon generated as a result of building construction, maintenance, operation, and demolition is offset through either green power generation or the purchase of high-quality carbon offsets. - LCA of building materials including these life cycle stages: - Upfront Carbon (Life Cycle Stages A1-5) - Use Stage Embodied Carbon (Life Cycle Stages B1-5) - End of Life Carbon (Life Cycle Stages C1-4) - Report the embodied carbon intensity of the project (Total Embodied Carbon/Gross Floor Area) - Minimum Performance: - Embodied Carbon Intensity is <= 500kgCO2e/m2 or it meets a >=10% reduction target vs baseline building.	**345 tonne CO2e** **704 $kgCO2_e/m^2$** Strategies to reduce to 10% below baseline or comply with 500 kg/m^2 limit are included in the LCA report.	Maybe
Energy Performance	+ Flexibility to choose the pathway to zero emissions with 3 different approaches to demonstrate energy efficiency: 1. Flexible Approach.- + TEDI Target - 4 different paths to meet TEDI requirements: **1.1. No Onsite Combustion-> Projects that dont use onsite combustion for all space heating, using equipment with a SCOP >=2 are not required to meet a TEDI target, but they still are required to report it.** **1.2. ZCB-Design TEDI Target-> 32 kWh/m2/yr** 1.3. Adjusted TEDI Target-> TBD 1.4. Detailed TEDI Analysis-> TBD + EUI Target - 2 different paths to meet EUI requirements: **1.5. Reference Building Performance Improvement-> Site EUI must be at least 25% better than the NECB 2017 without Renewable Energy.** 1.6. Absolute EUI-> 100 kwh/m2/yr (Considered as an Offices Building) 2. Passive Design Approach: TEDI of 22 kWh/m2/yr 3. Renewable Energy Approach: TEDI of 32 kWh/m2/yr and zero carbon balance for operational carbon achieved without green power products or carbon offsets.	TEDI: 138 kWh/m2/yr EUI: 195 kWh/m2/yr	Maybe
Impact and Innovation Strategies	+ Requires at least 2 Impact and Innovation strategies into design, one of which must come from the following list of pre-approaved strategies: - Onsite RE generating 5% of the energy needs or PV covering 75% of the roof area. - Any size installation of Building Integrated Photovoltaics (BIPV). - 100% of space heating designed to operate without combustion. - DHW without combustion in multi-residential projects. - Upfront carbon emissions (LC phase A) <= 0 after accounting for biogenic carbon sequestration. + Improvement beyond the minimum level of performance required for embodied carbon: - Strategy 1-> >= 20% vs baseline or <= 350 absolute embodied carbon intensity. - Strategy 2-> >= 40% vs baseline or <= 240 absolute embodied carbon intensity.	Options for compliance are available 1. 100% of space heating designed to operate without combustion. 2. Embodied carbon performance>= 20% vs baseline or <= 350 absolute embodied carbon intensity. 3. Onsite RE generating 5% of the energy needs or PV covering 75% of the roof area.	