seymour

1210 Seymour Street

Life Cycle Analysis Case Study

June 06, 2023

Click to Get Started

ZGF

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Introduction

Through this case study, ZGF demonstrates how to meet the 2025 Vancouver Building By-law (VBBL) Embodied Carbon Requirements on a **live project**, with **no projected additional cost** to the client, following the City of Vancouver Embodied Carbon Guidelines.

Tally LCA

14% overall **SAVING** from baseline

OneClick

22% overall **SAVING** from baseline

Two different softwares are used to compare results of the same decisions. Both **exceed** the 2025 City of Vancouver requirement of **10% reduction in embodied carbon from the baseline.**

An overall saving of 14-22% in whole building Global Warming Potential (GWP) was achieved by **improving concrete and insulation selection, reducing the parkade and optimizing the structure**.

Life Cycle Assessments (LCAs) are iterative, and this case study is a snapshot of ZGF's process currently (2023). There is no standard procedure for LCAs presently, but this study aims to refine the process of carbon accounting and guide future practitioners in Vancouver. See Assumptions and Methodology for further detail.

Team

Owner:
Vancouver Affordable Housing Agency

Operator:
Community Land Trust Foundation of BC

Developer:
New Commons Development

Architects:
ZGF Architects Inc.

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VBBL Embodied Carbon Requirements

Following the approval of Vancouver's Climate Emergency Action Plan in 2020, the Vancouver Building By-law (VBBL) now requires designers to record, and from 2025 reduce, the embodied carbon of new Part 3 buildings. This Case Study investigates a project aiming to meet the 2025 requirement of 10% reduction from the baseline.

Baseline Design

Following the City of Vancouver Embodied Carbon Guidelines (CoV Guidelines), the baseline should have typical construction assemblies and structure.

Baseline material GWP/unit should be from:

- Local, industry-wide, Environmental Product Declarations (EPDs)

If not

- Use a specified product in the CoV Guidelines

If not

- Use default data in calculation software

Or

- Use the baseline GWP/unit value in the Carbon Leadership Forum's Material Baselines Report

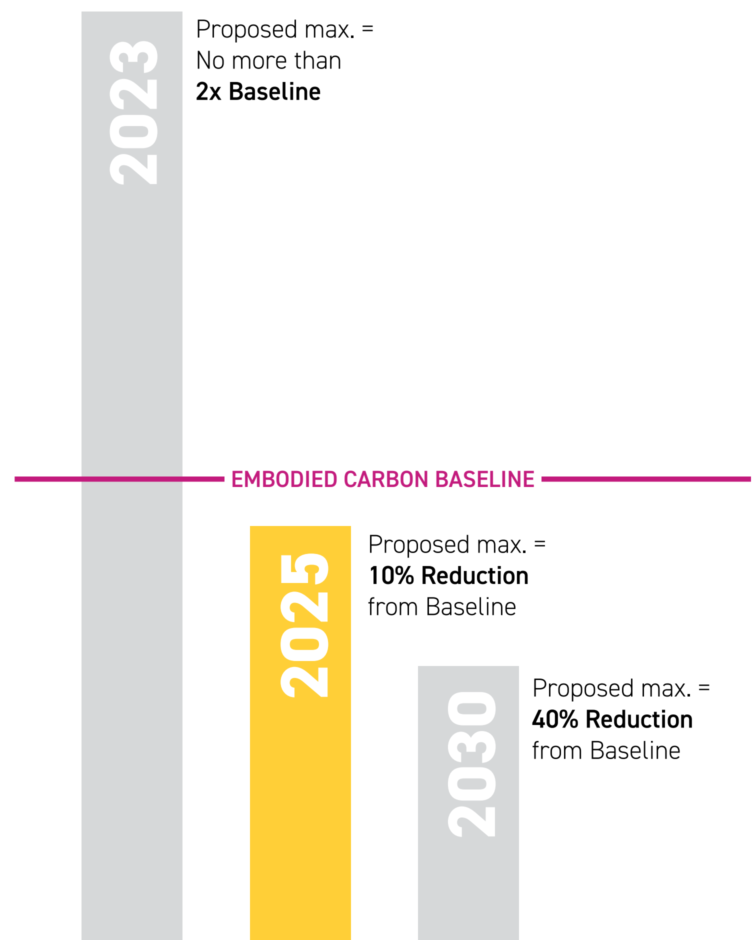
Proposed Design

Proposed material GWP/unit should be from:

- EPDs in the Project Specification (or Outline Specification)
- Values given by consultants (e.g. for this project, Structural provided the GWP/m^3 values for different concrete mixes)

If not

- Use the baseline value



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Project Overview

1210 Seymour Street is in the centre of downtown Vancouver, BC and will provide 112 efficient, affordable rental homes in a mix of studio, one bedroom and family units.

Design Architect
ZGF Architects Inc.

Structural System
Concrete with steel cladding

Gross Floor Area
8,800m^2 / 94,711 ft^2
including 1 level of parkade

Building Height
9 storey / 31m / 103'

Building Life
60 years

Life Cycle Analysis Boundaries

- Cradle to grave
- Includes interiors (partitions, finishes, ceilings and flooring)
- Excludes biogenic carbon
- Excludes Lifestage D (Beyond Life)

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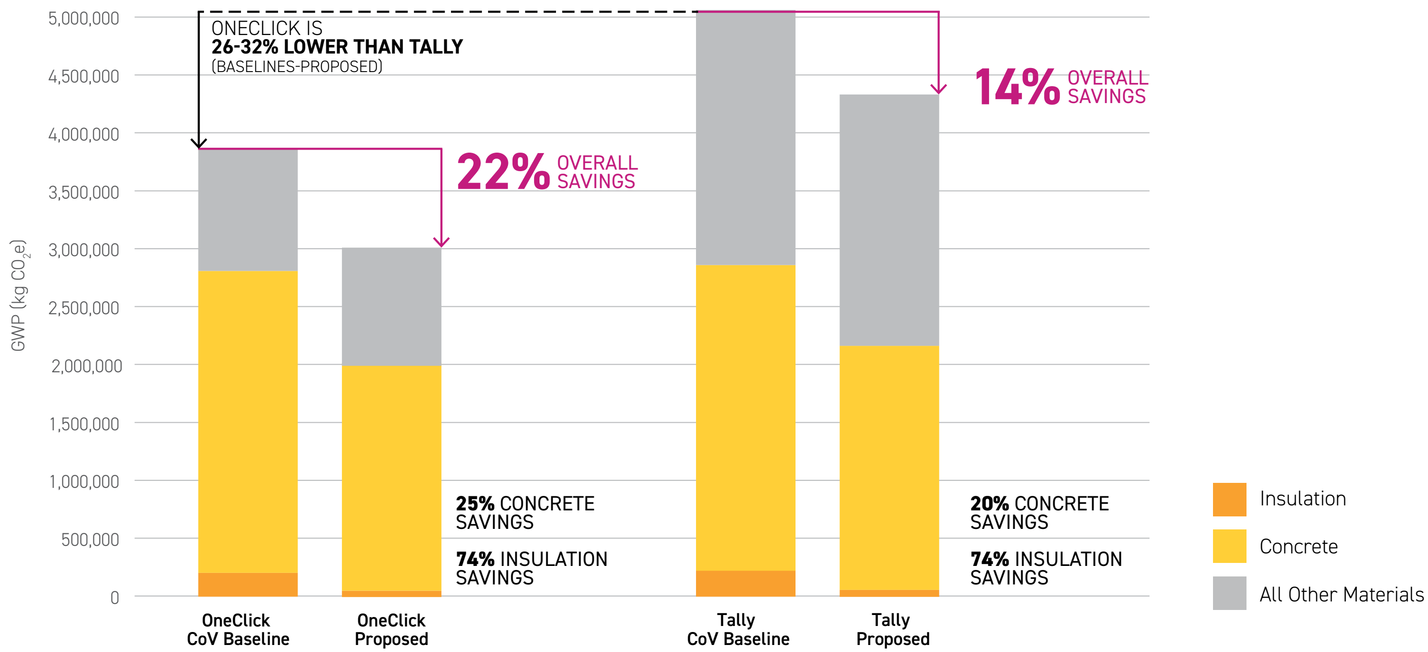
Life Cycle Analysis Results

We implemented four changes with **no projected additional cost.** In order of the most effective:

1. Reducing parking levels
2. Structural optimization (slab thicknesses reduced through aligning structural columns to avoid transfer slabs)
3. Low GWP concrete (mix designs provided by structural engineer)
4. Low GWP insulation (XPS and Mineral Wool insulation specified to low GWP versions)



LCA Software Comparison of GWP (kgCO_2e)

The City of Vancouver Guidelines understand that different software cannot be compared, which is why percentage reduction from the baseline is used, not the total GWP. Cormick compares different LCA software and finds OneClick produces less than half the total GWP of Tally with the same model (Comick, 2021). The GWP intensity is included in the Compliance Reports (see Oneclick GWP Intensity and Tally GWP Intensity). However, it is not used in the main body of this Case Study, as it is misleading when savings come from a reduction in floor area.

The most significant reasons for the differences between Tally and OneClick, are due to how they process quantities from Revit, how they create default values and the assumptions made in the Tally post-processing (see Compliance Reports in the Appendices).

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Example of concrete contents & GWP from BC Concrete

BC Concrete Mix 30Mpa with air (F-2)	GWP $kgCO_2eq.$
Regional Baseline	
GU, 20 SCM	269.83
GU, 0 SCM	317.51
GU,15 SCM	282.09
GU, 25 SCM	258.25
GU, 40 SCM	222.83
GUL, 0 SCM	294.22
GUL, 15 SCM	262.28
GUL, 25 SCM	240.78
GUL, 40 SCM	208.85

Recommendations for Material Selection

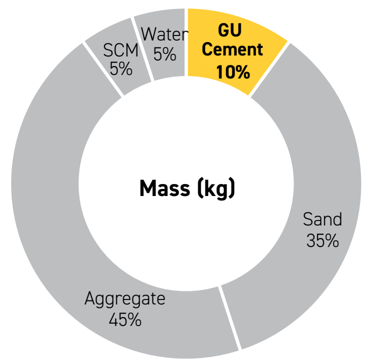
Concrete | Insulation

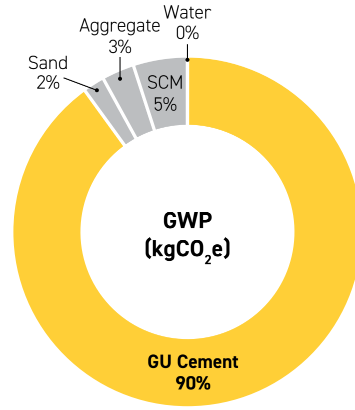
The graphs show the contents of concrete and their impact on the GWP. **Cement is only 10% of the mass, but 90% of the GWP.**

There are several ways to reduce the embodied carbon impact of concrete, including:

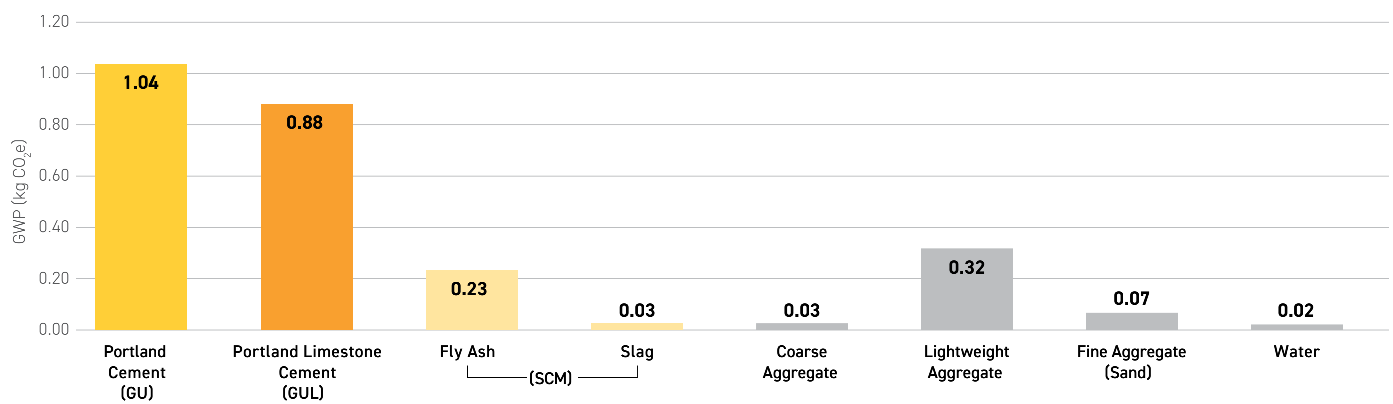
- Changing from **Portland Cement** (GU) to **Portland Limestone Cement** (GUL)
- **Increasing the Supplementary Cementitious Material** (SCM). Examples of SCM are: fly ash, slag cement or silica fume blended cement.

The table to the left highlights how GU and SCM affect the GWP/unit. The Seymour structural engineer provided the GWP/unit for this project.





Graph indicating relative mass and corresponding CO_2 contribution of each of the concrete ingredients for a typical concrete mix. Source: Lafarge Canada.



Graph indicating GWP contribution of each concrete ingredient per m^3 column. Source: ZGF Concrete calculator based on Tally database.

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Recommendations for Material Selection

The GWP from insulation was reduced by selecting CSA approved Canadian sourced materials with a low GWP. The products are listed below with links to their EPDs. Other low GWP insulation products are available.

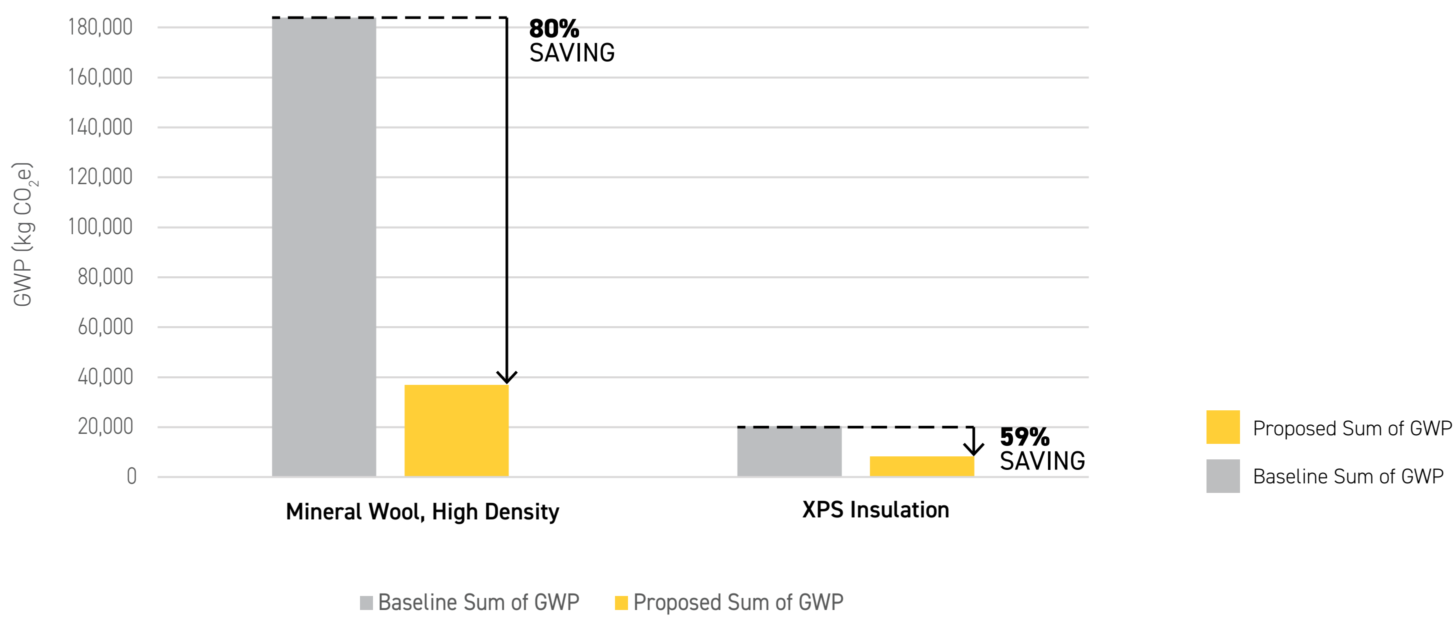
Baseline:

- NAIMA's Industry-average Mineral Wool
- DuPont's ST-100 XPS

Proposed:

- Rockwool Stone Wall Insulation
- SOPREMA SOPRA-XPS

Tally Insulation GWP



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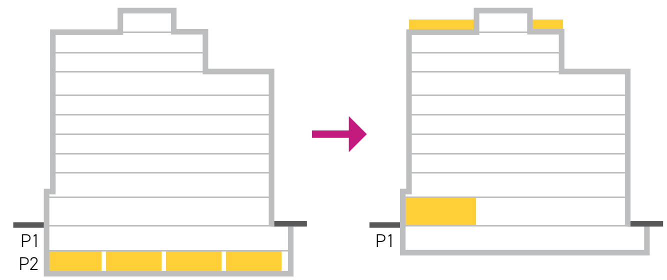
Recommendations for Volume Reduction

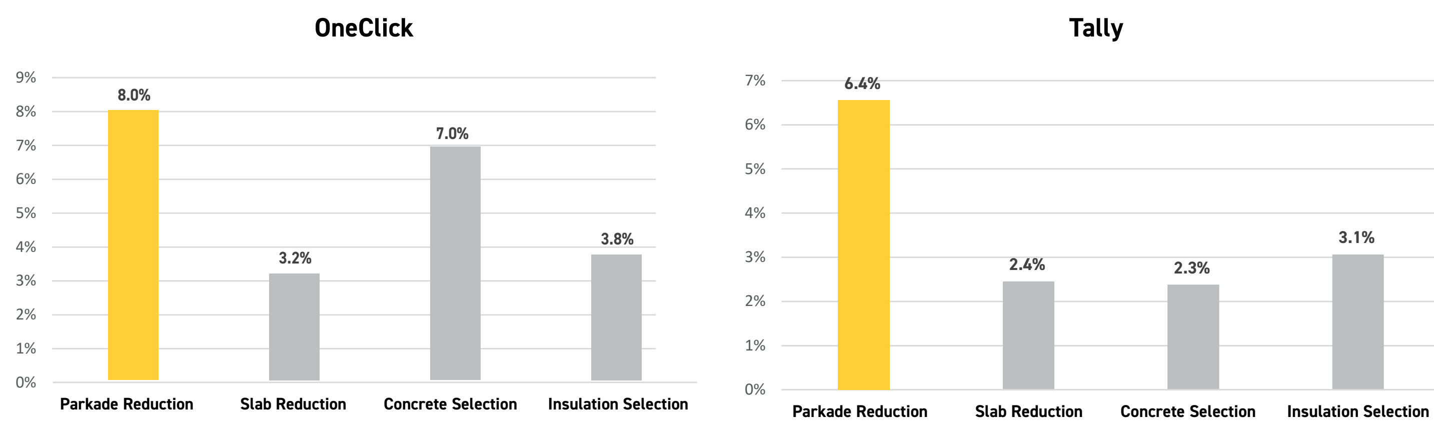
Parkade | Structure Optimization

The following strategies were used to reduce the parkade from two levels to one level:

- Replaced one loading space with two smaller stalls (which required city approval)
- Relocated the mechanical to the roof and above the parkade ramp
- Reduced the size of all the utility rooms
- Optimized car and bike stall layouts
- Relocation of spaces allowed fire travel safety distances to work without an extra level



Percentage GWP Savings of Different Choices (compared to Baseline building)



The above graph shows that reducing parkade levels is one of the most significant changes you can make.

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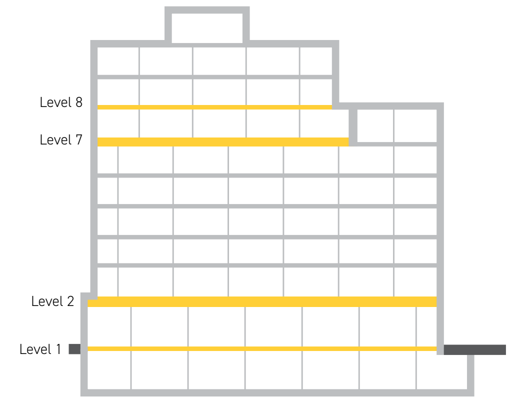
Parkade | **Structure Optimization**

The suspended floor slabs have the most GWP out of all concrete elements, over 50% of the total (see graph below).

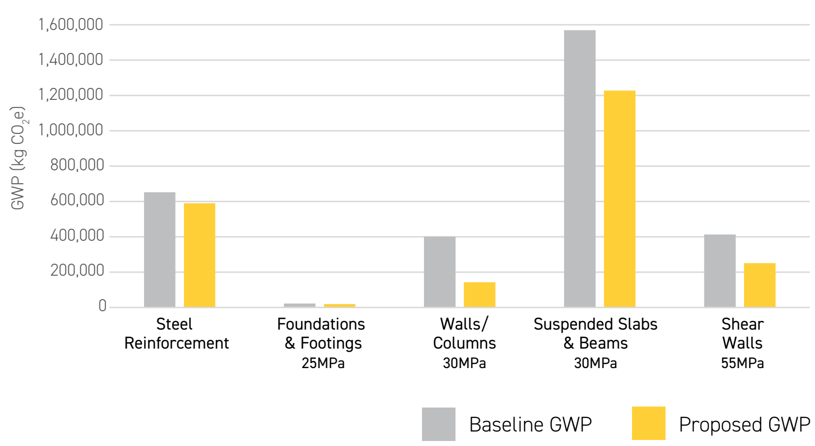
The table to the bottom right 'Slab Reductions' highlights the reduction in slab thickness through refining the unit plan layout and subsequent structural design.

This results in a reduction of 124,000kgCO_2, 27% of the baseline suspended floor slabs and 2.5% of the overall baseline building calculated through Tally (3% when calculated through OneClick).

These estimates are conservative as they only include lifestages A1-A3 for concrete only, and the rebar was kept the same pre and post volume reduction.



Tally Concrete Division Breakdown



Slab Reductions

	Initial	Current
Level 8	457.0mm (1'6")	203.2mm (8")
Level 7	Full Transfer	Partial Transfer
Level 2	660.4mm (2'2")	965.2mm (3'2")
Level 1	625.2mm (3'2")	304.8mm (1'0")

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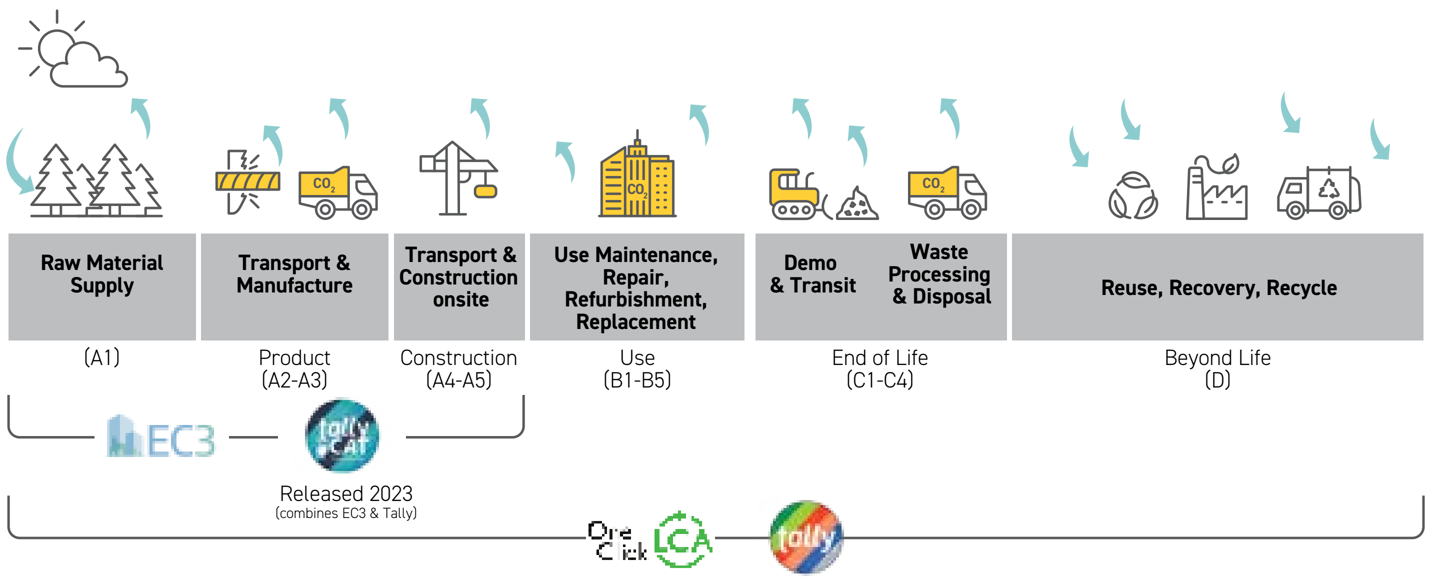
The below diagram shows the different LCA softwares available and which lifestages they cover. We decided to use both Tally and OneClick to ensure the simple changes we made are enough to meet the 2025 VBBL (Vancouver Building By-law) requirements in two of the most common softwares today.

As seen on the Life Cycle Analysis Results page, the two softwares produce different results. The most significant reasons are:

- how quantities are processed from Revit
- how default values are created
- Tally post-processing assumptions (see Appendix B.1 for a detailed explanation)



As per City of Vancouver Embodied Carbon Guidelines v.02, biogenic carbon is excluded, Life-Cycle D (Beyond Life) is excluded and interiors (partitions, finishes, ceilings and flooring) are included in this Case Study.

For detailed explanations of method and assumptions, see the Compliance Reports in the Appendices.

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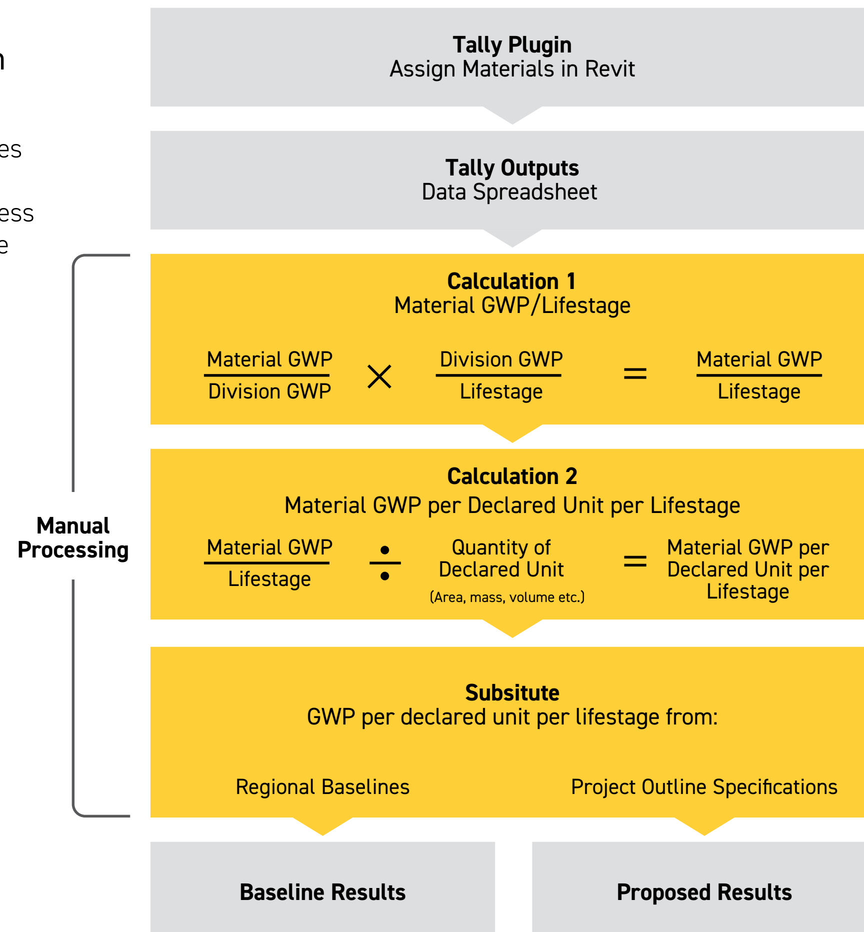
Tally works by assigning its own values and assumptions to Revit elements then outputting the data in a spreadsheet.

The City of Vancouver Embodied Carbon Guidelines process of developing baseline and proposed designs, means that teams will have to post-process if they use Tally. The steps are broken down in the diagram to the right.



For detailed explanations of method and assumptions, see the [Compliance Reports in the Appendices.]

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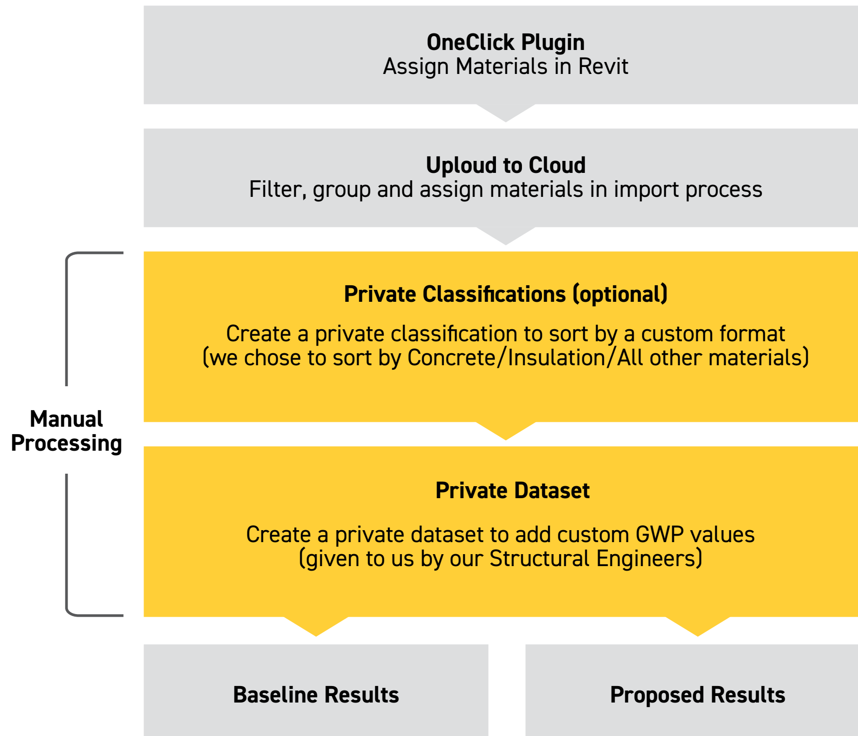
OneClick is an LCA software that consists of a Revit plugin and a cloud based analysis tool.

The plugin is used for assigning materials to Revit elements. It is then uploaded to the cloud to refine these materials and produce the graphs to analyze the data.

The manual processing highlighted right, is specific to this project and optional for future teams using OneClick. See Summary of Manual Changes for explanation of why and how we did these.



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Areas for Further Savings

In future, the following areas would be targeted for further GWP savings:

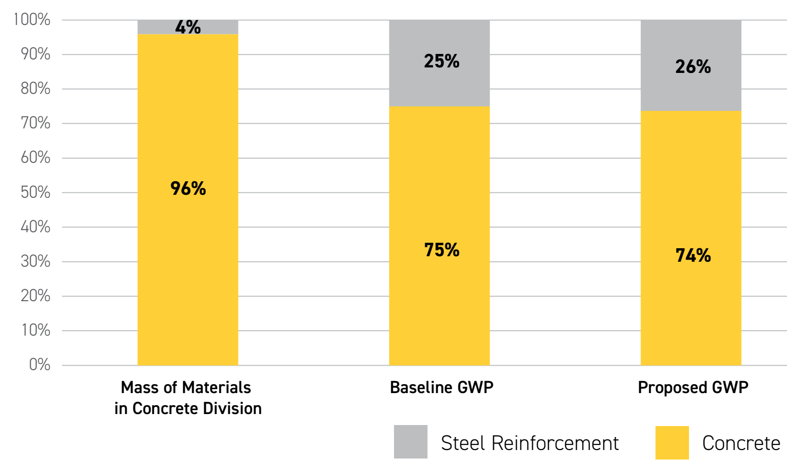
1. Select a low GWP steel reinforcement
Steel rebar accounts for 4% of the mass of the Concrete division, but 25% of the GWP (see right). Where possible, specify rebar that is produced through electric arc furnaces, rather than blast furnaces.

2. Select a low GWP metals
The Metal division is primarily made of Steel Stud Framing (61%) and Stainless Steel cladding (28%). This division has the second largest proportion of GWP (shown in the lower right chart), therefore speciffying low GWP products could have a significant impact.

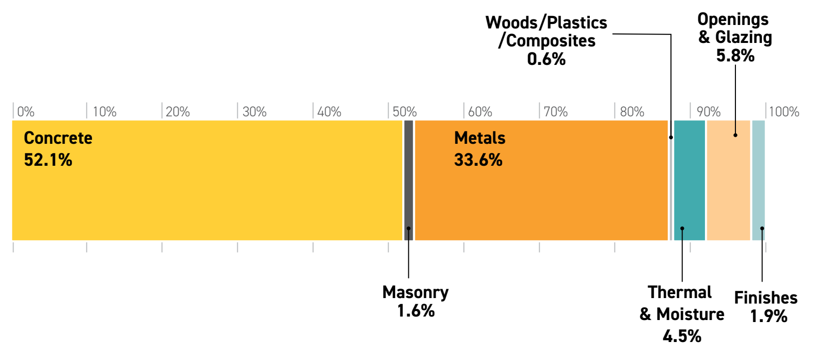
3. Select low GWP Openings & Glazing
This division includes glass, frames/mullions, doors and door hardware.

Note: Interior materials are included, as per CoV Embodied Carbon Guidelines v.02. However, they are mixed in with other materials. In future, separating enclosure, structural and interior systems is recommended, to understand their impact on percentage savings, but also to make it easier to align with certifications that exclude interiors in their LCA scope. Excluding interiors would automatically increase the percentage savings from baseline to proposed.

Portion of Mass vs Proportion of GWP in Tally Concrete Division



GWP Material Division Proportions City of Vancouver Baseline from Tally



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Appendix A: LCA Compliance Report - One Click

Appendix B: LCA Compliance Report - Tally

Appendix C: Abridged Environmental Product Declarations

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A
LCA Compliance Report
One Click

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Whole Building Life Cycle Analysis with OneClick

VAHA Seymour

Compliance Report 2023-06-26

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Executive Summary

Building Information

Project Name: VAHA Seymour

Project Location: 1210 Seymour St, Vancouver, BC VXV 1X1

Gross Floor Area: 8,800m^2 / 94,711 ft^2 (including 1 level of parkade)

Building Height : 9 storey / 31m / 103ft

Structural System: Concrete

LCA Parameters

Compliance: Vancouver Building By-law (VBBL), as per City of Vancouver Embodied Carbon Guidelines v.02

Software: OneClick v4.0.4 2022

LCA Scope: Substructure / Superstructure / Enclosure / Interiors (partitions, finishes, ceilings & flooring), as per the City of Vancouver Embodied Carbon Guidelines v.02 (CoV).

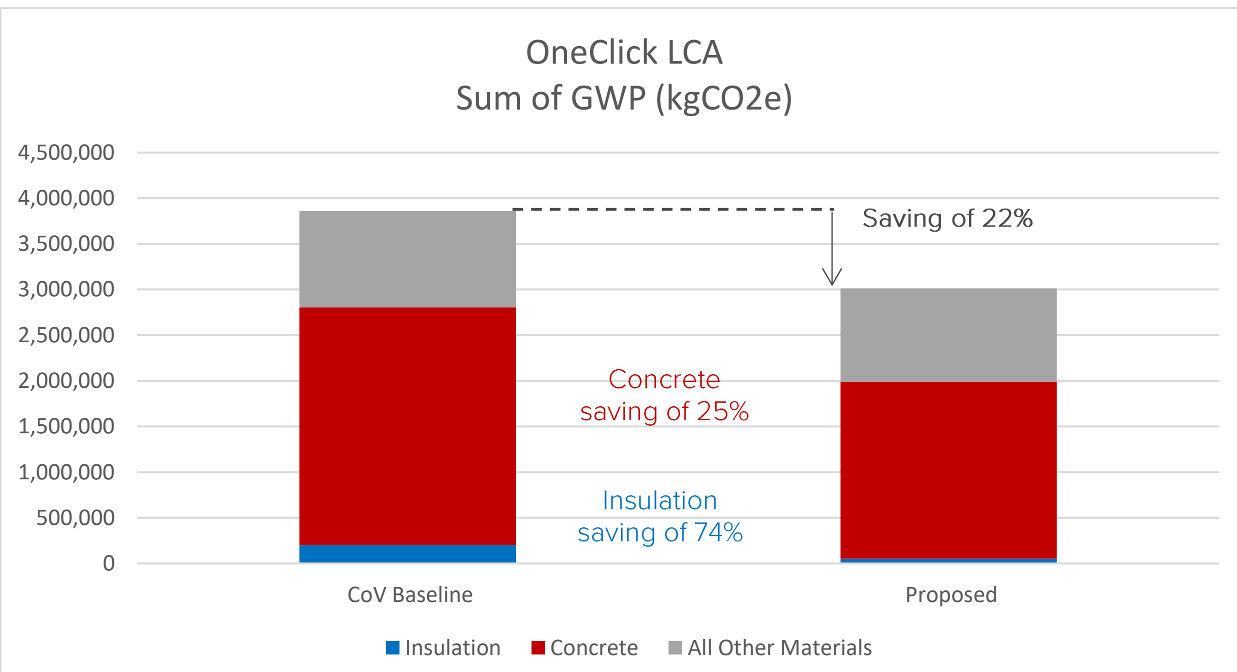
LCA Lifestages: Lifestages A-C. Biogenic carbon & Module D excluded.

LCA Service Life: 60 years

Target

- Vancouver Building By-law (VBBL)
  - no more than double baseline from 2023 / **10% reduction from 2025** / 40% reduction from 2030

Was the target achieved: ☒ Yes ☐ No



Notes:

- A saving of 22% was achieved, exceeding the Vancouver Building By-law (VBBL) 2025 target of 10% reduction.
- Reducing a parkade level was the most effective decision (8% saving), followed by the concrete mix design((7% saving), insulation selection (4% saving) and reducing the slabs through structural optimization (3% saving).
- All materials except insulation and concrete were kept the same as the baseline.

Project Information

LCA Author	ZGF Architects
LCA Reviewer	ZGF Architects
Design Architect	ZGF Architects
Architect on Record	ZGF Architects
Structural Engineer	Fast+Epp
General Contractor	Kindred Construction
Concrete Supplier, if known	
Key Stakeholders	

Floor Area & GWP Intensity

The floor area changes from baseline to proposed design, with the reduction of a parkade level. Consequently, the GWP intensity is a misleading metric and is not used elsewhere in this report. Additionally, the total GWP is not comparable between different software at the time of this report, therefore the percentage reduction from the baseline will be the dominant metric in the Results, in line with City of Vancouver (CoV) guidance.

	Floor Area	**ft²**	**m²**	**Total GWP, kgCO2eq**	**GWP Intensity, kgCO2eq/m²**
	without parkade	80,416	7,471		
Proposed Design	with 1 parkade level	94,711	8,800	3,013,464	342
Baseline Design	with 2 parkade levels	109,006	10,127	3,862,405	381

Summary of Assumptions

Baseline GWP Sources

Baseline Building – Sources of Major Materials:

Material		EPD Author	Link
Structure	Concrete	Concrete BC	SUSTAINABLE CONSTRUCTION - CONCRETEBC
	Steel, Rebar	CRSI	CRSI Environmental Product Declaration
	CMU	ASTM	311.EPD_for_CCMPA_Normal-Weight_And_Light-Weight_Concrete_Masonry_Units.pdf
Enclosure & Interior	Insulation, XPS	Dupont	buildingtransparency.org/ec3/epds/ec3b80r0
	Insulation, Mineral Wool	NAIMA	Product Definition (jm.com)
	Steel, Metal framing	OneClick default: Steel stud framing for drywall/gypsum plasterboard per sq. meter of wall area (incl. air gaps per m3), C-profile: 2-1/2 x 1 -1/5 inch, gauge 25, 10 ft. height x 12 inch (30 cm) spacing	
	Cladding, Steel	MCA	Product Definition (metalconstruction.org)
	Cladding, Fibre Cement	OneClick Default: Fibre cement boards, 1300 kg/m3 (81.16 lbs/ft3)	
	Aluminium Window (percentage weight: 30% aluminium, 61% glazing unit, 3% weather strip, 4% PVC, 1% hardware, 0.2% gaskets, 0.2% adhesives)	AluQuébec	EPD Project Detail (csaregistries.ca)
	Gypsum Plasterboard (interior finish & exterior sheathing)	Gypsum Association	EPD10270.pdf (nsf.org)
	Clay Brick	CalStar Products	CalStar EPD Document_Final.pdf (sustainableproducts.com)

Notes:

- See Appendix C for abridged EPD's.
- Products chosen based on the CoV Guidelines
    - either specifically mentioned, as with XPS insulation, or are regional baselines

Proposed GWP Sources

Proposed Building – Sources of Major Materials:

Material		**Same as baseline?**	**EPD Author**	**Link**
Structure	Concrete	☐	Fast & Epp	Attachment link to the product-EPD
	Rebar, Steel	☒	CRSI	CRSI Environmental Product Declaration
	CMU	☒	ASTM	311.EPD_for_CCMPA_Normal-Weight_And_Light-Weight_Concrete_Masonry_Units.pdf
Enclosure & Interior	Insulation, XPS	☐	Soprema	SOPRA-XPS - Download our EPD I SOPREMA
	Insulation, Mineral Wool Board	☐	Rockwool	rockwool-stone-wool-environmental-product-declaration-epd.pdf
	Metal framing, Steel	☒	OneClick default: Steel stud framing for drywall/gypsum plasterboard per sq. meter of wall area (incl. air gaps per m3), C-profile: 2-1/2 x 1 - 1/5 inch, gauge 25, 10 ft. height x 12 inch (30 cm) spacing	
	Cladding, Steel	☒	MCA	Product Definition (metalconstruction.org)
	Cladding, Fibre Cement	☒	OneClick Default: Fibre cement boards, 1300 kg/m3 (81.16 lbs/ft3)	
	Aluminium Window (percentage weight: 30% aluminium, 61% glazing unit, 3% weather strip, 4% PVC, 1% hardware, 0.2% gaskets, 0.2% adhesives)	☒	AluQuébec	EPD Project Detail (csaregistries.ca)
	Gypsum Plasterboard (interior finish & exterior sheathing)	☒	Gypsum Association	EPD10270.pdf (nsf.org)
	Clay Brick	☒	CalStar Products	CalStar EPD Document_Final.pdf (sustainableproducts.com)

Notes:

- See Appendix C for abridged EPD's.
- Products chosen based on Outline Specification. If not specified in Outline Specification, baseline value is used.

Material Quantities

Quantities of key materials

Material		**Baseline**	**Proposed** if same as baseline, -	**Declared units**	**Source**		
					BIM	Costing	Other
Structure	Concrete	6,530	5,055	m^3	☒	☐	☐
	Steel, Rebar	830,756	710,756	kg	☒	☐	☐
	CMU	302	220	m^3	☒	☐	☐
Enclosure	Insulation, XPS	687.22 m^2 *6.1 = 4192	-	m^2.RSI	☒	☐	☐
	Insulation, Mineral Wool	4722 m^2 *6.87 = 32,440	4515 m^2 *6.87 = 31,018	m^2.RSI	☒	☐	☐
	Metal framing, Steel	67,105	67,043	kg	☒	☐	☐
	Cladding, Steel	2433	-	m^2	☒	☐	☐
	Cladding, Fibre cement	427.6	-	m^2	☒	☐	☐
	Aluminium Window	3,804	-	m^2	☒	☐	☐
	Exterior Sheathing, Gypsum	2,006	-	m^2	☒	☐	☐
	Interior Finish, Gypsum	35,130	-	m^2			
	Clay Brick	6000	-	kg			

Notes:

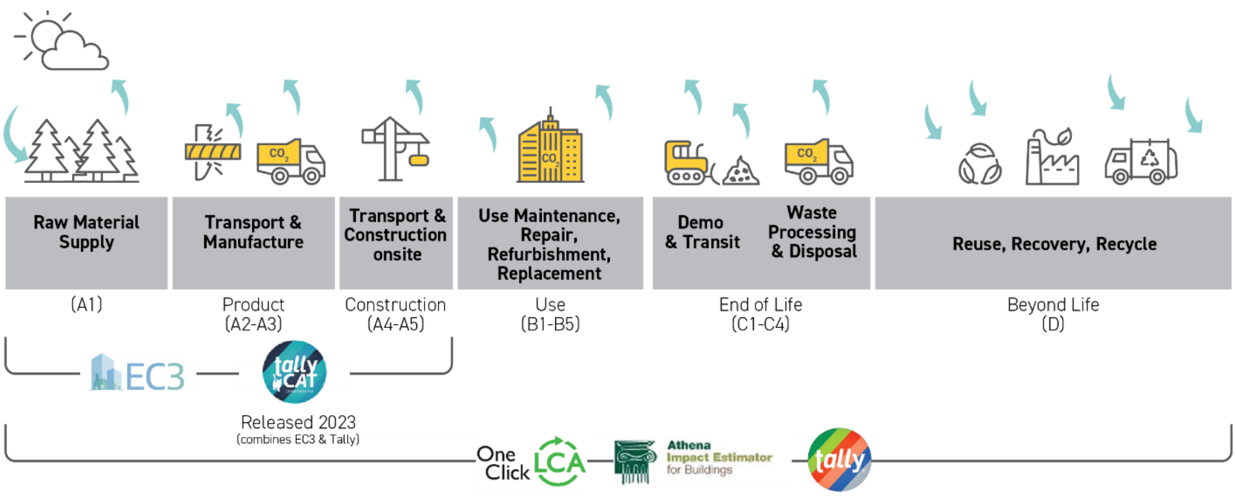
- Parkade level reduction and structural optimization is responisble for proposed reductions in quantities. See Results – Volume Reductions for details.

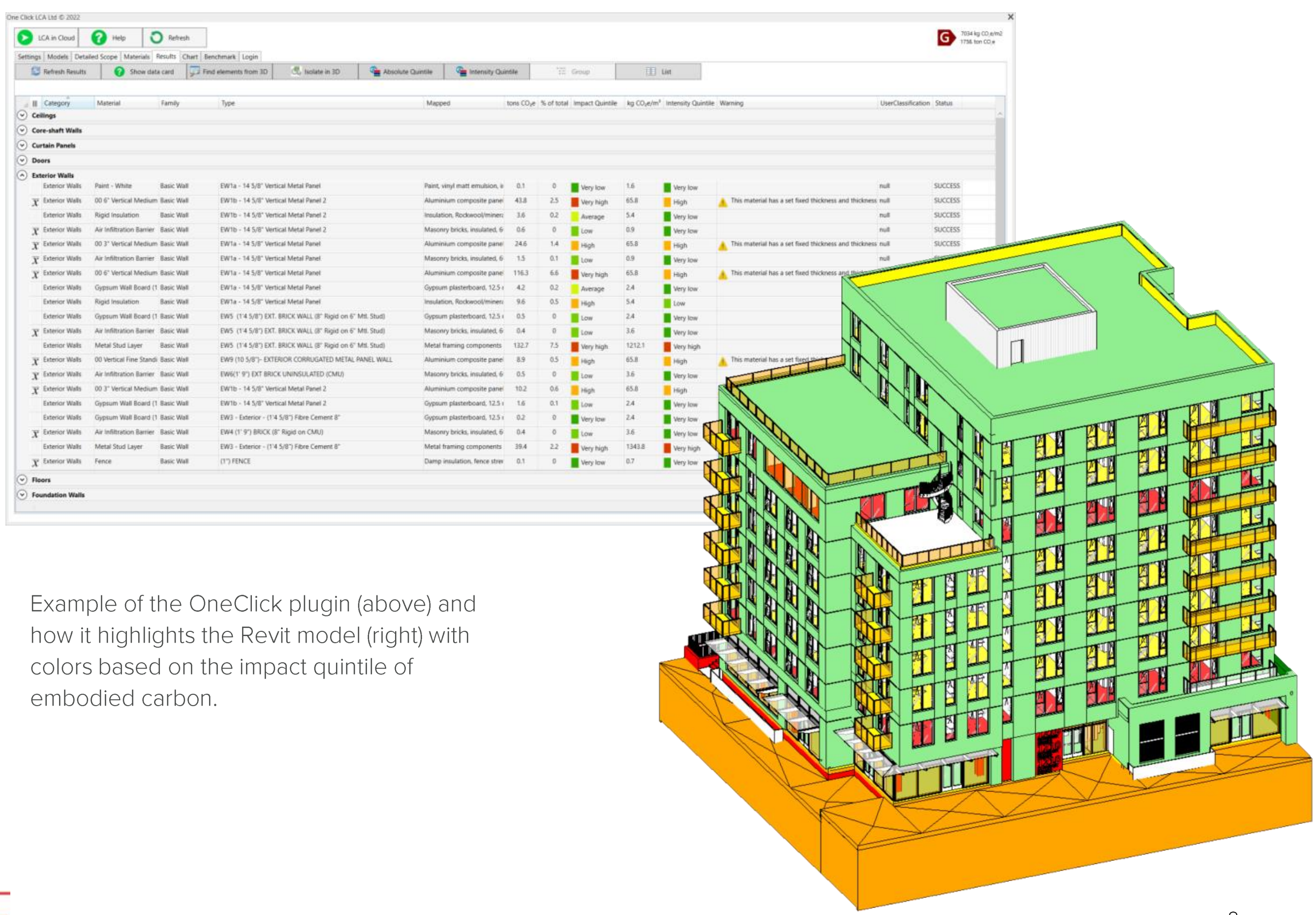
LCA Methodology

Overview

OneClick is an LCA software that consists of a Revit plugin and a website. You use the plugin for assigning materials to Revit elements, then upload to the website to refine the materials and produce the graphs that allow you to analyze the data.

OneClick covers life-stages A-C (all life-stages described in the image above). It is important to note that in this LCA, biogenic carbon is excluded, Life-cycle D is excluded and interiors are included.



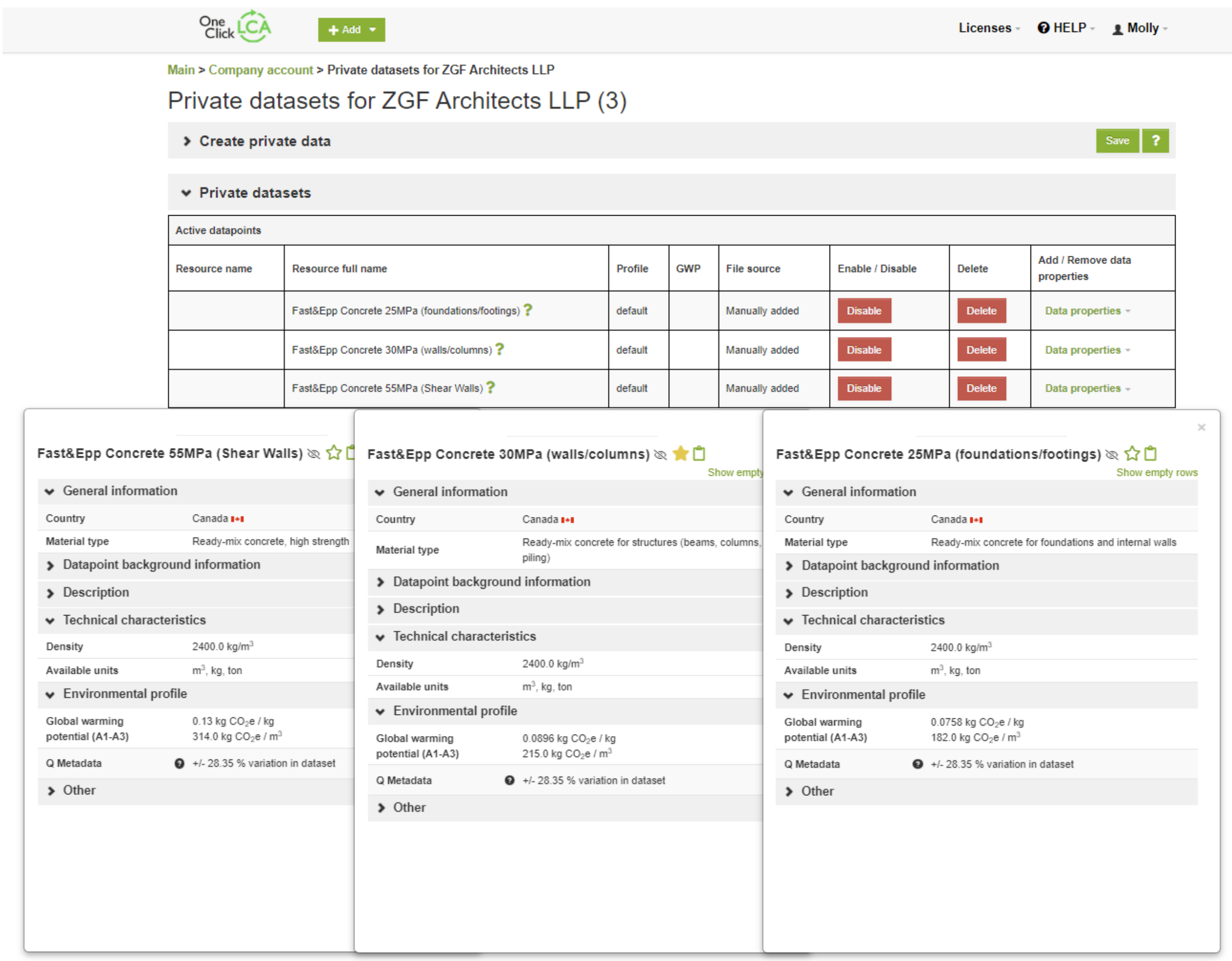


Example of the OneClick plugin (above) and how it highlights the Revit model (right) with colors based on the impact quintile of embodied carbon.

Summary of Manual Changes

Private Datasets

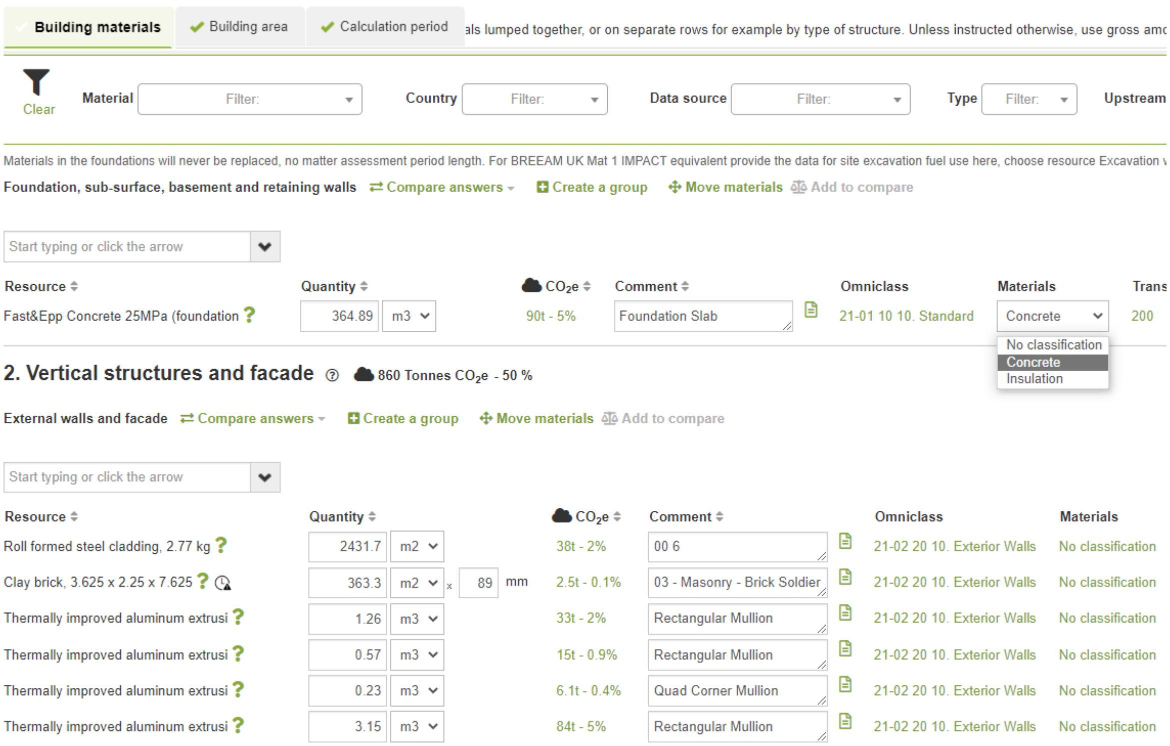
There were 2 semi-manual changes made with this OneClick LCA. The first was to add in GWP values of concrete mixes with different strengths, which were given to us by our Structural Consultant. OneClick allows you to do this through adding 'Private EPDs'.

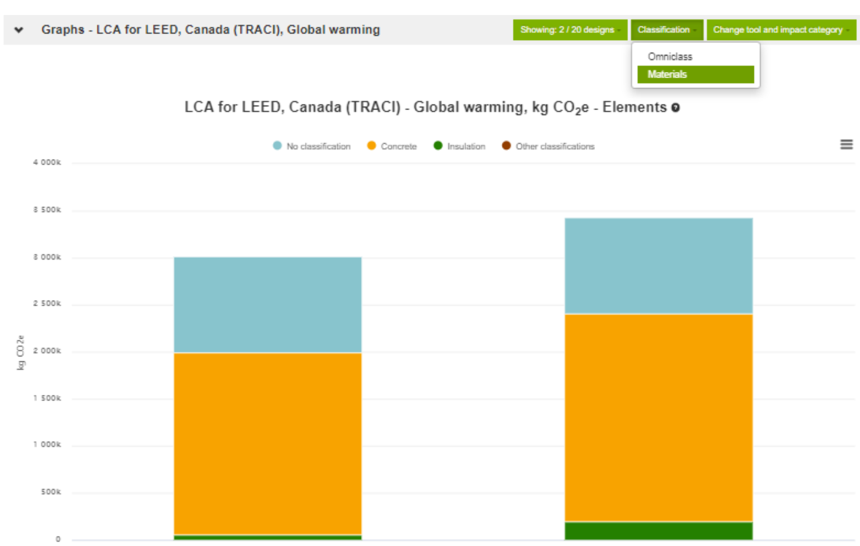


Private Classifications

The second manual change, was based on our desire for a graph that compares the materials of the whole baseline building with the whole proposed building. You can also create this graph through post-processing the data from the report. We chose this method so that it automatically updates and allows us to compare multiple designs live (see bottom screenshot).

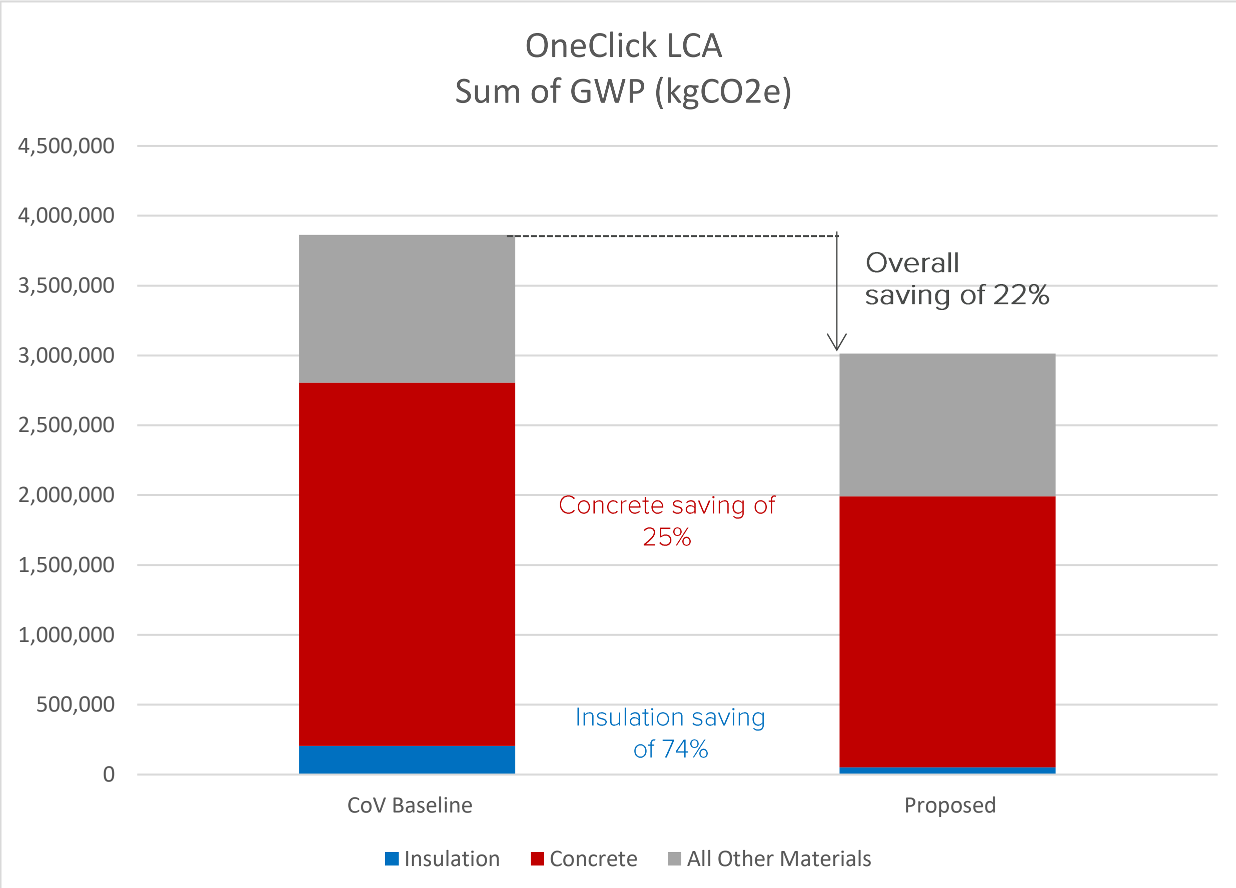
A 'Private Classification' titled 'Materials' was created. We created three options: Concrete, Insulation and No Classification. By labelling the relevant materials, it allowed us to produce a simple bar chart that summarised the changes made in this LCA.

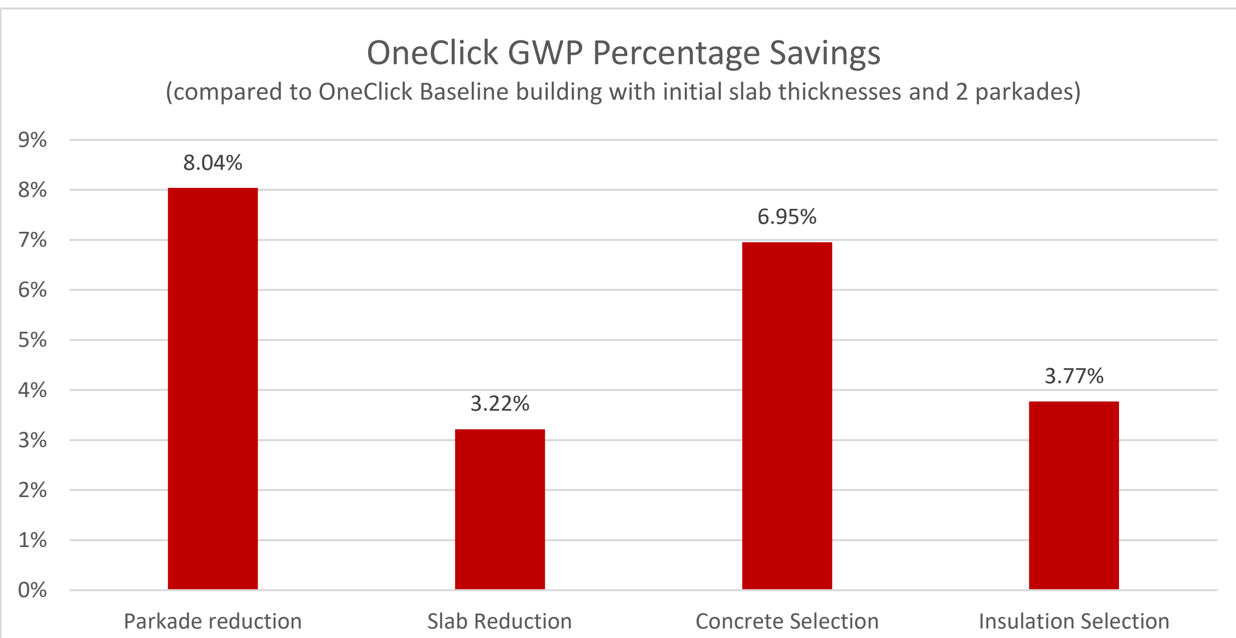




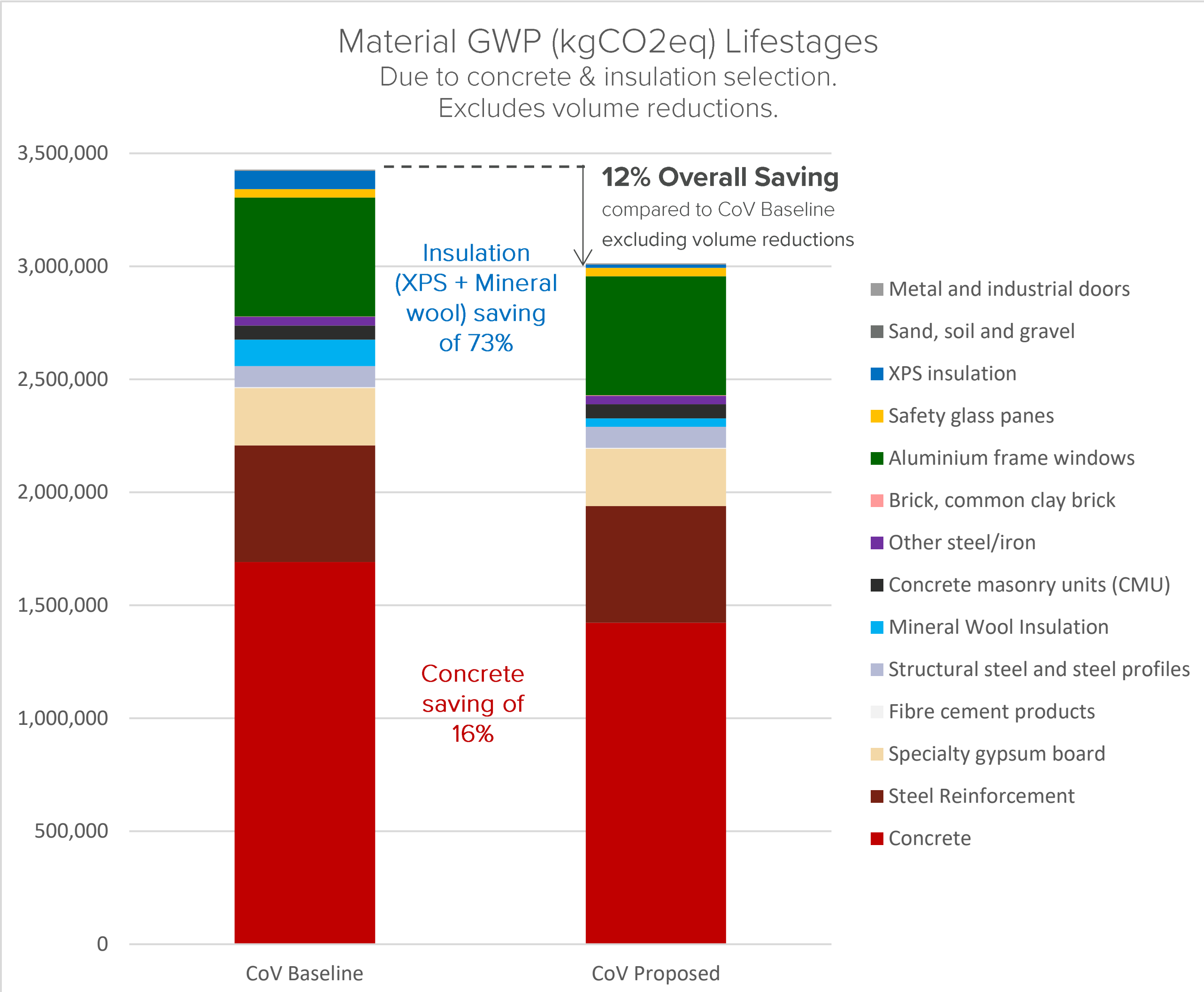
Results - Overall

The 2025 VBBL requirement of 10% reduction from the baseline was exceeded through four changes that have no projected additional cost. Improving the concrete mix was the most effective decision, followed by reducing a parkade level, then choosing a low GWP insulation and finally reducing the slab thicknesses through structural optimization.





Results – Material breakdown



Concrete is the division with the highest proportion of GWP, 49% of the baseline building GWP (excludes rebar). The next section details how we brought this number down in the proposed design.

The windows are the joint second most embodied carbon intensive material in the baseline, with 15%, and should be an area targeted for future improvement. This LCA however, focuses on no projected additional cost decisions and therefore improving the fenestration was ruled out based on expense.

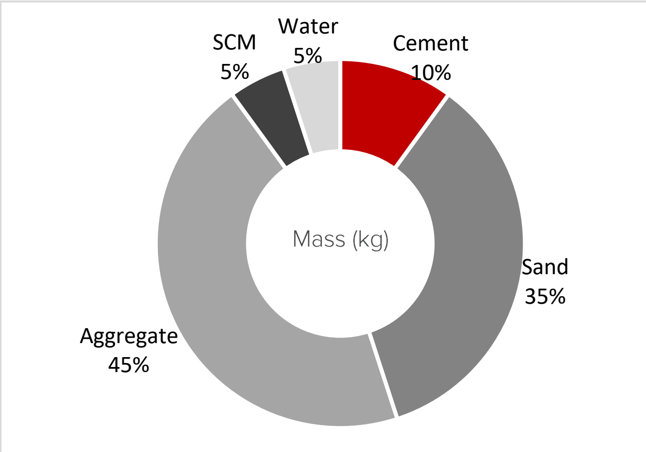
Steel rebar has 15% of the baseline building GWP, but is not improved from baseline to proposed, partly due to a lack of EPD's available at this time.

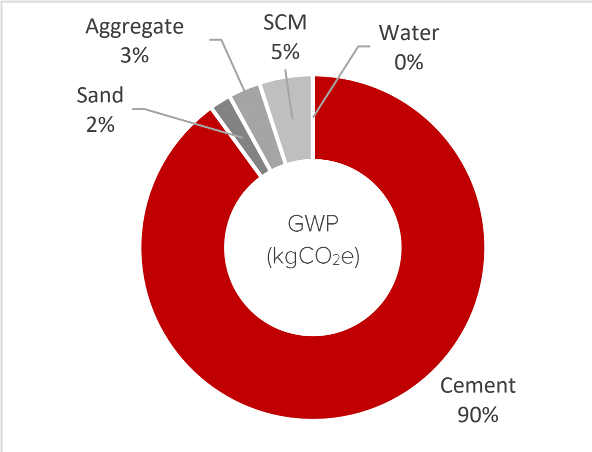
Although the insulation is a relatively small proportion of the total GWP (5% of the baseline), the decision to switch to low GWP products was a simple, low/no-cost decision. Combined with low GWP concrete and volume reductions, this allowed us to exceed our goal of a 10% reduction overall.

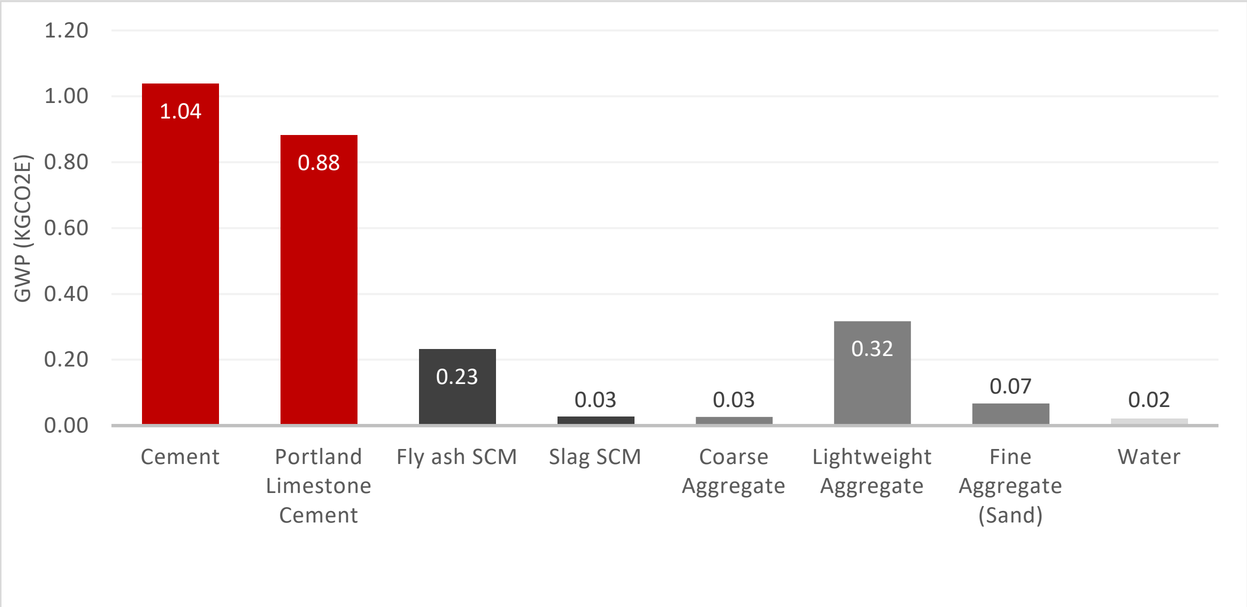
It should also be noted that the interior materials are mixed in with all materials. This is due to the City of Vancouver Embodied Carbon Guidelines v.02 requiring them (specifically partitions, finishes, ceilings & flooring). In future workflows, interiors should be separated to understand their impact on percentage savings. Interiors are optional in v.03 of the guidelines.

Concrete Mix

The below graphs show the contents of concrete and their impact on the GWP. As you can see, cement is only 10% of the mass, but 90% of the GWP.





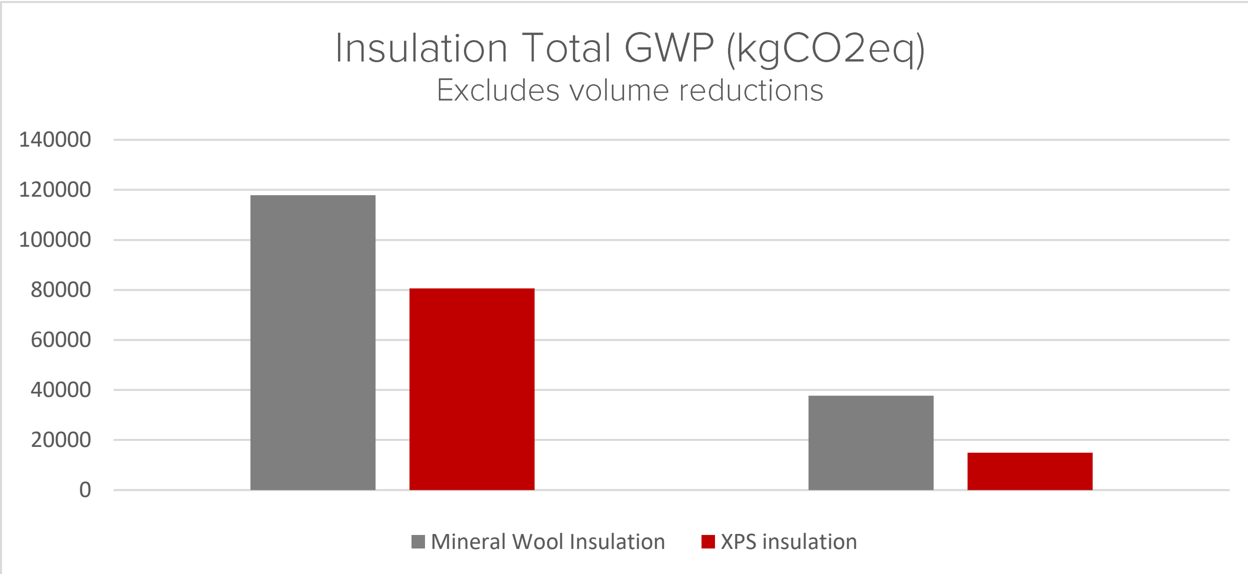


Therefore the 2 best ways to reduce concrete emissions are:

- Changing from Portland cement to Portland Limestone Cement
- Increasing the SCM (supplementary cementitious material)
  - Examples of SCM are: fly ash, slag cement or silica fume blended cement

We do not know the exact mix designs of the mixes given to us by our structural engineers, but it is safe to assume they use Portland limestone cement and SCM. There are other ways of reducing GWP of concrete, but these are the easiest to achieve significant savings.

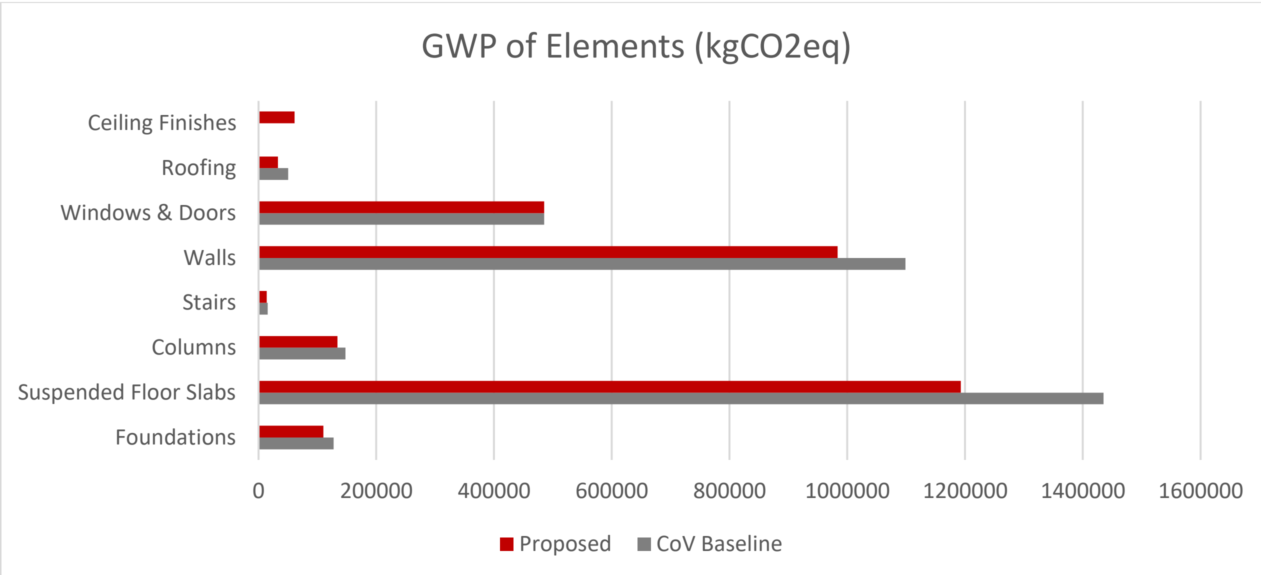
Insulation GWP Reduction



The GWP from insulation was reduced by 73% excluding volume reduction (74% with volume reductions), by selecting CSA approved Canadian sourced materials with a low GWP. There was an 81% saving in XPS and 68% saving in mineral wool (excluding volume reductions from parkade). See the Summary of Assumptions for the EPDs of these products.

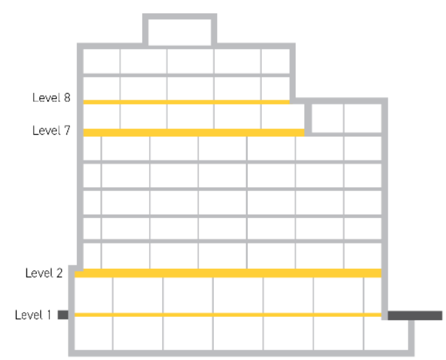
Results - Volume Reduction

Slab reductions



The above comparison of elements shows that the suspended floor slabs are responsible for most of the GWP emissions. Therefore, reducing its volume is an effective way to gain savings. The following floor slabs were changed by the below amounts after consulting with the structural engineer to create a more efficient design that limits transfer slabs.

- L1: was 3'2", now 1" (from 965.2mm, to 304.8mm)
- L2: was 2'2", now 3'2" (from 660.4mm, to 965.2mm)
- L8: was 1'6", now 8" (from 457mm, to 203.2mm)



The below estimates for the baseline suspended floor slabs are conservative as they only include lifestages A1-A3 for concrete. Also, the rebar was kept the same pre and post volume reduction.

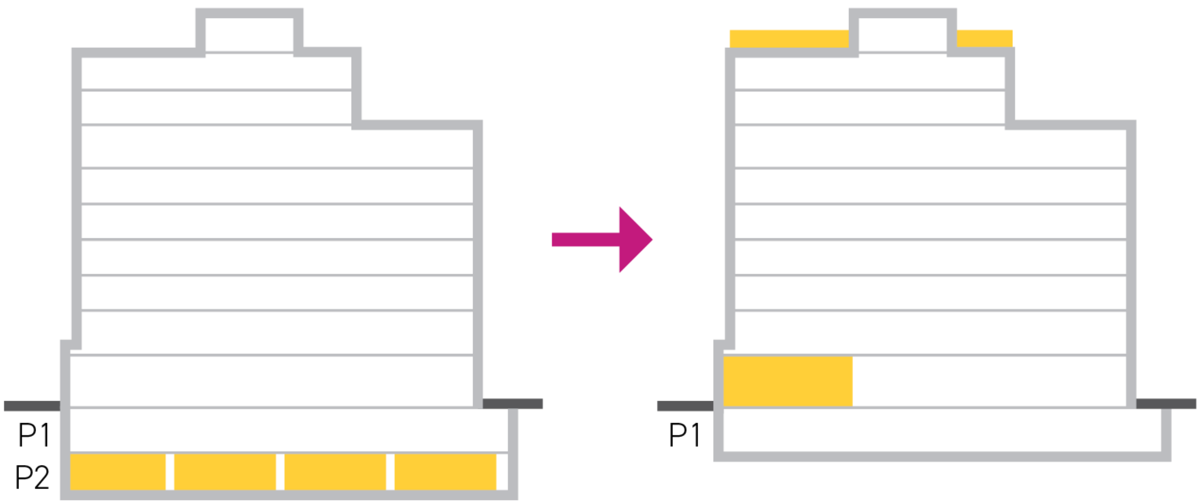
Slab Level	Gross Floor Area (m^2)	Initial Slab Thickness (m)	Proposed Slab Thickness (m)	Reduction (m^3)	GWP per unit (regional baseline)	GWP Saving (Lifestages A1-A3)
L1	921	0.97	0.30	609	259	157,764
L2	941	0.66	0.97	-287	259	-74,249
L8	622	0.46	0.20	157	259	40,730
					Slab Reduction Saving	124,244
					Saving (% of Initial Slab)	**27%**
					Whole Building Saving (% of baseline building)	**3%**

ZGF

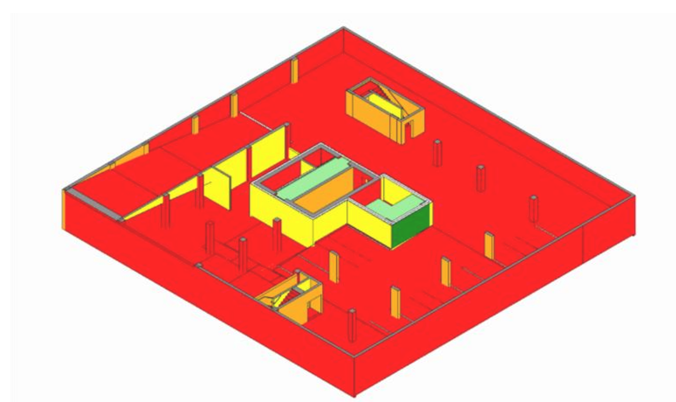
Parkade Reduction

The GWP of a parkade level was calculated by running the model with only the parkade, through OneClick again. The parkade was reduced from 2 levels to 1, through the following decisions:

- Swapped a loading space for 2 smaller stalls (required city approval)
- Relocated mechanical above the parkade ramp/on the roof
- Reduced the size on all the utility rooms
- More efficient with the car and bike stalls
- 2 parkade levels initially, was to ensure exiting worked with max travel distances for fire safety



Saving (% of Initial Parkade)	**50%**
Whole Building Saving (% of OneClick baseline building with initial slabs and 2 parkade levels)	**8%**



B
LCA Compliance Report
Tally

ZGF

Whole Building Life Cycle Analysis with Tally

VAHA Seymour

Compliance Report 2023-06-26

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Executive Summary

Building Information

Project Name: VAHA Seymour

Project Location: 1210 Seymour St, Vancouver, BC VXV 1X1

Gross Floor Area: 8,800m^2 / 94,711 ft^2 (including 1 level of parkade)

Building Height : 9 storey / 31m / 103ft

Structural System: Concrete

LCA Parameters

Compliance: Vancouver Building By-law (VBBL), as per City of Vancouver Embodied Carbon Guidelines v.02

Software: Tally version 2022.01.08.01

LCA Scope: Substructure / Superstructure / Enclosure / Interiors (partitions, finishes, ceilings & flooring), as per the City of Vancouver Embodied Carbon Guidelines v.02 (CoV).

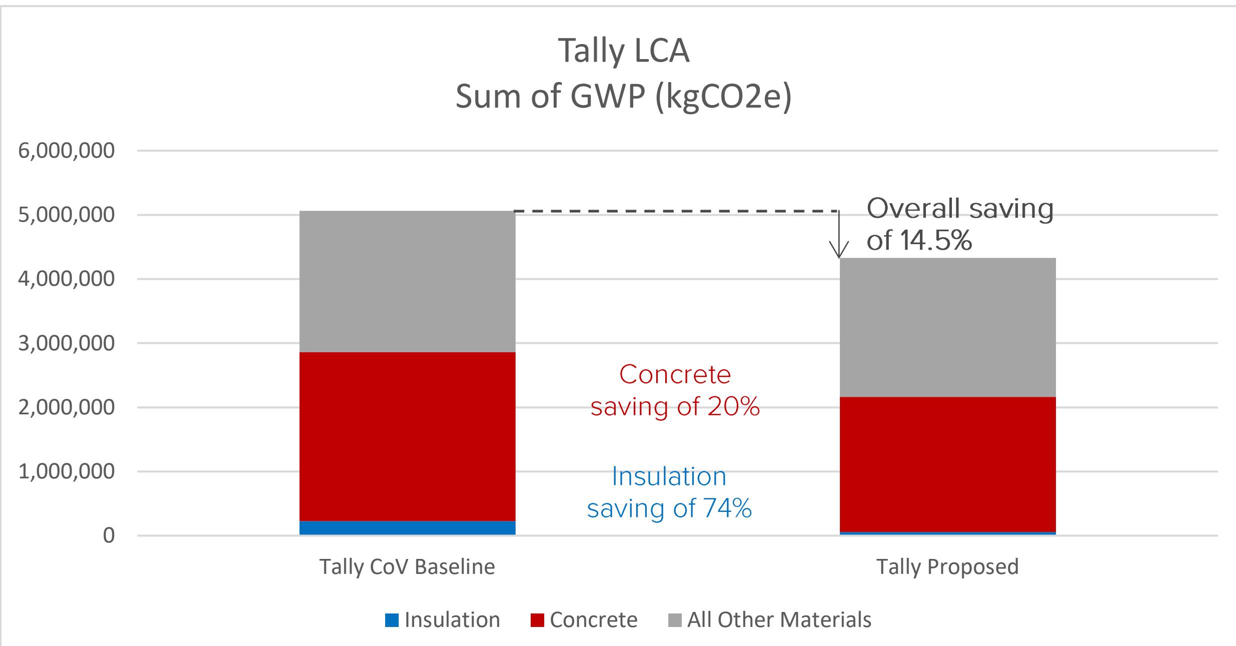
LCA Lifestages: Lifestages A-C. Biogenic carbon & Module D excluded.

LCA Service Life: 60 years

Target

- Vancouver Building By-law (VBBL)
  - no more than double baseline from 2023 / **10% reduction from 2025** / 40% reduction from 2030

Was the target achieved: ☒ **Yes** ☐ **No**



Notes:

- A saving of 14.5% was achieved, exceeding the Vancouver Building By-law (VBBL) 2025 target of 10% reduction.
- Reducing a parkade level was the most effective decision, followed by the insulation selection, reducing the slabs through structural optimization and the concrete mix selection.
- All materials except insulation and concrete were kept the same as the baseline.

Project Information

LCA Author	ZGF Architects
LCA Reviewer	ZGF Architects
Design Architect	ZGF Architects
Architect on Record	ZGF Architects
Structural Engineer	Fast+Epp
General Contractor	Kindred Construction
Concrete Supplier, if known	
Key Stakeholders	

Floor Area & GWP Intensity

The floor area changes from baseline to proposed design, with the reduction of a parkade level. Consequently, the GWP intensity is a misleading metric and is not used elsewhere in this report. Additionally, the total GWP is not comparable between different software at the time of this report, therefore the percentage reduction from the baseline will be the dominant metric in the Results, in line with City of Vancouver (CoV) guidance.

	Floor Area	**ft^2**	**m^2**	**Total GWP, kgCO2eq**	**GWP Intensity, kgCO2eq/m^2**
	without parkade	80,416	7,471		
Proposed Design	with 1 parkade level	94,711	8,800	4,455,446	506
Baseline Design	with 2 parkade levels	109,006	10,127	5,191,463	513

Summary of Assumptions

Baseline GWP Sources

Baseline Building – Sources of Major Materials:

Material		EPD Author	Link
Structure	Concrete	Concrete BC	810.CRMCA_EPD_BC.pdf (concretebc.ca)
	Steel, Rebar	CRSI	CRSI Environmental Product Declaration
	CMU	Mutual Materials	EDP (mutualmaterials.com)
Enclosure & Interior	Insulation, XPS	Dupont	buildingtransparency.org/ec3/epds/ec3b80r0
	Insulation, Mineral Wool	NAIMA	Product Definition (jm.com)
	Steel, Metal framing	Default	
	Cladding, Galvanized steel	Default	
	Cladding, Fibre cement	Equitone	en_epd_equitone_natura_textura_2019_2024.pdf
	Aluminium profile	Default	
	Glazing, triple, insulated (air)	Defualt	
	Gypsum Plasterboard (interior finish & exterior sheathing)	Gypsum Association	EPD10270.pdf (nsf.org)
	Clay Brick	Default	

Notes

- See Appendix C for abridged EPD's.
- Products chosen based on the CoV Guidelines
    - either specifically mentioned, as with XPS insulation, or are a regional baseline.
- 'Default' values are averages generated from GaBi LCA database (except for some specific manufacturers' EPDs).[1] See Appendix 2 for comparison of baseline and proposed A1-A3 GWP per declared units for all materials.

[1] Cormick, Hayley (2018): Comparing Three Building Life Cycle Assessment Tools for the Canadian Construction Industry. Toronto Metropolitan University. Thesis. https://doi.org/10.32920/ryerson.14664510.v1, pg29-30

Proposed GWP Sources

Proposed Building – Sources of Major Materials:

Material		**Same as baseline?**	**EPD Author**	**Link**
Structure	Concrete	☐	Fast & Epp	Attachment link to the product-EPD
	Steel, Rebar	☒	CRSI	CRSI Environmental Product Declaration
	CMU	☒	Mutual Materials	EDP (mutualmaterials.com)
Enclosure & Interior	Insulation, XPS	☐	Soprema	SOPRA-XPS - Download our EPD I SOPREMA
	Insulation, Mineral Wool	☐	Rockwool	rockwool-stone-wool-environmental-product-declaration-epd.pdf
	Steel, Metal framing	☒	Default	
	Cladding, Galvanized steel	☒	Default	
	Cladding, Fibre cement	☒	Equitone	en_epd_equitone_natura_textura_2019_2024.pdf
	Aluminium profile	☒	Default	
	Glazing, triple, insulated (air)	☒	Default	
	Gypsum Plasterboard (interior finish & exterior sheathing)	☒	Gypsum Association	EPD10270.pdf (nsf.org)
	Clay Brick	☒	Default	

Notes:

- See Appendix C for abridged EPD's.
- Products chosen based on Outline Specification. If not specified in Outline Specification, baseline value is used.
- See Appendix 2 for comparison of baseline and proposed A1-A3 GWP per declared units for all materials.

Material Quantities

Quantities of key materials

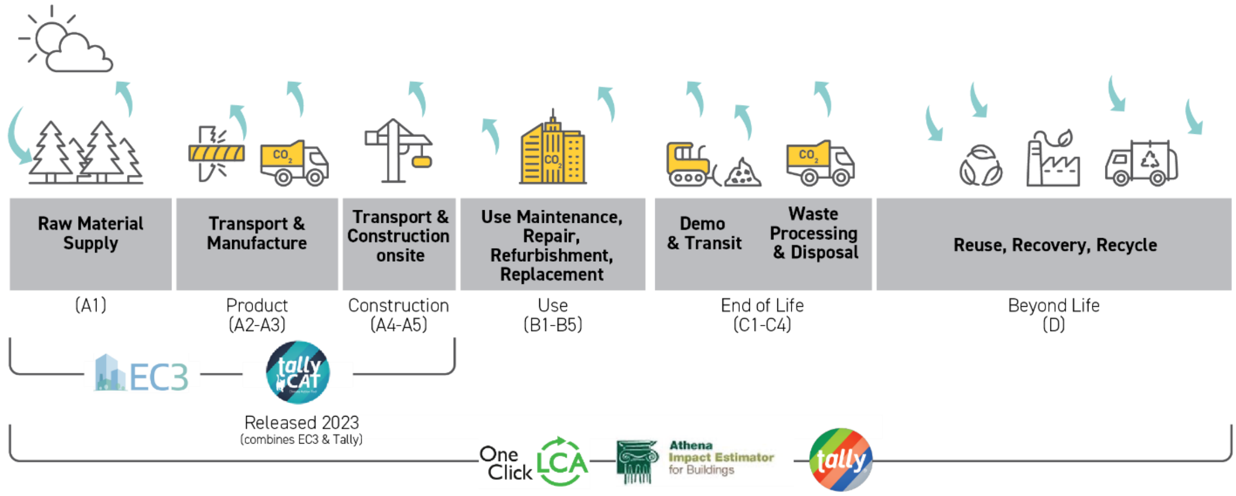
Material		Baseline	Proposed if same as baseline, -	Declared units	Source		
					BIM	Costing	Other
Structure	Concrete	5,599	4,510	m^3	☒	☐	☐
	Steel, Rebar	523,362	474,916	kg	☒	☐	☐
	CMU	139	101	kg	☒	☐	☐
Enclosure & Interior	Insulation, XPS	687 m^2 *6.1 = 4192	-	m^2.RSI	☒	☐	☐
	Insulation, Mineral Wool	3,281 m^2 *6.87 = 22,540	3,074 m^2 *6.87 = 21,118	m^2.RSI	☒	☐	☐
	Metal framing, Steel	218,942	217,408	kg	☒	☐	☐
	Cladding, Steel	230,888	167,180	kg	☒	☐	☐
	Cladding, Fibre cement	596	389	m^2	☒	☐	☐
	Aluminium Profile	8,289	-	m^2	☒	☐	☐
	Glazing, Triple, insulated (air)	59,471	58,995	kg	☒	☐	☐
	Exterior sheathing, Gypsum	3,043	-	m^2	☒	☐	☐
	Interior Finish, Gypsum	9,952	-	m^2			
	Clay brick	64,156	-	kg	☒	☐	☐

Notes:

- Parkade level reduction and structural optimization is responisble for proposed reductions in quantities. See Results – Volume Reductions for details.

LCA Methodology

Overview



EC3 is a database of materials with Environmental Product Declarations (EPDs), that we used to gain proposed GWP values for this LCA. Tally is the LCA software we used; it covers all life stages of a material. Tally works by assigning its own values and assumptions to Revit elements then outputting the data in a spreadsheet. The data is then manually processed to get exact GWP per declared unit numbers, which can then be substituted with baseline and proposed values from the City of Vancouver Guidelines or product EPDs (as shown in the table below).

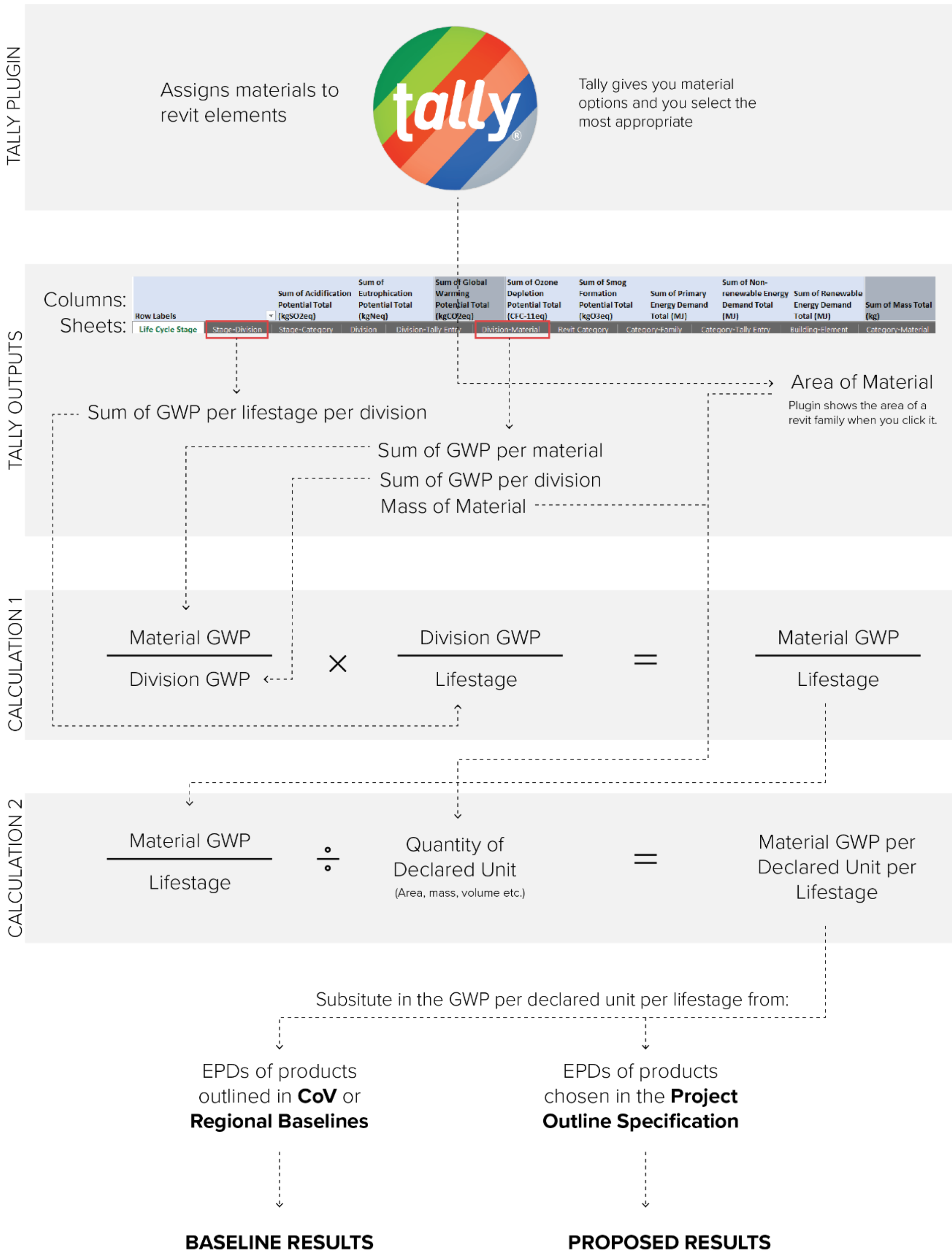
It is important to note that in this LCA, biogenic carbon is excluded, Life-cycle D is excluded and interiors are included.

Automatic Tally Values | Calculated Tally Values | Manual input

		Sum of GWP (kgCO2eq)	Tally GWP (kgCO2e/Unit)	Baseline GWP (kgCO2e/unit)	Proposed GWP (kgCO2e/unit)
Division	Material	A1-D	A1 - A3	A1 - A3	A1 - A3
03 - Concrete		3,293,941			
	Steel reinforcement	884866.902	1	0.8	0.8
	Suspended slabs & beams, 30MPa, 5000psi	1,309,142	441	219.7	182
	Foundations & Footings, 25MPa, 4000psi	277,663	515	269.83	215
	Walls/Columns, 30MPa, 5000psi	397,298	603	258.92	248
	Shear Walls, 8000psi	424,971	612	402.11	314
04 - Masonry		59319			
	Brick, generic	20,482	0	0	0
	Concrete masonry unit (CMU), hollow-core	28,834	251	284.5	284.5
	Mortar type N	4,158	0	0	0
	Steel, reinforcing rod	5,845	1	0	0
06 - Wood/Plastics/Composites		33414			
	Fiber cement structural panel, Eternit, Eterplan - EPD	17,125	41	0	15.86
	Fiberglass mat gypsum sheathing board	16,279	0	0	0
	Red oak lumber, 2 inch	0	0	0	0
	Wood stain, water based	10	1	0	0
07 - Thermal and Moisture Protection		427303			
	Aluminum extrusion, AEC - EPD	1,920	3	0	0
	Fasteners, stainless steel	17	2	0	0

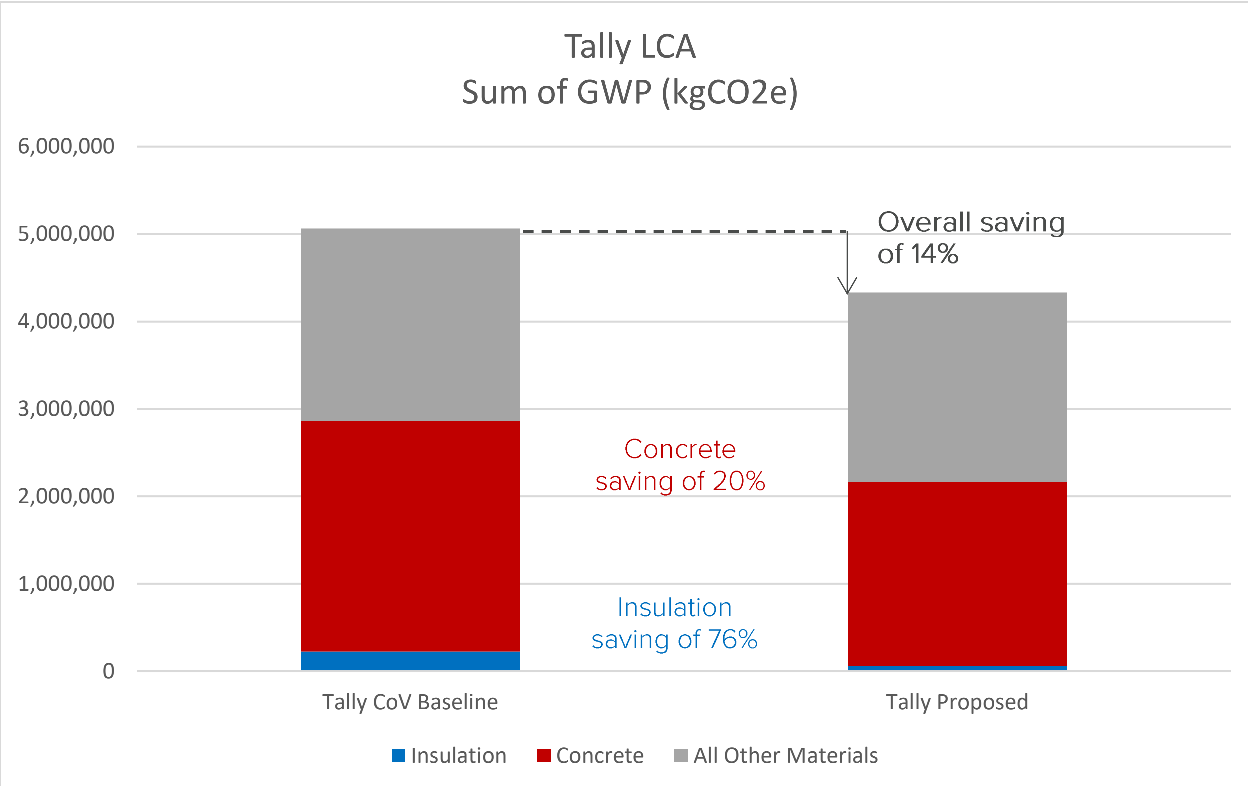
Summary of Manual Changes

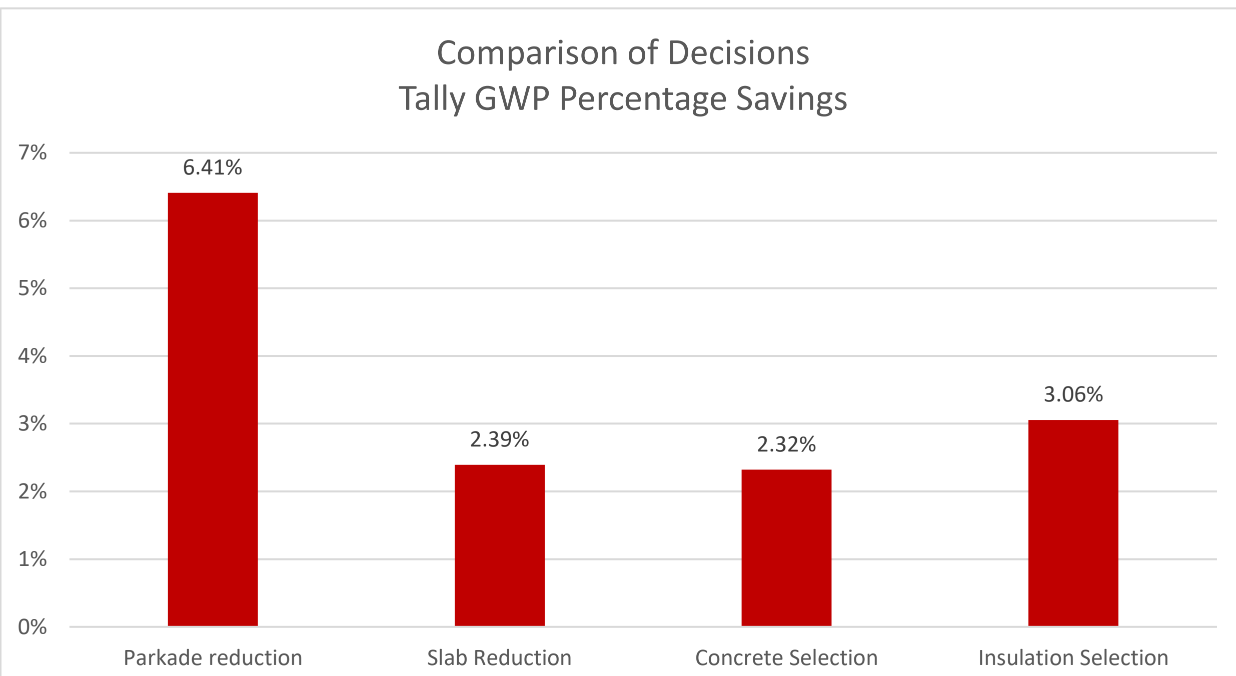
Any post-processing is likely to cause inaccuracies from assumptions and human error and should be avoided if possible. It was unavoidable in this instance, so all assumptions and methods are visually explained in the below diagram and fully explained in Appendix 1. This ensures the limits of this LCA are understood and the conclusions are tempered approporiately.



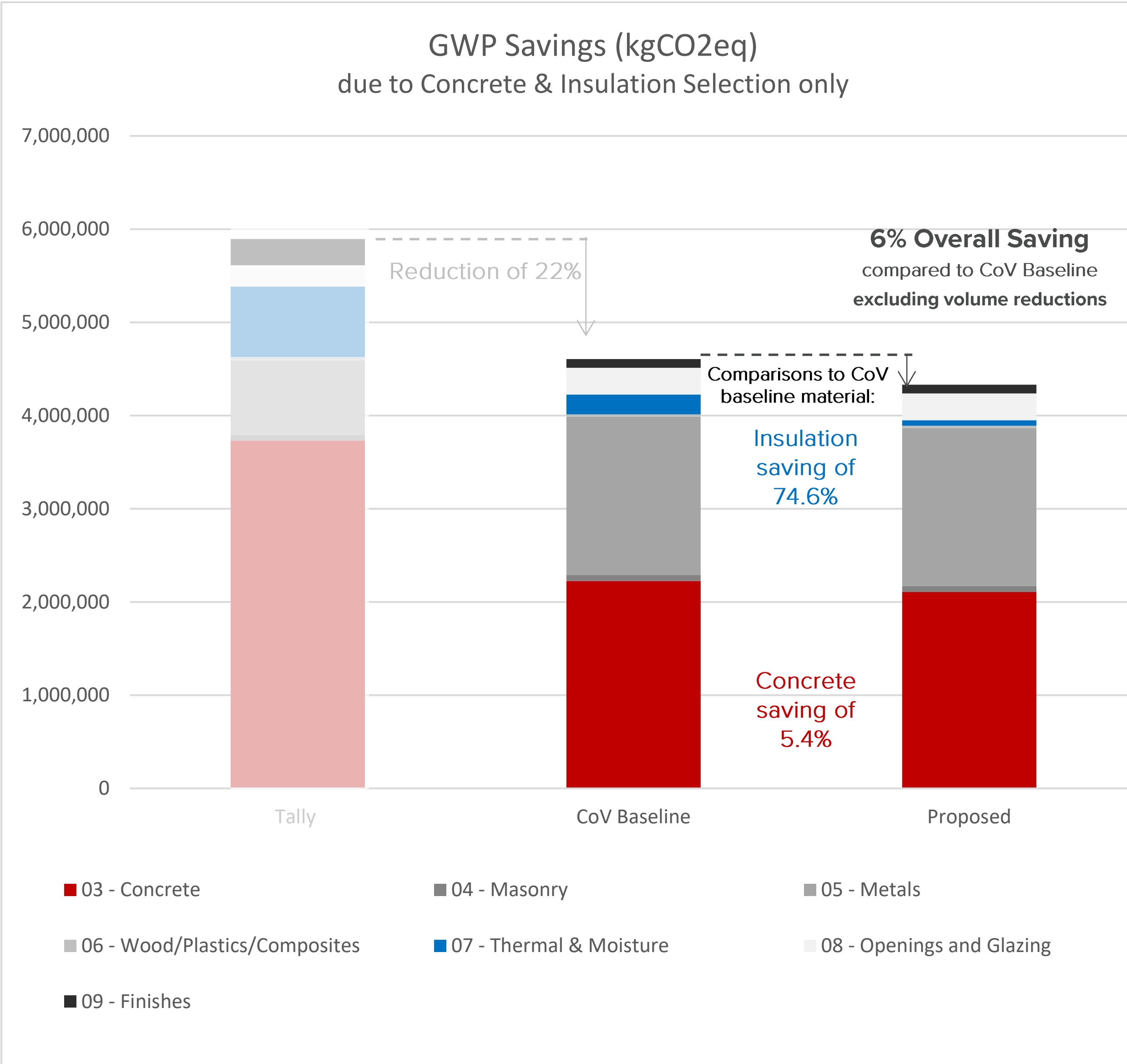
Results – Overall

The 2025 VBBL requirement of 10% reduction from the baseline was exceeded through four changes that have no projected additional cost. Reducing a parkade level was the most effective decision, followed by the insulation selection, reducing the slabs through structural optimization and the concrete mix selection.





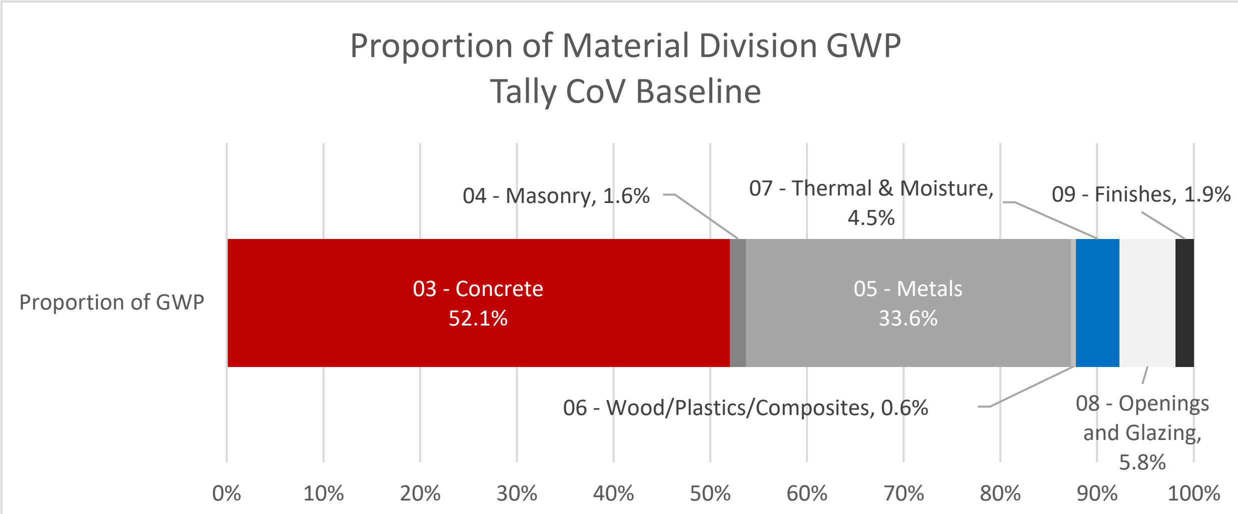
Results – Material Breakdown



A 6% saving compared to the whole baseline building was achieved through the selection of low GWP concrete and insulation.

The baseline complies with the City of Vancouver Embodied Carbon Guidelines (CoV Guidelines), and the proposed uses products specified in the Outline Specification (see Summary of Assumptions for Baseline and proposed product sources). Tally raw outputs do not meet City of Vancouver Guidelines, as you cannot select specific products, only averages. The results are shown greyed out in the above graph, to illustrate the significant difference the selection of specific products makes.

It should also be noted that the interior materials are mixed in with all materials. This is due to the City of Vancouver Embodied Carbon Guidelines v.02 including them (specifically partitions, finishes, ceilings & flooring). In future workflows, interiors should be separated to understand their impact on percentage savings.



Concrete is the division with the highest GWP, accounting for over 50% of the overall building GWP in the chart above. As explained in concrete division breakdown following this section, the steel rebar is included in this division and accounts for a sizable proportion of the GWP. See the next section for how we reduced the concrete GWP without projected additional costs.

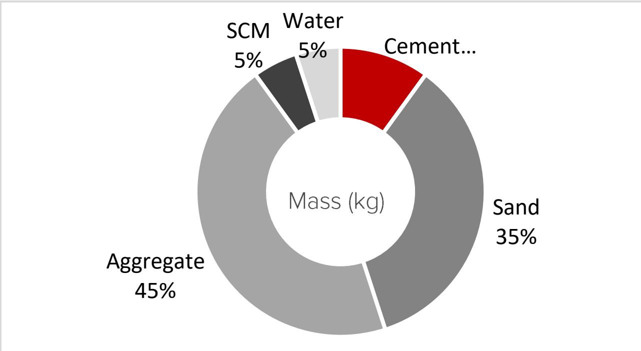
The second largest proportion is metals, which primarily consists of the steel panel cladding and stud framing (mullions are in the Openings and Glazing section and steel rebar is within the Concrete division). This material division was not improved in the proposed due a likely increase in costs and a current lack of EPDs, but should be targeted in future.

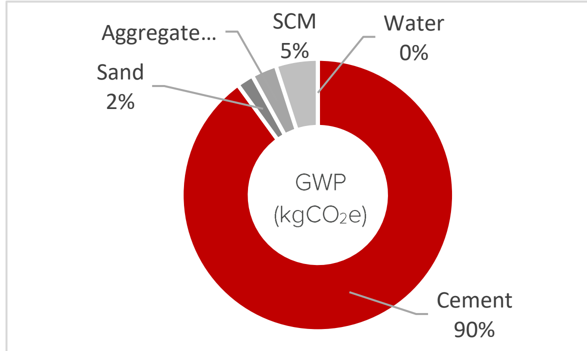
Similarly, the Openings and Glazing division should specify low GWP products in future, but this is likely to be costly and the 2025 VBBL requirements have been met through the other decisions.

The Thermal and Moisture Protection division is predominantly insulation. Although it is a small proportion of the total GWP, the decision to switch to low GWP products was a simple, low cost decision and combined with low GWP concrete and volume reductions, allowed us to reach our goal.

Concrete Mix

The below graphs show the contents of an average concrete mix and each ingredients' impact on the GWP. As you can see, cement is only 10% of the mass, but 90% of the GWP.



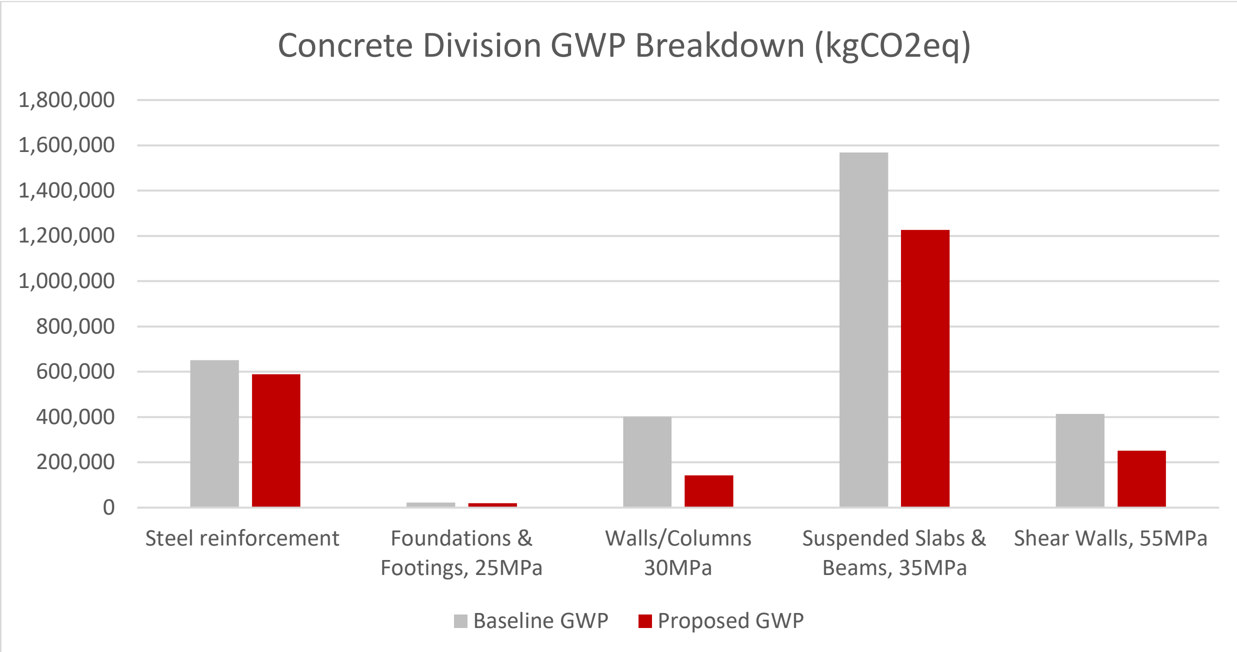


Therefore the 2 best ways to reduce concrete emissions are:

- Changing from Portland cement to Portland Limestone Cement
- Increasing the SCM (supplementary cementitious material)
  - Examples of SCM are: fly ash, slag cement or silica fume blended cement

We do not know the exact mix designs of the mixes given to us by our structural engineers, but it is safe to assume they use Portland limestone cement and SCM. There are other ways of reducing GWP of concrete, but these are the easiest to achieve significant savings.

The bar graph below breaks down the Concrete Division results into elements. Savings from baseline to proposed are due to volume reductions (see Results – Volume Reduction.), and low GWP concrete & insulation selections (see previous page).



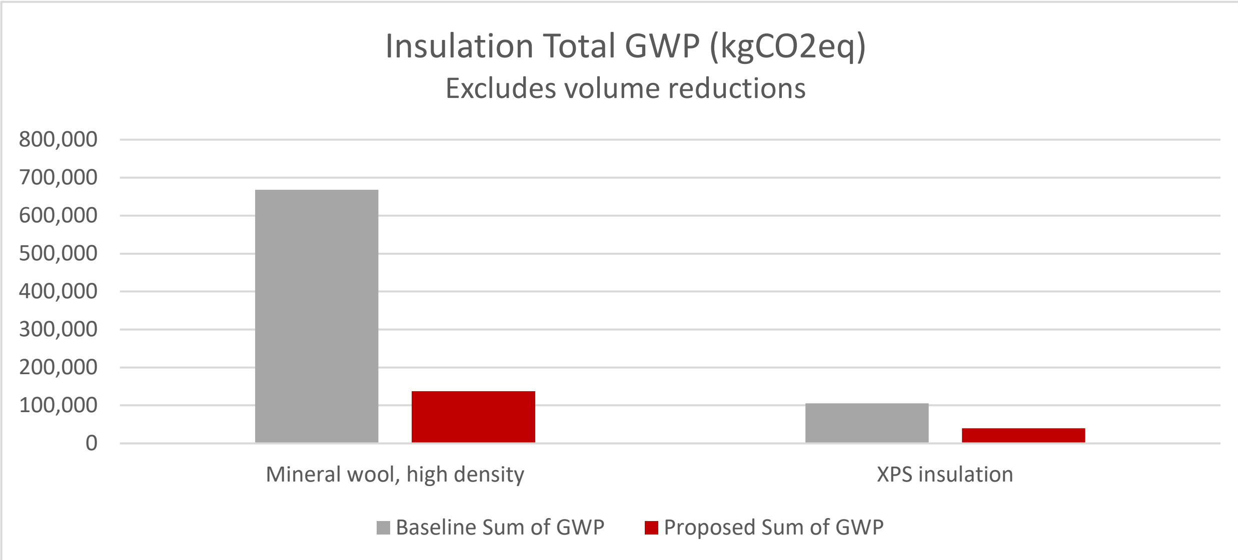
MATERIAL IN CONCRETE DIVISION	% MASS	% GWP IN BASELINE	BASELINE GWP/UNIT	PROPOSED GWP/UNIT	GWP/UNIT REDUCTION
Steel Reinforcement	4.17%	25.09%	0.80	0.80	0%
Foundations & Footings, 25MPa	1.68%	0.95%	219.70	182	17%
Walls/Columns 30MPa	10.61%	7.26%	269.83	215	20%
Suspended Slabs & Beams, 35MPa	70.56%	53.74%	258.92	248	4%
Shear Walls, 55MPa	12.98%	12.96%	402.11	314	22%

Concrete division conclusions:

- The suspended floor slabs have the greatest proportion of GWP
  - Contain the most of the mass (70% of the concrete division).
  - Reducing the thickness achieves significant savings, as explained in Slab Reductions

- Steel reinforcement disproportionally affects the GWP.
  - Accounts for 5% of the mass, but 25% of the GWP.
  - The regional baseline of 0.8kgCO_2 is used for both the baseline and proposed. Specifying a lower GWP steel could have significant savings, but has not been done for this LCA as EPD's are not readily available at this time.
  - Reducing the amount of steel reduces embodied carbon, as detailed in Results – Volume Reduction.

Insulation GWP Reduction



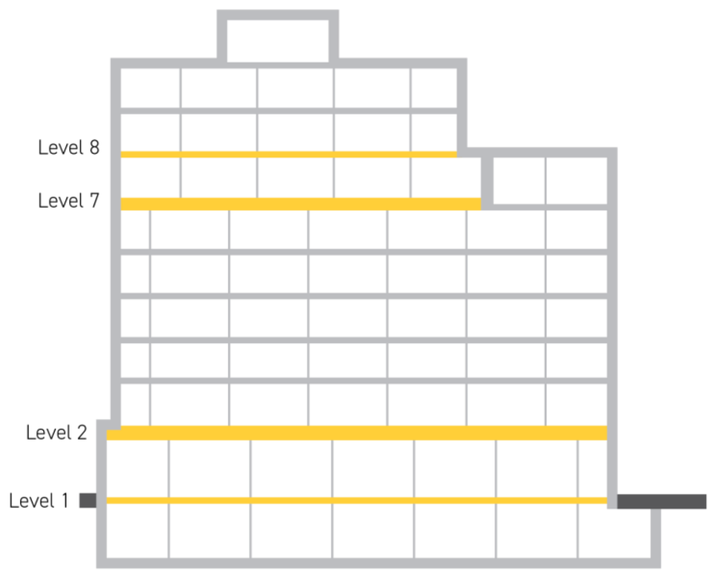
The GWP from the Thermal & Moisture Protection division (98% of which is insulation) was reduced by 74.6% of the baseline GWP amount, by selecting CSA approved Canadian sourced materials with a low GWP. There was an 59% saving in XPS and 80% saving in mineral wool (excludes volume reductions from parkade). See the Summary of Assumptions for the EPDs of these products.

Results - Volume Reduction

Slab reductions

The baseline has different slab thicknesses to the proposed design. As seen in Concrete Mix, the suspended floor slab is the most impactful concrete element. Therefore, reducing its volume is an effective way to gain savings. The following floor slabs were changed by the below amounts, after consulting with the structural engineer to create a more efficient design that limits transfer slabs.

- L1: was 3'2", now 1" (from 965.2mm, to 304.8mm)
- L2: was 2'2", now 3'2" (from 660.4mm, to 965.2mm)
- L8: was 1'6", now 8" (from 457mm, to 203.2mm)



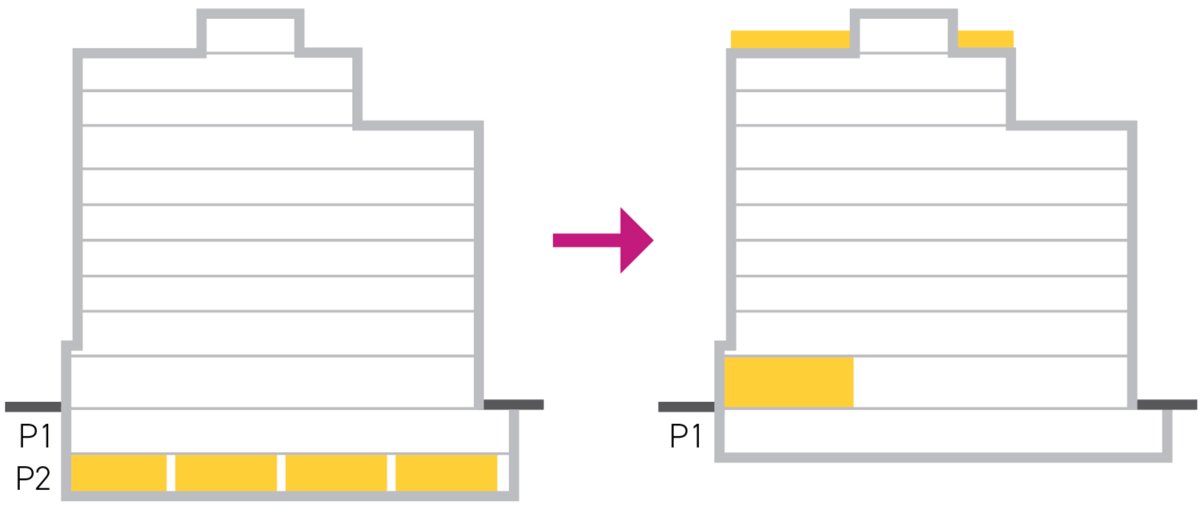
The below estimates are conservative as they only include lifestages A1-A3 for concrete only, the rebar was kept the same pre and post volume reduction.

Slab Level	Gross Floor Area (m^2)	Initial Slab Thickness (m)	Proposed Slab Thickness (m)	Reduction (m^3)	GWP per unit (regional baseline)	GWP Saving (Lifestages A1-A3)
L1	921	0.97	0.30	609	259	157,764
L2	941	0.66	0.97	-287	259	-74,249
L8	622	0.46	0.20	157	259	40,730
					Slab Reduction Saving	124,244
					Saving (% of Initial Slab)	**27%**
					Whole Building Saving (% of baseline building)	**2%**

Parkade Reduction

The GWP of a parkade level was calculated by running the model with only the parkade through tally, then post-processing, as was done for the main LCA. The parkade was reduced from 2 levels to 1, through the following decisions:

- Swapped a loading space for 2 smaller stalls (required city approval)
- Relocated mechanical above the parkade ramp/on the roof
- Reduced the size on all the utility rooms
- More efficient with the car and bike stalls
- 2 parkade levels initially, was to ensure exiting worked with max travel distances for fire safety



Saving (% of Initial Parkade)	**50%**
Whole Building Saving (% baseline building)	**6.6%**

Conclusion:

- Reducing a parkade level is the most substantial way to achieve savings (shown in Comparison of Decisions graph in Results - Overall)

Appendices

Appendix 1 | Justification of Manual Changes

1.1 | Material Life-stages

Tally doesn't separate materials per life-stage, only divisions of material (as shown below, left). It does however, separate material GWP of all lifestages (below, right).

Row Labels	Sum of Global Warming Potential Total (kgCO2eq)	Sum of Mass Total (kg)
[A1-A3] Product	**5,074,165.73**	**12,873,406.11**
03 - Concrete	3,048,452.72	11,317,380.24
04 - Masonry	52,282.72	303,171.51
05 - Metals	1,277,648.15	479,907.21
06 - Wood/Plastics/Composites	31,233.85	40,119.86
07 - Thermal and Moisture Protection	391,471.17	122,393.18
08 - Openings and Glazing	160,739.38	75,097.22
09 - Finishes	112,337.73	535,336.89
[A4] Transportation	**49,597.32**	
03 - Concrete	28,239.88	
04 - Masonry	2,889.36	
05 - Metals	8,654.91	
06 - Wood/Plastics/Composites	374.74	
07 - Thermal and Moisture Protection	1,377.35	
08 - Openings and Glazing	3,057.16	
09 - Finishes	5,003.92	
[B2-B5] Maintenance and Replacement	**673,991.11**	**788,988.17**
03 - Concrete	18,767.42	94,972.55
04 - Masonry	0.00	0.00
05 - Metals	398,729.74	83,736.72

Report Summary | Revit model | Life Cycle Stage | **Stage-Division**

Row Labels	Sum of Global Warming Potential Total (kgCO2eq) All Lifestages	Sum of Mass Total (kg)
03 - Concrete	**3,293,940.75**	**11,412,352.79**
Steel, fabricated steel reinforcement, CRSI - EPD	99,208.92	57,485.65
Steel, reinforcing rod	785,657.98	552,967.45
Structural concrete, 3000 psi, 0% fly ash and slag	1,309,141.51	6,597,532.85
Structural concrete, 4000 psi, 0% fly ash and slag	277,663.48	1,198,108.87
Structural concrete, 5000 psi, 0% fly ash and slag	397,297.60	1,464,488.74
Structural concrete, 8000 psi, Pacific Northwest regional average	424,971.25	1,541,769.22
04 - Masonry	**59,319.45**	**303,171.51**
Brick, generic	20,482.31	64,155.64
Concrete masonry unit (CMU), hollow-core	28,833.82	202,684.54
Mortar type N	4,157.94	32,217.19
Steel, reinforcing rod	5,845.39	4,114.14
05 - Metals	**1,132,317.10**	**563,643.93**
Aluminum extrusion, painted, AEC - EPD	0.00	0.00
Galvanized steel	476,949.43	217,407.56
Mineral wool, high density, NAIMA - EPD	329,663.77	178,762.92
Powder coating, metal stock	3,148.96	293.07
Stainless steel sheet, Chromium 18/8	321,599.04	166,321.96
Steel, sheet	955.90	858.42

Stage | Stage-Division | Stage-Category | Division | Division-Tally Entry | **Division-Material**

To get the material GWP per lifestage it was assumed that the proportion of material GWP for all lifestages (A1-D) compared to Total GWP for all lifestages (A1-D), was the same in each lifestage.

CALCULATION 1

$$\frac{\text{Material GWP}}{\text{Division GWP}} \times \frac{\text{Division GWP}}{\text{Lifestage}} = \frac{\text{Material GWP}}{\text{Lifestage}}$$

This is a good assumption for concrete, as the materials that make up the division are all the same and will likely come from the same place too. The reasoning breaks down with the other, broader divisions where materials can be drastically different. However, this was the simplest way to get to a GWP per declared unit for each lifestage, which is needed to be able to substitute baseline and proposed GWP per declared unit values.

With more time available, tally could be run with a single material to gain the actual GWP per lifestage. However, it was deemed superfluous to the final conclusions to laboriously run each material again.

1.2 | GWP to GWP/declared unit

Tally only the gives sum of GWP and we need it divided by the declared unit to be able to switch in baseline/proposed values. The declared units are different depending on the element, so calculations had to be used to find it.

CALCULATION 2

$$\frac{\text{Material GWP}}{\text{Lifestage}} \div \text{Quantity of Declared Unit} = \text{Material GWP per Declared Unit per Lifestage}$$

(Area, mass, volume etc.)

Inaccuracies:

- Concrete declared unit is volume.
  - Volume = Mass/Density
  - The average density of 2400kg/m^3 was used
  - Different concrete mixes have different densities so some accuracy is lost by using the average.
- Area depends on the accuracy of the modelling
  - How walls are joined and whether they are modelled at the correct height greatly affects the area.
  - It is very difficult to verify the accuracy of the model

The most common declared units for materials are summarized in the below table, for more all materials see Appendix 1.

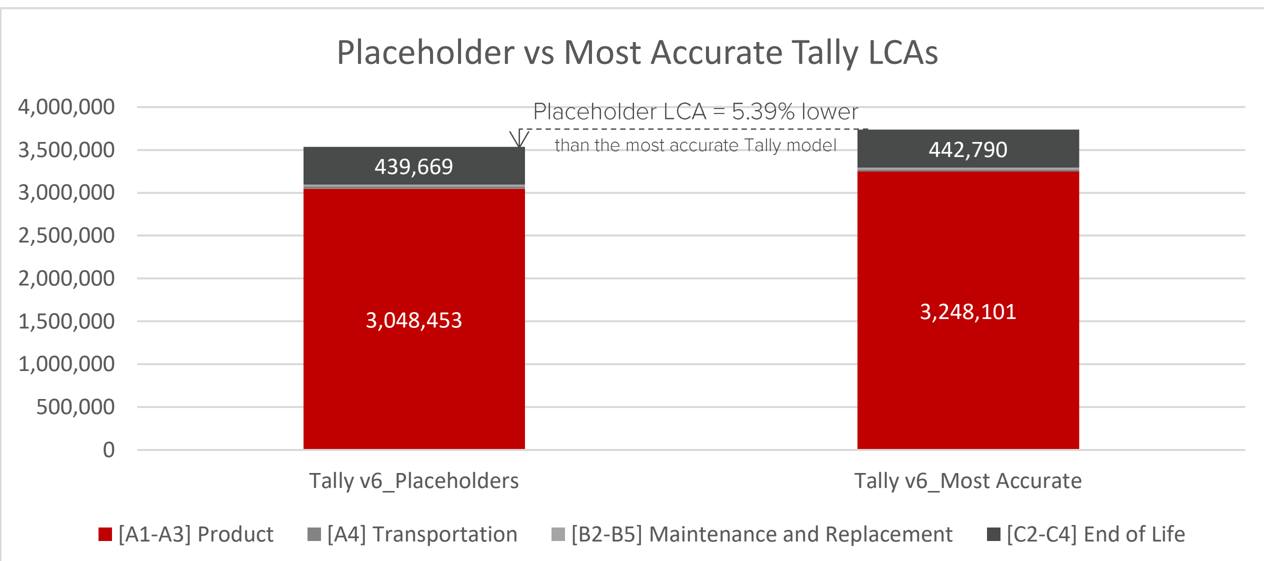
MATERIAL	UNIT
Steel reinforcement	kg
Concrete	m^3
Insulation	m^2.RSI
Cladding	m^2

1.3 | Concrete Categories

Concrete is organized by element in the City of Vancouver (CoV) Guidelines, as well as in the values we received from the structural consultant (Fast & Epp). This presented a problem, as Tally groups concrete volumes together by strength. To get around this, placeholder concrete mixes were assigned to specific elements. This is tracked in the table below, along with the baseline and proposed GWP per declared unit of lifestages A1-A3.

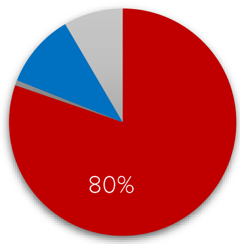
TALLY PLACEHOLDER MATERIAL NAME	ELEMENT NAME	BASELINE: BC CONCRETE (GWP per m^3)	PROPOSED: FAST & EPP (STRUCTURAL) (GWP per m^3)
Structural concrete, 4000 psi, 0% fly ash and slag	Foundations & Footings, 25MPa, 4000psi	219.7	182
Structural concrete, 5000 psi, 0% fly ash and slag	Walls/Columns, 30MPa, 5000psi	269.83	215
Structural concrete, 3000 psi, 0% fly ash and slag	Suspended slabs & beams, 30MPa, 5000psi	258.92	248
Structural concrete, 8000 psi, Pacific Northwest regional average	Shear Walls, 8000psi	402.11	314

The main problem with this solution, is that the GWP per Lifestage is still relied on to be able to get the GWP per Lifestage for each material, but as it is from placeholder concretes, it is no longer totally accurate. To test the margin of error on this, we ran Tally again with the concretes set to the most accurate mixes (only one element changes, 3000psi goes to 5000psi).



As you can see from the graph above, the difference between concrete GWPs of the 2 models is small enough to be negligible, especially considered that raw tally data is not used in this LCA, as baseline conditions set by CoV cannot be met without substituting GWP per declared unit values.

Appendix 2 | A1-A3 GWP per declared unit



A1-A3 GWP per declared unit is shown in the below table. Some products have more lifestages available (see sources in Summary of Assumptions), however A1-A3 is only shown here as it is responsible for 80% of the GWP (see above). The Tally GWP per Unit is used if there is no baseline value.

DIVISION	MATERIAL	TALLY GWP PER UNIT (kgco2e/unit)	BASELINE GWP PER UNIT (kgco2e/unit)	PROPOSED GWP PER UNIT (kgco2e/unit)
03 – Concrete	Steel reinforcement	1.34	0.80	0.80
	Suspended slabs & beams, 30MPa, 5000psi	440.74	219.70	182
	Foundations & Footings, 25MPa, 4000psi	514.75	269.83	215
	Walls/Columns, 30MPa, 5000psi	602.57	258.92	248
	Shear Walls, 8000psi	612.23	402.11	314
04 - Masonry	Brick, generic	0.28		
	Concrete masonry unit (CMU), hollow-core	251.06	285	285
	Mortar type N	0.11		
	Steel, reinforcing rod	1.25		
05 - Metals	Galvanized steel	2.48		
	Mineral wool moved to 07	0.00		
	Powder coating, metal stock	12.12		
	Stainless steel sheet, Chromium 18/8	2.18		
	Steel, sheet	1.26		
06 – Wood/Plastics/Composites	Fiber cement structural panel, Eternit, Eterplan - EPD	41.12	15.86	15.86
	Fiberglass mat gypsum sheathing board	0.49		
	Wood stain, water based	1.16		
07 - Thermal and Moisture Protection	Aluminum extrusion, AEC - EPD	1.50		

	Fasteners, stainless steel	1.37		
	Fiber cement board	0.37		
	Mineral wool, high density, NAIMA - EPD	3.57	8.16	1
	Polyethelene sheet vapor barrier (HDPE)	1.35		
	SBS modified bitumen, assembly (base & cap), ARMA - EPD	0.35		
	XPS insulation, Foamular average, Owens Corning - EPD	4.96	3.51	2
08 - Openings and Glazing	Aluminum extrusion, anodized, AEC - EPD	3.05		
	Door frame, wood, no door	3.37		
	Door, interior, wood, hollow core	0.44		
	Door, interior, wood, MDF core	0.62		
	Fasteners, galvanized steel	1.64		
	Frit (for glazing)	0.46		
	Glazing, double, 3 mm, laminated safety glass	1.26		
	Glazing, monolithic sheet, generic	67.44		
	Glazing, monolithic sheet, safety glass	0.29		
	Glazing, monolithic sheet, tempered	105.55		
	Glazing, triple, insulated (air)	0.00		
	Hardware, aluminum	1.77		
	Hardware, stainless steel	1.34		
	Hollow door, exterior, steel, fire-rated	1.19		
	Hollow door, exterior, steel, galvanized	1.39		
	Hollow door, exterior, steel, powder-coated	1.89		
	Hollow door, interior, steel, galvanized, large vision panel	1.12		
	Hollow door, interior, steel, unfinished	1.08		
	Laminating (for glazing)	16.00		
	Spandrel, aluminum, insulated (1 core)	2.29		
	Stainless steel door hinge	3.31		
	Venting window unit framing	2.06		

	Window frame, aluminum, powder-coated, fixed, insulated	2.93		
09 - Finishes	Acoustic ceiling tile (ACT), mineral fiber board	0.56		
	Suspended grid	0.65		
	Wall board, gypsum, fire-resistant (Type X)	39.71	2.98	2.89
	Wall board, gypsum, natural	3.23	2.98	2.89

C

Abridged Environmental Product Declarations (EPDs)

Concrete - BC

Steel, Rebar - CRSI

CMU - Mutual Materials

Cladding, Fibre Cemet - Equitone

Gypsum Plasterboard - Gypsum Assosication

Insulation, Mineral Wool - NAIMA

Insulation, Mineral Wool - Rockwool Stone Wool

Insulation, XPS - Du Pont Stryrofoam Brand ST-100

Insulation, XPS - Soprema SOPRA-XPS

Abridged version of EPD. Full document online:
https://concretebc.ca/wp-content/uploads/2022/10/810.CRMCA_EPD_BC.pdf

Environmental Product Declaration

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Concrete BC Member Industry-Wide EPD for

READY-MIXED CONCRETE

Table 9. LCA Results 25 MPa Concrete without air (N)

	Unit	Baseline 25 MPa Concrete without air (N) GU 20 SCM	25 MPa Concrete without air (N) GU	25 MPa Concrete without air (N) GU 15 SCM	25 MPa Concrete without air (N) GU 25 SCM	25 MPa Concrete without air (N) GU 40 SCM	25 MPa Concrete without air (N) GUL	25 MPa Concrete without air (N) GUL 15 SCM	25 MPa Concrete without air (N) GUL 25 SCM	25 MPa Concrete without air (N) GUL 40 SCM
Environmental impacts										
GWP	kg CO_2 eq.	219.70	257.85	229.24	211.02	182.24	239.24	213.44	197.03	171.07
ODP	kg CFC-11 eq.	8.67E-06	9.04E-06	8.76E-06	8.61E-06	8.30E-06	8.56E-06	8.36E-06	8.25E-06	8.02E-06
EP	kg N eq.	0.19	0.21	0.20	0.19	0.18	0.20	0.19	0.18	0.17
AP	kg SO_2 eq.	0.96	0.98	0.96	0.96	0.94	0.93	0.92	0.92	0.91
POCP	kg O_3 eq.	21.27	21.78	21.40	21.20	20.77	20.63	20.42	20.34	20.08
Use of primary resources										
RPR_E	MJ, NCV	124.56	142.37	129.01	120.48	107.07	141.04	127.88	119.48	106.27
RPR_M	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$NRPR_E$	MJ, NCV	1457.37	1564.03	1484.03	1435.18	1352.60	1206.30	1180.35	1166.24	1137.71
$NRPR_M$	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Use of secondary resources										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	92.27	115.54	98.09	86.86	69.41	104.53	88.74	78.59	62.79
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Abiotic depletion potential										
ADPf	MJ, LHV	609.84	648.39	619.48	601.47	571.97	629.90	603.78	587.56	560.86
ADPe	kg Sb	1.20E-04	1.25E-04	1.21E-04	1.19E-04	1.15E-04	1.24E-04	1.21E-04	1.18E-04	1.15E-04
Consumption of freshwater resources										
FW	m^3	2.26	2.39	2.29	2.23	2.13	2.33	2.24	2.19	2.10
Waste and output flows										
HWD	kg	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
NHWD	kg	51.12	64.00	54.34	48.13	38.47	57.80	49.07	43.46	34.74
HLRW	m3	1.82E-09	1.82E-09	1.82E-09	1.82E-09	1.82E-09	1.82E-09	1.82E-09	1.82E-09	1.82E-09
ILLRW	m3	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional inventory parameters for transparency										
CCE	kg CO_2 eq.	106.41	133.25	113.12	100.18	80.05	120.80	102.55	90.82	72.57

Table 10. LCA Results 30 MPa Concrete with air (F-2)

	Unit	Baseline 30 MPa Concrete with air (F-2) GU 20 SCM	30 MPa Concrete with air (F-2) GU	30 Mpa Concrete with air (F-2) GU 15 SCM	30 Mpa Concrete with air (F-2) GU 25 SCM	30 Mpa Concrete with air (F-2) GU 40 SCM	30 Mpa Concrete with air (F-2) GUL	30 Mpa Concrete with air (F-2) GUL 15 SCM	30 Mpa Concrete with air (F-2) GUL 25 SCM	30 Mpa Concrete with air (F-2) GUL 40 SCM
Environmental impacts										
GWP	kg CO_2 eq.	269.83	317.51	282.09	258.25	222.83	294.22	262.28	240.78	208.85
ODP	kg CFC-11 eq.	1.07E-05	1.12E-05	1.08E-05	1.06E-05	1.03E-05	1.06E-05	1.03E-05	1.02E-05	9.90E-06
EP	kg N eq.	0.24	0.26	0.24	0.23	0.22	0.24	0.23	0.22	0.20
AP	kg SO_2 eq.	1.14	1.16	1.14	1.13	1.12	1.09	1.09	1.08	1.08
POCP	kg O_3 eq.	24.95	25.59	25.12	24.80	24.33	24.15	23.89	23.72	23.46
Use of primary resources										
RPR_E	MJ, NCV	147.17	169.43	152.89	141.76	125.23	167.77	151.48	140.52	124.23
RPR_M	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$NRPR_E$	MJ, NCV	1748.38	1881.71	1782.66	1716.00	1616.95	1433.90	1401.77	1380.14	1348.01
$NRPR_M$	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Use of secondary resources										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	115.54	144.64	123.02	108.48	86.86	130.85	111.30	98.14	78.59
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Abiotic depletion potential										
ADPf	MJ, LHV	692.72	740.91	705.11	681.01	645.21	717.76	685.42	663.65	631.31
ADPe	kg Sb	1.42E-04	1.48E-04	1.43E-04	1.40E-04	1.36E-04	1.47E-04	1.42E-04	1.39E-04	1.35E-04
Consumption of freshwater resources										
FW	m^3	2.36	2.52	2.40	2.32	2.20	2.44	2.34	2.26	2.15
Waste and output flows										
HWD	kg	0.02	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.02
NHWD	kg	64.01	80.11	68.15	60.10	48.13	72.34	61.54	54.27	43.47
HLRW	m3	1.80E-09	1.80E-09	1.80E-09	1.80E-09	1.80E-09	1.80E-09	1.80E-09	1.80E-09	1.80E-09
ILLRW	m3	5.65E-08	5.65E-08	5.65E-08	5.65E-08	5.65E-08	5.65E-08	5.65E-08	5.65E-08	5.65E-08
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional inventory parameters for transparency										
CCE	kg CO_2 eq.	133.25	166.80	141.88	125.10	100.18	151.22	128.63	113.42	90.82

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Table 11. LCA Results 30 MPa Concrete without air (N)	Unit	Baseline 30 MPa Concrete without air (N) GU 20 SCM	30 MPa Concrete without air (N) GU	30 Mpa Concrete without air (N) GU 15 SCM	30 Mpa Concrete without air (N) GU 25 SCM	30 Mpa Concrete without air (N) GU 40 SCM	30 Mpa Concrete without air (N) GUL	30 Mpa Concrete without air (N) GUL 15 SCM	30 Mpa Concrete without air (N) GUL 25 SCM	30 Mpa Concrete without air (N) GUL 40 SCM
Environmental impacts										
GWP	kg CO_2 eq.	258.92	303.87	269.82	247.34	213.28	281.65	250.94	230.67	199.96
ODP	kg CFC-11 eq.	1.03E-05	1.07E-05	1.04E-05	1.01E-05	9.81E-06	1.01E-05	9.88E-06	9.72E-06	9.47E-06
EP	kg N eq.	0.23	0.25	0.23	0.22	0.21	0.23	0.22	0.21	0.20
AP	kg SO_2 eq.	1.10	1.12	1.10	1.09	1.08	1.06	1.05	1.05	1.04
POCP	kg O_3 eq.	24.19	24.79	24.33	24.03	23.58	23.42	23.17	23.01	22.76
Use of primary resources										
RPR_E	MJ, NCV	141.95	162.94	147.04	136.55	120.65	161.35	145.69	135.36	119.70
RPR_M	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$NRPR_E$	MJ, NCV	1681.49	1807.20	1711.96	1649.11	1553.87	1379.98	1349.08	1328.69	1297.79
$NRPR_M$	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Use of secondary resources										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	110.56	137.99	117.21	103.49	82.71	124.83	106.03	93.63	74.83
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Abiotic depletion potential										
ADPf	MJ, LHV	672.55	717.99	683.57	660.84	626.42	695.91	664.81	644.28	613.18
ADPe	kg Sb	1.34E-04	1.39E-04	1.35E-04	1.32E-04	1.28E-04	1.38E-04	1.34E-04	1.31E-04	1.27E-04
Consumption of freshwater resources										
FW	m^3	2.35	2.50	2.39	2.31	2.20	2.43	2.33	2.26	2.16
Waste and output flows										
HWD	kg	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
NHWD	kg	61.25	76.43	64.93	57.34	45.83	69.02	58.63	51.77	41.39
HLRW	m3	1.81E-09	1.81E-09	1.81E-09	1.81E-09	1.81E-09	1.81E-09	1.81E-09	1.81E-09	1.81E-09
ILLRW	m3	5.79E-08	5.79E-08	5.79E-08	5.79E-08	5.79E-08	5.79E-08	5.79E-08	5.79E-08	5.79E-08
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional inventory parameters for transparency										
CCE	kg CO_2 eq.	127.50	159.13	135.17	119.35	95.38	144.27	122.54	108.20	86.47

Table 14. LCA Results 35 MPa Concrete with air (F-2)

	Unit	Baseline 35 MPa Concrete with air (F-2) GU 20 SCM	35 Mpa Concrete with air (F-2) GU	35 Mpa Concrete with air (F-2) GU 15 SCM	35 Mpa Concrete with air (F-2) GU 25 SCM	35 Mpa Concrete with air (F-2) GU 40 SCM	35 Mpa Concrete with air (F-2) GUL	35 Mpa Concrete with air (F-2) GUL 15 SCM	35 Mpa Concrete with air (F-2) GUL 25 SCM	35 Mpa Concrete with air (F-2) GUL 40 SCM
Environmental impacts										
GWP	kg CO_2 eq.	310.51	365.00	324.13	297.06	255.34	338.09	301.24	276.84	239.21
ODP	kg CFC-11 eq.	1.23E-05	1.28E-05	1.24E-05	1.22E-05	1.18E-05	1.21E-05	1.19E-05	1.17E-05	1.14E-05
EP	kg N eq.	0.27	0.30	0.28	0.27	0.25	0.28	0.26	0.25	0.23
AP	kg SO_2 eq.	1.28	1.31	1.29	1.28	1.26	1.23	1.22	1.22	1.21
POCP	kg O_3 eq.	27.94	28.67	28.12	27.81	27.21	27.01	26.71	26.56	26.21
Use of primary resources										
RPR_E	MJ, NCV	168.15	193.59	174.51	161.85	142.39	191.67	172.88	160.40	141.24
RPR_M	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$NRPR_E$	MJ, NCV	2004.30	2156.68	2042.39	1968.78	1850.01	1639.38	1602.31	1580.16	1539.89
$NRPR_M$	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Use of secondary resources										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	133.83	167.08	142.14	125.52	100.16	151.15	128.59	113.55	90.62
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Abiotic depletion potential										
ADPf	MJ, LHV	785.25	840.33	799.02	772.05	729.48	813.58	776.27	751.97	713.45
ADPe	kg Sb	1.90E-04	1.96E-04	1.91E-04	1.88E-04	1.83E-04	1.95E-04	1.90E-04	1.87E-04	1.82E-04
Consumption of freshwater resources										
FW	m^3	2.46	2.65	2.51	2.42	2.28	2.56	2.44	2.35	2.23
Waste and output flows										
HWD	kg	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.02	0.02
NHWD	kg	74.13	92.54	78.73	69.53	55.50	83.56	71.10	62.79	50.12
HLRW	m3	1.79E-09	1.79E-09	1.79E-09	1.79E-09	1.79E-09	1.79E-09	1.79E-09	1.79E-09	1.79E-09
ILLRW	m3	5.59E-08	5.59E-08	5.59E-08	5.59E-08	5.59E-08	5.59E-08	5.59E-08	5.59E-08	5.59E-08
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional inventory parameters for transparency										
CCE	kg CO_2 eq.	154.34	192.68	163.93	144.75	115.51	174.69	148.62	131.23	104.73

Table 23. LCA Results 55 MPa Concrete with air (C-XL)

	Unit	Baseline 55 MPa Concrete with air (C-XL) GU 25 SCM	55 MPa Concrete with air (C-XL) GU	55 MPa Concrete with air (C-XL) GU 15 SCM	55 MPa Concrete with air (C-XL) GU 25 SCM	55 MPa Concrete with air (C-XL) GU 40 SCM	55 MPa Concrete with air (C-XL) GUL	55 MPa Concrete with air (C-XL) GUL 15 SCM	55 MPa Concrete with air (C-XL) GUL 25 SCM	55 MPa Concrete with air (C-XL) GUL 40 SCM
Environmental impacts										
GWP	kg CO_2 eq.	402.11	495.93	439.40	402.11	344.72	458.85	407.87	374.27	322.50
ODP	kg CFC-11 eq.	1.66E-05	1.75E-05	1.69E-05	1.66E-05	1.60E-05	1.66E-05	1.61E-05	1.59E-05	1.55E-05
EP	kg N eq.	0.36	0.40	0.37	0.36	0.33	0.37	0.35	0.33	0.31
AP	kg SO_2 eq.	1.67	1.71	1.69	1.67	1.64	1.61	1.60	1.59	1.58
POCP	kg O_3 eq.	35.98	37.18	36.43	35.98	35.17	34.89	34.48	34.26	33.80
Use of primary resources										
RPR_E	MJ, NCV	210.96	254.79	228.39	210.96	184.19	252.14	226.14	208.97	182.60
RPR_M	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$NRPR_E$	MJ, NCV	2611.96	2872.24	2714.14	2611.96	2449.38	2159.35	2108.06	2076.65	2022.16
$NRPR_M$	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Use of secondary resources										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	172.90	230.25	195.76	172.90	137.99	208.31	177.10	156.42	124.83
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Abiotic depletion potential										
ADPf	MJ, LHV	970.93	1065.36	1008.21	970.93	912.51	1028.51	976.88	943.25	890.43
ADPe	kg Sb	2.55E-04	2.67E-04	2.60E-04	2.55E-04	2.48E-04	2.65E-04	2.58E-04	2.54E-04	2.47E-04
Consumption of freshwater resources										
FW	m^3	2.68	3.00	2.80	2.68	2.49	2.88	2.70	2.59	2.41
Waste and output flows										
HWD	kg	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
NHWD	kg	95.77	127.51	108.42	95.77	76.44	115.14	97.90	86.47	69.03
HLRW	m3	1.78E-09	1.78E-09	1.78E-09	1.78E-09	1.78E-09	1.78E-09	1.78E-09	1.78E-09	1.78E-09
ILLRW	m3	5.30E-08	5.30E-08	5.30E-08	5.30E-08	5.30E-08	5.30E-08	5.30E-08	5.30E-08	5.30E-08
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional inventory parameters for transparency										
CCE	kg CO_2 eq.	199.39	265.54	225.76	199.39	159.13	240.74	204.67	180.77	144.27

Abridged version of EPD. Full document online:
crsi.org/wp-content/uploads/CRSI_Industry-Wide_EPD_Sep2022.pdf

ENVIRONMENTAL PRODUCT DECLARATION

According to ISO 14025 and ISO 21930:2017

STEEL REINFORCEMENT BAR

CONCRETE REINFORCING STEEL INSTITUTE

About the Concrete Reinforcing Steel Institute
Founded in 1924, the Concrete Reinforcing Steel Institute (CRSI) is a technical institute and Standards Developing Organization (SDO) that stands as the authoritative resource for information related to steel reinforced concrete construction. CRSI offers many industry-trusted technical publications, standards documents, design aids, reference materials, and educational opportunities.

Membership Facts
Approximately 8 million tons of reinforcing steel (rebar) is manufactured per year using scrap steel in efficient manufacturing operations. It is estimated that the industry impacts over 75,000 people in steel transportation and placement.

CRSI members include manufacturers, fabricators, material suppliers, and placers of steel reinforcing bars and related products as well as professionals who are involved in the research, design, and construction of steel reinforced concrete. CRSI members employ approximately 15,000 people in steel production and rebar fabrication at over 450 locations in 47 states throughout North America.

CRSI Concrete Reinforcing Steel Institute

Issue Date: September 20, 2022

Valid Until: September 19, 2027

Declaration Number: EPD 362

EPD SUMMARY

This document is a Type III environmental product declaration by Concrete Reinforcing Steel Institute (CRSI) that is certified by ASTM International (ASTM) as conforming to the requirements of ISO 14025. ASTM has assessed that the Life Cycle Assessment (LCA) information fulfills the requirements of ISO 14040 and ISO 14044 in accordance with the instructions listed in the referenced product category rules. The intent of this document is to further the development of environmentally compatible and sustainable construction methods by providing comprehensive environmental information related to potential impacts in accordance with international standards.

No comparisons or benchmarking is included in this EPD. Environmental declarations from different programs based upon differing PCRs may not be comparable. Comparison of the environmental performance of construction works and construction products using EPD information shall be based on the product's use and impacts at the construction works level. In general, EPDs may not be used for comparability purposes when not considered in a construction works context. Given this PCR ensures products meet the same functional requirements, comparability is permissible provided the information given for such comparison is transparent and the limitations of comparability explained. When comparing EPDs created using this PCR, variations and deviations are possible. Example of variations: Different LCA software and background LCI datasets may lead to different results for upstream or downstream of the life cycle stages declared.

Table 1. A1-A3 GWP results for 1 metric ton of fabricated steel reinforcement (rebar)

Indicator	Unit	A1	A2	A3	A1-A3
Global Warming Potential	kg CO_2 eq.	7.78E+02	4.90E+01	2.70E+01	8.54E+02

Table 2. A1-A3 LCIA results for 1 metric ton of fabricated steel reinforcement bar (rebar)

Indicator	Unit	A1	A2	A3	A1-A3
Ozone Depletion Potential	kg CFC 11 eq.	8.30E-10	8.38E-15	2.57E-10	1.09E-09
Acidification Potential	kg SO2 eq.	1.58E+00	5.27E-01	6.10E-02	2.17E+00
Eutrophication Potential	kg N eq.	7.87E-02	3.21E-02	6.11E-03	1.17E-01
Smog Formation Potential	kg O3 eq.	3.47E+01	1.30E+01	1.48E+00	4.91E+01
Abiotic Depletion Potential (Fossil)	MJ, surplus	7.61E+02	9.18E+01	1.63E+02	1.02E+03

SCOPE AND BOUNDARIES OF THE LIFE CYCLE ASSESSMENT

The Life Cycle Assessment (LCA) was performed according to ISO 14040 (ISO, 2020a) and ISO 14044 (ISO, 2020b) following the requirements of the ASTM EPD Program Instructions and the referenced PCR.

System Boundary: Cradle-to-gate

Allocation Method: Mass allocation (multi-output allocation approach)

Declared Unit: 1 metric ton (1,000 kg) of fabricated steel reinforcement (rebar)

Abridged version of EPD. Full document online:
https://www.mutualmaterials.com/wp-content/uploads/2021/07/EPD_MUTUAL_MATERIALS_KENT_HS1-STD_20210712.pdf

MUTUAL MATERIALS

ENVIRONMENTAL PRODUCT DECLARATION

CMU: HS1 STD • Kent Plant

MUTUALMATERIALS.
WWW.MUTUALMATERIALS.COM

This Environmental Product Declaration (EPD) reports the impacts for 1 m^3 of concrete formed into manufactured concrete and masonry products meeting the following specifications:

- ASTM C90, Concrete Masonry Unit, Load-Bearing

PRODUCT DESCRIPTION

HS1 STD:
A CMU with medium weight aggregate and integral water repellent and color. Configurations for architectural masonry with structural and veneer applications. Typically used in constructing public and private buildings as well as residential applications. Minimum compressive strength: 3000 PSI. Dimensional properties as defined in ASTM C90.

ENVIRONMENTAL IMPACTS

Declared Product:
CMU: HS1 STD • Kent Plant
Density Factor: 7 kg / m^3
Compressive strength: 21 MPa

Declared Unit: 1 m^3 of concrete formed into manufactured concrete masonry product (CMU)

Global Warming Potential (kg CO_2-eq)	**284**
Acidification Potential (kg SO_2-eq)	**1.28**
Eutrophication Potential (kg N-eq)	**0.28**
Smog Creation Potential (kg O_3-eq)	**26.3**
Ozone Depletion Potential (kg CFC-11-eq)	**1.28E-5**

Material Composition: Aggregate (natural), Pumice, Portland cement, Batch water, Admixture (plasticizing)

Additional detail and impacts are reported on page five of this EPD

PROGRAM OPERATOR

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428

DATE OF ISSUE

07/03/2021 **(valid for 5 years until 07/03/2026)**

DECLARATION OF ENVIRONMENTAL INDICATORS DERIVED FROM LCA

Impact Assessment	Unit	A1	A2	A3	Total
Global warming potential (GWP)	kg CO_2-eq	2.2E+02	3.43E+01	3.02E+01	2.84E+02
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11-eq	1.12E-05	1.43E-09	1.62E-06	1.28E-05
Eutrophication potential (EP)	kg N-eq	1.12E-01	2.52E-02	1.44E-01	2.81E-01
Acidification potential of soil and water sources (AP)	kg SO_2-eq	7.32E-01	4.24E-01	1.2E-01	1.28E+00
Formation potential of tropospheric ozone (POCP)	kg O_3-eq	1.43E+01	1.08E+01	1.21E+00	2.63E+01

Resource Use					
Abiotic depletion potential for non-fossil mineral resources (ADPelements)*	kg Sb-eq	9.47E-07	-	3.15E-06	4.1E-06
Abiotic depletion potential for fossil resources (ADPfossil)	MJ	7.43E+01	4.85E+02	4.2E+02	9.79E+02
Renewable primary energy resources as energy (fuel), (RPRE)*	MJ	1.21E+02	0E+00	2.93E+02	4.14E+02
Renewable primary resources as material, (RPRM)*	MJ	0E+00	-	0E+00	0E+00
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ	1.23E+03	4.85E+02	4.68E+02	2.18E+03
Non-renewable primary resources as material (NRPRM)*	MJ	1.28E+00	-	0E+00	1.28E+00
Consumption of fresh water	m^3	3.03E+00	-	2.23E-01	3.25E+00

Secondary Material, Fuel and Recovered Energy					
Secondary Materials, (SM)*	kg	-	-	0E+00	0E+00
Renewable secondary fuels, (RSF)*	MJ	-	-	0E+00	0E+00
Non-renewable secondary fuels (NRSF)*	MJ	-	-	0E+00	0E+00
Recovered energy, (RE)*	MJ	-	-	0E+00	0E+00

Waste & Output Flows					
Hazardous waste disposed*	kg	2.93E-02	-	0E+00	2.93E-02
Non-hazardous waste disposed*	kg	5.17E-02	-	1.17E+00	1.22E+00
High-level radioactive waste*	m^3	2.39E-04	-	2.46E-08	2.39E-04
Intermediate and low-level radioactive waste*	m^3	3.67E-08	-	2.35E-07	2.71E-07
Components for reuse*	kg	-	-	0E+00	0E+00
Materials for recycling*	kg	-	-	4.54E-01	4.54E-01
Materials for energy recovery*	kg	-	-	0E+00	0E+00
Recovered energy exported from the product system*	MJ	-	-	0E+00	0E+00

Additional Inventory Parameters for Transparency					
Emissions from calcination and uptake from carbonation*	kg CO_2-eq	0E+00	0E+00	0E+00	0E+00

* Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories.

- Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete. Use caution when interpreting data in these categories

No substances required to be reported as hazardous are associated with the production of this product.

REFERENCES

- ISO 14025: 2006 – Environmental labels and declarations – Type III environmental declarations – Principles and procedures
- ISO 14040: 2006 – Environmental management – Life cycle assessment – Principles and framework
- ISO 14044: 2006/Amd 2:2020 – Environmental management – Life cycle assessment – Requirements and guidelines
- ISO 21930:2017 Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services
- Part A: Life Cycle Assessment Calculation Rules and Report Requirements UL Environment (December 2018, version 3.2)
- Part B: Concrete Masonry and Segmental Concrete Paving Product EPD Requirements UL Environment (November 2020, v1.0)

MUTUAL MATERIALS
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Bellevue, WA 98005
(888) 688-8250

KENT
7414 S 206TH ST
KENT, WA 98032

ENVIRONMENTAL PRODUCT DECLARATION

as per /ISO 14025/ and /EN 15804/

Owner of the Declaration	Eternit GmbH
Programme holder	Institut Bauen und Umwelt e.V. (IBU)
Publisher	Institut Bauen und Umwelt e.V. (IBU)
Declaration number	EPD-ELH-20180136-CAC1-EN
ECO EPD Ref. No.	
Issue date	25.01.2019
Valid to	24.01.2024

NATURA, TEXTURA and MATERIA Fiber-Cement Panels

ETEX

www.ibu-epd.com / https://epd-online.com

5. LCA: Results

The environmental impacts of 1m² NATURA, TEXTURA and MATERIA manufactured by Eternit N.V. are outlined below. The modules to DIN EN 15804 marked “x” in the overview are addressed here.
The following tables depict the results of estimated impact, the use of resources as well as the waste and output flows relating the declared unit.

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED)

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
X	X	X	X	X	X	X	MNR	MNR	MNR	X	X	X	X	X	X	X

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT: declared unit and product

Parameter	Unit	A1	A2	A3	A4	A5	B1	B2	B6	B7	C1	C2	C3	C4	D
GWP	[kg CO_2-Eq.]	8.06E+0	5.04E-1	2.76E+0	1.43E+0	2.85E-1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	2.40E-2	1.63E-1	0.00E+0	1.82E-1	-1.86E-1
ODP	[kg CFC11-Eq.]	3.15E-7	8.32E-8	2.61E-7	2.52E-7	2.05E-8	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.06E-9	2.87E-8	0.00E+0	2.81E-8	-1.64E-8
AP	[kg SO_2-Eq.]	2.42E-2	5.35E-3	4.89E-3	5.39E-3	1.30E-3	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.12E-4	6.14E-4	0.00E+0	9.96E-4	-4.63E-5
EP	[kg $(PO_4)^{3-}$-Eq.]	2.72E-3	5.68E-4	1.01E-3	9.34E-4	1.25E-4	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.99E-5	1.06E-4	0.00E+0	2.35E-4	2.44E-4
POCP	[kg ethene-Eq.]	1.31E-3	1.86E-4	3.43E-4	2.36E-4	8.49E-5	0.00E+0	0.00E+0	0.00E+0	0.00E+0	3.87E-6	2.69E-5	0.00E+0	5.64E-5	-3.04E-5
ADPE	[kg Sb-Eq.]	1.12E-5	1.07E-6	5.24E-6	5.09E-6	3.64E-6	0.00E+0	0.00E+0	0.00E+0	0.00E+0	4.00E-9	5.80E-7	0.00E+0	3.17E-7	-3.77E-8
ADPF	[MJ]	6.60E+1	7.07E+0	3.95E+1	2.09E+1	3.03E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	2.58E-1	2.38E+0	0.00E+0	2.50E+0	4.96E+0

Caption	GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources

RESULTS OF THE LCA - RESOURCE USE: declared unit and product

Parameter	Unit	A1	A2	A3	A4	A5	B1	B2	B6	B7	C1	C2	C3	C4	D
PERE	[MJ]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
PERM	[MJ]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
PERT	[MJ]	8.12E+0	1.43E-1	1.80E+1	2.94E-1	6.27E-1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.07E-2	3.35E-2	0.00E+0	5.42E-2	-5.83E-1
PENRE	[MJ]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
PENRM	[MJ]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
PENRT	[MJ]	8.22E+1	7.78E+0	4.91E+1	2.27E+1	3.71E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	2.92E-1	2.58E+0	0.00E+0	2.74E+0	-3.58E+0
SM	[kg]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.15E+0
RSF	[MJ]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
NRSF	[MJ]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
FW	[m³]	7.56E-3	1.67E-4	3.98E-3	5.17E-4	1.92E-4	0.00E+0	0.00E+0	0.00E+0	0.00E+0	5.26E-5	5.89E-5	0.00E+0	5.20E-5	-6.71E-4

Caption	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water

RESULTS OF THE LCA – OUTPUT FLOWS AND WASTE CATEGORIES: declared unit and product

Parameter	Unit	A1	A2	A3	A4	A5	B1	B2	B6	B7	C1	C2	C3	C4	D
HWD	[kg]	4.81E-5	4.80E-6	7.68E-5	1.41E-5	3.36E-6	0.00E+0	0.00E+0	0.00E+0	0.00E+0	9.18E-8	1.60E-6	0.00E+0	2.77E-6	1.84E-6
NHWD	[kg]	6.93E-1	1.74E-1	1.73E+0	8.33E-1	2.45E-1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	5.44E-4	9.49E-2	0.00E+0	2.83E+0	1.07E-2
RWD	[kg]	1.83E-4	4.77E-5	8.98E-5	1.42E-4	1.26E-5	0.00E+0	0.00E+0	0.00E+0	0.00E+0	4.39E-7	1.61E-5	0.00E+0	1.54E-5	2.28E-5
CRU	[kg]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	6.88E-1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
MFR	[kg]	0.00E+0	0.00E+0	1.05E+0	0.00E+0	3.88E-2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
MER	[kg]	0.00E+0	0.00E+0	4.40E-3	0.00E+0	2.36E-2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
EEE	[MJ]	0.00E+0	0.00E+0	1.91E-1	0.00E+0	8.71E-1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
EET	[MJ]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0

Caption	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EEE = Exported thermal energy

6. LCA: Interpretation

In the manufacturing (A1-A3) if 1m² NATURA, TEXTURA and MATERIA, the use of non-renewable primary energy sources accounts for 138 MJ/m². The use of renewable primary energy sources accounts for 26,1 MJ/m².
The use of **non-renewable primary energy sources** during NATURA, TEXTURA and MATERIA

Abridged version of EPD. Full document online:
https://info.nsf.org/Certified/Sustain/ProdCert/EPD10270.pdf

Certified Environmental Product Declaration
www.nsf.org

An Environmental Product Declaration

According to ISO 14025:2006 and ISO 21930:2017

An industry average cradle-to-gate EPD for 5/8" Type X Conventional Gypsum Board produced by Gypsum Association member companies for the USA and Canadian Markets.

NSF Certification, LLC	Date of issue: 28/04/2020
Ann Arbor, MI	Period of validity: 5 years
www.nsf.org	Declaration No.: EPD 10270

Table 3 Product Stage (A1-A3) - EPD Results – 92.9 m² (1MSF) of 15.9 mm (5/8)" Type X conventional gypsum board

Impact categories and inventory indicators	Unit	A1, Extraction and upstream production	A2, Transport to factory	A3, Manufacturing	Total
Global warming potential, GWP 100[1)]	kg CO_2 eq	55.5	9.9	211.6	**277**
Ozone depletion potential, ODP[1)]	kg CFC-11 eq	6.0E-06	8.0E-10	2.8E-05	**3.4E-05**
Smog formation potential, SFP[1)]	kg O_3 eq	2.91	3.71	5.15	**11.8**
Acidification potential, AP[1)]	kg SO_2 eq	0.189	0.14	0.35	**0.67**
Eutrophication potential, EP[1)]	kg N eq	0.250	0.0079	0.34	**0.60**
Abiotic depletion potential, ADP surplus, TRACI[1)]	MJ surplus	97.6	19.9	457.4	**575**
ADP LHV, CML[2)]	MJ LHV	697.1	134.4	3,014	**3,845**
Renewable primary energy carrier used as energy, RPR_E	MJ LHV	129.2	0	55	**184**
Renewable primary energy carrier used as material, RPR_M[3)]	MJ LHV	0	0	0	**0**
Non-renewable primary energy carrier used as energy, $NRPR_E$	MJ LHV	770.8	135.8	3194	**4,100**
Non-Renewable primary energy carrier used as material, $NRPR_M$[3)]	MJ LHV	0	0	0	**0**
Secondary material, SM[3)]	kg	608	0	0	**608**
Renewable secondary fuel, RSF[3)]	MJ LHV	0	0	0	**0**
Non-renewable secondary fuel, NRSF[3)]	MJ LHV	0	0	0	**0**
Recovered energy, RE[3)]	MJ LHV	0	0	0	**0**
Consumption of fresh water[3)]	m^3	0.443	0	0.78	**1.22**
Hazardous waste disposed, HWD[3)]	kg	0	0	0	**0**
Non-hazardous waste disposed, NHWD[3)]	kg	4.7349	0	5.9	**10.6**
High-level radioactive waste, conditioned, to final repository, HLRW[3)]	m^3	4.1E-08	1.3E-11	1.1E-07	**1.5E-07**
Intermediate- and low-level radioactive waste, conditioned, to final repository, ILLRW[3)]	m^3	4.3E-07	1.0E-10	9.1E-07	**1.3E-06**
Components for re-use, CRU[3)]	kg	0	0	0	**0**
Materials for recycling, MR[3)]	kg	0	0	28.3	**28.3**

Abridged version of EPD. Full document online:
www.jm.com/content/dam/jm/global/en/building-insulation/Files/BI%20Toolbox/Mineral-Wool-Environmental-Product-Declaration.pdf

ENVIRONMENTAL PRODUCT DECLARATION

MINERAL WOOL BOARD

NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION

Mineral wool insulation products: saving energy, reducing pollution, and contributing to a sustainable environment.

NAIMA
NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION

The North American Insulation Manufacturers Association (NAIMA) is the association for North American manufacturers of fiber glass, rock wool, and slag wool insulation products. The Association seeks to promote energy efficiency and environmental preservation through the use of fiber glass, rock wool, and slag wool insulation, and to encourage the safe production and use of these materials. NAIMA advocates for improved energy efficiency in homes and buildings as the quickest and most cost-effective way to reduce energy use and lower greenhouse gas emissions.

Insulation saves 12 times as much energy per pound in its first year of use as the energy used to produce it. In fact, insulation in place in U.S. buildings reduces the amount of carbon dioxide emissions by 780 million tons per year.

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4.2. Life Cycle Inventory Results: Light Density Board

Table 10. Resource Use: Light Density Board

PARAMETER	A1-A3	A4	A5	C2	C4
Renewable primary resources used as energy carrier (fuel) RPR_E [MJ, LHV]	1.56E+00	1.38E-01	1.57E-01	1.50E-03	8.64E-02
Renewable primary resources with energy content used as material, RPR_M [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-renewable primary resources used as energy carrier (fuel), $NRPR_E$ [MJ, LHV]	3.95E+01	5.60E+00	2.17E+00	6.06E-02	1.22E+00
Non-renewable primary resources with energy content used as material, $NRPR_M$ [MJ, LHV]	3.99E-01	0.00E+00	1.23E-02	0.00E+00	0.00E+00
Secondary materials, SM [kg]	1.66E+00	0.00E+00	5.13E-02	0.00E+00	0.00E+00
Renewable secondary fuels, RSF [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-renewable secondary fuels, NRSF [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered energy, RE [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fresh water, FW [m^3]	9.39E-03	6.74E-04	4.37E-04	7.29E-06	1.48E-04

Table 11. Output Flows and Waste Categories: Light Density Board

PARAMETER	A1-A3	A4	A5	C2	C4
Hazardous waste disposed, HWD [kg]	8.75E-08	4.35E-08	4.76E-09	4.71E-10	4.22E-09
Non-hazardous waste disposed, NHWD [kg]	7.74E-01	2.10E-04	9.45E-02	2.27E-06	1.74E+00
High-level radioactive waste, HLRW [kg]	1.50E-06	1.48E-08	7.54E-08	1.61E-10	1.59E-08
Intermediate- & low-level radioactive waste, ILLRW [kg]	4.07E-05	4.01E-07	1.93E-06	4.34E-09	3.78E-07
Components for reuse, CRU [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling, MR [kg]	0.00E+00	0.00E+00	3.19E-03	0.00E+00	0.00E+00
Materials for energy recovery, MER [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, electrical EEE [MJ, LHV]	0.00E+00	0.00E+00	1.72E-02	0.00E+00	0.00E+00
Exported energy, thermal EET [MJ, LHV]	0.00E+00	0.00E+00	6.89E-03	0.00E+00	0.00E+00

4.3. Life Cycle Impact Assessment Results: Heavy Density Board

Table 12. North American Impact Assessment Results: Heavy Density Board

TRACI v2.1	A1-A3	A4	A5	C2	C4
Global warming potential, GWP 100 [kg CO_2 eq]	8.16E+00	3.33E-01	3.51E-01	1.03E-02	1.89E-01
Ozone depletion potential, ODP [kg CFC-11 eq]	7.48E-11	1.15E-14	2.34E-12	3.56E-16	3.42E-14
Acidification potential, AP [kg SO_2 eq]	1.89E-02	1.66E-03	8.48E-04	4.83E-05	8.58E-04
Eutrophication potential, EP [kg N eq]	7.64E-04	1.33E-04	4.56E-05	3.93E-06	4.35E-05
Photochemical ozone creation potential, POCP [kg O_3 eq]	2.00E-01	5.51E-02	1.11E-02	1.60E-03	1.70E-02
Abiotic depletion potential (fossil), ADP_{fossil} [MJ, surplus]	7.65E+00	6.34E-01	2.96E-01	1.96E-02	3.72E-01

4.4. Life Cycle Inventory Results: Heavy Density Board

Table 13. Resource Use: Heavy Density Board

PARAMETER	A1-A3	A4	A5	C2	C4
Renewable primary resources used as energy carrier (fuel) RPR_E [MJ, LHV]	3.77E+00	1.18E-01	2.29E-01	3.64E-03	2.10E-01
Renewable primary resources with energy content used as material, RPR_M [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-renewable primary resources used as energy carrier (fuel), $NRPR_E$ [MJ, LHV]	9.90E+01	4.75E+00	4.04E+00	1.47E-01	2.97E+00
Non-renewable primary resources with energy content used as material, $NRPR_M$ [MJ, LHV]	1.24E+00	0.00E+00	3.85E-02	0.00E+00	0.00E+00
Secondary materials, SM [kg]	4.33E+00	0.00E+00	1.34E-01	0.00E+00	0.00E+00
Renewable secondary fuels, RSF [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-renewable secondary fuels, NRSF [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered energy, RE [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fresh water, FW [m^3]	2.28E-02	5.72E-04	8.57E-04	1.77E-05	3.60E-04

Table 14. Output Flows and Waste Categories: Heavy Density Board

PARAMETER	A1-A3	A4	A5	C2	C4
Hazardous waste disposed, HWD [kg]	2.12E-07	3.70E-08	8.61E-09	1.14E-09	1.02E-08
Non-hazardous waste disposed, NHWD [kg]	2.38E+00	1.79E-04	2.23E-01	5.53E-06	4.23E+00
High-level radioactive waste, HLRW [kg]	3.93E-06	1.26E-08	1.51E-07	3.90E-10	3.86E-08
Intermediate- & low-level radioactive waste, ILLRW [kg]	1.07E-04	3.40E-07	3.98E-06	1.05E-08	9.18E-07
Components for reuse, CRU [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling, MR [kg]	0.00E+00	0.00E+00	4.37E-03	0.00E+00	0.00E+00
Materials for energy recovery, MER [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, electrical EEE [MJ, LHV]	0.00E+00	0.00E+00	2.16E-02	0.00E+00	0.00E+00
Exported energy, thermal EET [MJ, LHV]	0.00E+00	0.00E+00	8.66E-03	0.00E+00	0.00E+00

4.5. Scaling to Other R-values

Environmental performance results are presented per functional unit, defined as 1 m^2 of R_{SI} = 1 m^2K/W insulation. In the US, insulation is typically purchased based on board thickness and R-value stated in units of $ft^2\cdot°F\cdot hr/Btu$. Environmental impacts per square meter of these alternative R-values can be calculated by multiplying the above results by scaling factors presented in Table 15 for select board thicknesses and a range of board densities.

Abridged version of EPD. Full document online:
www.rockwool.com/siteassets/o2-rockwool/documentation/epd/rockwool-stone-wool-environmental-product-declaration-epd.pdf

ENVIRONMENTAL PRODUCT DECLARATION

ROCKWOOL™ STONE WOOL Insulation

ROCKWOOL NORTH AMERICA

ROCKWOOL™ Stone Wool/Mineral Wool Insulation is optimized for performance, delivering on Thermal Comfort, Acoustics, Fire protection and more.

ROCKWOOL North America is Part of the ROCKWOOL Group, the world's leading stone wool/mineral wool manufacturer. Operating globally for over 80 years, over 30 years in North America the company manufactures stone wool insulation products that serve a wide range of applications in the Commercial, Residential, and Industrial/Technical segments.

Across the full range of our products and operations, ROCKWOOL is dedicated to enriching modern living. We strive to increase our positive impact on people and society by maximizing our positive product impact and minimizing our operational footprint. We recognize that operating with integrity and as a responsible business is equally important and underpins everything we do.

The United Nations Sustainable Development Goals (SDGs) steer our ambitions. We committed to 10 out of the 17 SDGs – pursuing the goals where we can have the greatest impact and that are the most aligned with our business competencies.

Our Environmental Product Declaration is another element of our commitment to serving our customers and the industry's requirements for sustainable solutions.

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LCA: Results

The table below shows the results of the LCA.

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED)

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
X	X	X	X	X	X	X	MNR	MNR	MNR	MND	MND	X	X	X	X	X

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT: 1 m² of thermal insulation product with an R=1m²K/W

CML 2001 – April 2013

Parameter	Unit	A1-A3	A4	A5	B1	B2	C1	C2	C3	C4	D	D/1	D/2
GWP	[kg CO_2-Eq.]	1,31E+00	4,25E-01	2,65E-01	0,00E+00	0,00E+00	0,00E+00	5,29E-03	0,00E+00	2,20E-02	-9,93E-02		
ODP	[kg R11-Eq.]	2,11E-09	7,06E-17	3,50E-10	0,00E+00	0,00E+00	0,00E+00	8,76E-19	0,00E+00	1,28E-16	2,27E-15		
AP	[kg SO_2-Eq.]	1,03E-02	3,60E-04	2,62E-04	0,00E+00	0,00E+00	0,00E+00	4,84E-06	0,00E+00	1,32E-04	-2,44E-04		
EP	[kg $(PO_4)^{3-}$-Eq.]	1,14E-03	7,96E-05	4,96E-05	0,00E+00	0,00E+00	0,00E+00	1,09E-06	0,00E+00	1,50E-05	-1,99E-05		
POCP	[kg ethene-Eq.]	1,84E-03	1,38E-06	4,56E-05	1,54E-10	0,00E+00	0,00E+00	-1,40E-07	0,00E+00	1,01E-05	-3,35E-05		
ADPE	[kg Sb-Eq.]	4,63E-07	3,29E-08	7,19E-09	0,00E+00	0,00E+00	0,00E+00	4,09E-10	0,00E+00	8,10E-09	-1,61E-08		
ADPF	[MJ]	1,57E+01	5,79E+00	5,97E-01	0,00E+00	0,00E+00	0,00E+00	7,19E-02	0,00E+00	3,08E-01	-2,70E+00		

TRACI2.1

Parameter	Unit	A1-A3	A4	A5	B1	B2	C1	C2	C3	C4	D	D/1	D/2
GWP	[kg CO_2-Eq.]	1,31E+00	4,25E-01	3,00E-01	0,00E+00	0,00E+00	0,00E+00	5,29E-03	0,00E+00	2,20E-02	-9,94E-02		
ODP	[kg CFC11-Eq.]	2,38E-09	-1,32E-15	4,31E-10	0,00E+00	0,00E+00	0,00E+00	-1,65E-17	0,00E+00	-9,03E-16	1,50E-14		
AP	[kg SO_2-Eq.]	1,01E-02	4,05E-04	4,94E-04	0,00E+00	0,00E+00	0,00E+00	5,55E-06	0,00E+00	1,41E-04	-2,46E-04		
EP	[kg N-Eq.]	6,20E-04	7,08E-05	3,89E-05	0,00E+00	0,00E+00	0,00E+00	9,13E-07	0,00E+00	6,48E-06	-7,92E-06		
SP	[kg O_3-Eq.]	6,63E-02	6,63E-03	3,94E-03	2,80E-09	0,00E+00	0,00E+00	9,44E-05	0,00E+00	2,67E-03	-2,91E-03		

Caption	GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources; SP=Smog Creation Potential

RESULTS OF THE LCA - RESOURCE USE: 1 m² of thermal insulation product with an R=1m²K/W

Parameter	Unit	A1-A3	A4	A5	B1	B2	C1	C2	C3	C4	D	D/1	D/2
PERE	[MJ]	3,88E+00	3,24E-01	1,91E+00	0,00E+00	0,00E+00	0,00E+00	4,06E-03	0,00E+00	3,97E-02	-3,27E-01		
PERM	[MJ]	2,29E+00	0,00E+00	-1,74E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00		
PERT	[MJ]	6,17E+00	3,24E-01	1,66E-01	0,00E+00	0,00E+00	0,00E+00	4,06E-03	0,00E+00	3,97E-02	-3,27E-01		
PENRE	[MJ]	1,50E+01	5,83E+00	7,56E-01	0,00E+00	0,00E+00	0,00E+00	7,23E-02	0,00E+00	3,19E-01	-3,08E+00		
PENRM	[MJ]	2,91E+00	0,00E+00	-6,76E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00		
PENRT	[MJ]	1,79E+01	5,83E+00	6,89E-01	0,00E+00	0,00E+00	0,00E+00	7,23E-02	0,00E+00	3,19E-01	-3,08E+00		
SM	[kg]	6,41E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,41E-02		
RSF	[MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00		
NRSF	[MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00		
FW	[m³]	1,44E-02	5,70E-04	8,21E-04	0,00E+00	0,00E+00	0,00E+00	7,07E-06	0,00E+00	8,04E-05	-1,37E-03		

Caption	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water

RESULTS OF THE LCA – OUTPUT FLOWS AND WASTE CATEGORIES: 1 m² of thermal insulation product with an R=1m²K/W

Parameter	Unit	A1-A3	A4	A5	B1	B2	C1	C2	C3	C4	D	D/1	D/2
HWD	[kg]	4,18E-07	3,24E-07	1,50E-08	0,00E+00	0,00E+00	0,00E+00	4,03E-09	0,00E+00	5,44E-09	-9,09E-10		
NHWD	[kg]	1,32E-01	4,72E-04	1,54E-02	0,00E+00	0,00E+00	0,00E+00	5,86E-06	0,00E+00	1,48E+00	6,42E-03		
RWD	[kg]	7,49E-04	7,88E-06	3,23E-05	0,00E+00	0,00E+00	0,00E+00	9,79E-08	0,00E+00	4,28E-06	-1,05E-04		
CRU	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00		
MFR	[kg]	0,00E+00	0,00E+00	3,71E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00		
MER	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00		
EEE	[MJ]	0,00E+00	0,00E+00	2,28E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00		
EET	[MJ]	0,00E+00	0,00E+00	6,84E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00		

Caption	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EEE = Exported thermal energy

Abridged version of EPD. Full document online:
https://buildingtransparency.org/ec3/epds/ec3b80r0

Environmental Product Declaration

Styrofoam™ Brand ST-100 Products

DuPont™ Styrofoam™ Brand ST-100 XPS Insulation products offer high, long-term thermal resistance, moisture resistance, and a wide variety of sizes and edge treatments for both residential and commercial applications.

DUPONT

The biggest sustainability problems can't be solved without big contributions from the building and construction industry. Solving these problems calls for sweeping transformation in today's building practices. As DuPont Performance Building Solutions, we're up to the challenge, and have charted a course to help make sustainability a reality in the building industry over the next decade. Inspired by the United Nations' Sustainable Development Goals (UN SDGs), and in support of the DuPont 2030 Sustainability Goals, we are committed to deliver solutions that help solve climate change, drive the circular economy, deliver safer solutions and help communities thrive.

Our Product Stewardship commitment drives us toward a vision that every product we bring to the market is safe for use across its life cycle, compliant, risk-managed, trusted, and contributing to a sustainable society. As part of this vision, we recognize the stakeholder need regarding product transparency beyond the Safety Data Sheet and are committed to providing transparency documents for products in our portfolio.

For additional details on our sustainability journey, please see: https://www.dupont.com/building/sustainability.html

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4. Life Cycle Assessment Results

Table 10: Description of the system boundary modules

	PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
	Raw material supply	Transport	Manufacturing	Transport from gate to site	Assembly/Install	Use	Maintenance	Repair	Replacement	Refurbishment	Building Operational Energy Use During Product Use	Building Operational Water Use During Product Use	Deconstruction	Transport	Waste processing	Disposal	Reuse, Recovery, Recycling Potential
EPD Type Cradle to Grave	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	MND

4.1. Life Cycle Impact Assessment Results

All results are given per functional unit, which is 1 m^2 of insulation material with a thickness that gives an average thermal resistance RSI = 1 m^2K/W over 75 years.

Table 11: North American Impact Assessment Results

TRACI v2.1	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
GWP 100 [kg CO_2 eq]	3.51E+00	6.95E-02	5.50E-02	1.16E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.58E-03	0.00E+00	1.44E+00
ODP [kg CFC-11 eq]	4.05E-09	8.88E-18	4.05E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.69E-19	0.00E+00	1.08E-16
AP [kg SO_2 eq]	5.27E-03	1.15E-04	6.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.26E-05	0.00E+00	1.47E-04
EP [kg N eq]	4.85E-04	1.81E-05	7.06E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.98E-06	0.00E+00	8.26E-06
POCP [kg O_3 eq]	1.07E-01	2.53E-03	1.17E-03	1.61E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.76E-04	0.00E+00	2.78E-03
Resources [MJ]	8.26E+00	1.31E-01	8.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.43E-02	0.00E+00	6.56E-02

Table 12: EU Impact Assessment Results

CML v4.2	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
GWP 100 [kg CO_2 eq]	3.51E+00	6.94E-02	5.50E-02	1.16E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.58E-03	0.00E+00	1.44E+00
ODP [kg CFC-11 eq]	7.00E-09	8.88E-18	7.00E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.69E-19	0.00E+00	1.08E-16
AP [kg SO_2 eq]	4.49E-03	8.81E-05	4.91E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.61E-06	0.00E+00	1.34E-04
EP [kg PO_4^{-3} eq]	6.99E-04	2.40E-05	9.46E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E-06	0.00E+00	1.67E-05
POCP [kg ethene eq]	5.17E-04	-2.15E-05	6.78E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-2.35E-06	0.00E+00	1.18E-06
$ADP_{element}$ [kg Sb-eq]	3.04E-05	1.18E-08	3.05E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.29E-09	0.00E+00	6.75E-09
ADP_{fossil} [MJ, LHV]	6.12E+01	9.79E-01	6.36E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E-01	0.00E+00	5.06E-01

Abridged version of EPD. Full document online:
https://www.soprema.ca/en/transparency-sopra-xps-epd

ENVIRONMENTAL
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DECLARATION

SOPREMA

EXTRUDED POLYSTYRENE THERMAL INSULATION BOARD

SOPRA-XPS™

Specialised in the manufacturing of sealing, insulation, vegetative and soundproofing products and solutions for the roofing, building envelope and civil engineering fields worldwide, SOPREMA presents the environmental product declaration (EPD) of its extruded polystyrene thermal insulation board SOPRA-XPS™.

This EPD presents the results of the life cycle assessment (LCA) of the insulation board, encompassing the raw materials supply, manufacturing, transport, installation, use, and end-of-life stages (i.e., cradle to grave).

The EPD and LCA were prepared by CT Consultant according to EN 15804, ISO 14025 and ISO 21930, and verified by Marie Bellemare (Marie Bellemare Consulting).

For further information about the products manufactured by SOPREMA, visit https://www.soprema.ca/

Period of validity: December 2021 – December 2026

7 | LIFE CYCLE IMPACT ASSESSMENT RESULTS

The results of the life cycle impact assessment are reported for 1 m² of insulation board giving an average thermal resistance of RSI = 1 m²K/W. The results were calculated for six impact categories using the TRACI 2.1 impact assessment method [3], and are reported for each declared life cycle module [8,15].

Table 15. Life cycle impact assessment results calculated with TRACI 2.1

INDICATOR		UNIT	TOTAL	PRODUCTION STAGE (A1-A3)			CONSTRUCTION STAGE (A4-A5)		USE STAGE (B1 - B7)		END-OF-LIFE STAGE (C1 - C4)			
				A1	A2	A3	A4	A5	B1	B2-B7	C1	C2	C3	C4
Global warming potential	Fossil carbon	kg CO_2 eq	2.06E+0	1.35E+0	2.33E-1	2.12E-1	9.07E-2	8.88E-3	3.13E-2	0.00E+0	0.00E+0	1.16E-2	0.00E+0	1.23E-1
	Biogenic carbon[1]	kg CO_2 eq	-2.32E-5	-4.9318E-2	0.00E+0	4.9295E-2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
	Total[2]	kg CO_2 eq	2.06E+0	1.30E+0	2.33E-1	2.62E-1	9.07E-2	8.88E-3	3.13E-2	0.00E+0	0.00E+0	1.16E-2	0.00E+0	1.23E-1
Acidification potential		kg SO_2 eq	8.60E-3	5.43E-3	1.93E-3	5.90E-4	4.70E-4	3.97E-5	0.00E+0	0.00E+0	0.00E+0	5.12E-5	0.00E+0	8.47E-5
Eutrophication potential		kg N eq	3.00E-3	2.02E-3	2.90E-4	3.10E-4	2.60E-4	3.39E-5	0.00E+0	0.00E+0	0.00E+0	1.44E-5	0.00E+0	7.27E-5
Smog formation potential		kg O_3 eq	1.29E-1	6.04E-2	4.13E-2	8.24E-3	1.10E-2	5.30E-4	3.06E-3	0.00E+0	0.00E+0	1.18E-3	0.00E+0	3.01E-3
Ozone depletion potential		kg CFC-11 eq	1.96E-7	9.16E-8	5.54E-8	2.39E-8	1.71E-8	1.41E-9	0.00E+0	0.00E+0	0.00E+0	2.62E-9	0.00E+0	3.64E-9
Abiotic depletion potential (fossil resources)		MJ (LHV)	5.58E+0	4.41E+0	4.97E-1	4.17E-1	1.71E-1	2.17E-2	0.00E+0	0.00E+0	0.00E+0	2.38E-2	0.00E+0	3.59E-2

[1] Since TRACI 2.1 considers biogenic CO_2 as equal to 0, the removal of biogenic carbon and emissions of biogenic CO_2 and methane were modeled separately according to assumptions specific to this study. In order to avoid double counting, the impact factor for biogenic methane in TRACI 2.1 was set to 0.

[2] The global warming potential impact category results are presented in three categories: 1) fossil carbon; 2) biogenic carbon (emissions and removals); 3) total (fossil and biogenic carbon).

It should be noted that the life cycle impact assessment results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks. These six impact categories are globally deemed mature enough to be included in Type III environmental declarations. Other categories are being developed and defined and LCA should continue making advances in their development, however the EPD users should not use additional measures for comparative purposes.