NewCAL – Final wbLCA Results Memo

To:	Dan Chen	Bargmann Hendrie + Archetype, Inc.
From:	Jacob Savona	The Green Engineer
Project:	NewCAL	
Re:	Whole Building Life Cycle Assessment – Final Results	
Date Issued:	7/5/23	

I. Introduction

1. Project Summary

The NewCAL project consists of the construction of an approximately 32,000 GSF new community center building that is being built to address the facility needs of seniors in Newton. The building will be 3 floors above grade and will accommodate amenities, offices, activity rooms, dining, gymnasium, fitness area and game rooms, classrooms, and support spaces (BOH, circulation, storage, etc.)].

2. Purpose

The purpose of this whole building life cycle assessment (wbLCA) is to determine the embodied impact reduction of the structure and enclosure materials of NewCAL from the 100% Construction Document (herein referred to as the 'proposed') design. The material "hot spots" from the initial baseline assessment were further studied through a material comparison analysis, where the goal was to identify material substitutions that would meet the noted carbon reduction targets below. The structure and enclosure material quantities of NewCAL from the November 15th, 2022 DD Set and Architectural and Structural 100% CD Set were used to create a baseline design (herein referred to as the 'baseline') that is identical, if not of a comparable, size, function, orientation, and operating energy performance.

In support of the project's goal to reduce environmental impacts, including embodied carbon reduction, The Green Engineer, Inc. (TGE) conducted a Whole-Building Life-Cycle Assessment (wbLCA) using the methodology prescribed by LEEDv4.1 credit for Building Life-Cycle Impact Reduction.

The LEED v4.1 Building Life-Cycle Impact Reduction credit, Option 2. Whole-Building Life Cycle Assessment (wbLCA), requires a life cycle assessment study of the projects structure and enclosure. The credit includes four optional paths – this assessment pursues Path 3. For new construction projects, a cradle-to-grave wbLCA enables the team to understand the cumulative energy use and other environmental consequences resulting from all phases of the building's life with regard to the design and materials used. By looking at how project materials impact the whole structure, the team can use the LCA study and results to gain a larger perspective and reduce overall long-term environmental effects.

Path 1: Conduct a life cycle assessment (LCA) of the project's structure and enclosure (1 point).

Path 2: Conduct an LCA of the project's structure and enclosure that demonstrates a minimum of 5% reduction, compared with a baseline building, in at least three of the six impact categories listed below, one of which must be global warming potential (2 points).

Path 3: Conduct an LCA of the project's structure and enclosure that demonstrates a minimum of 10% reduction, compared with a baseline building, in at least three of the six impact categories listed below, one of which must be global warming potential (3 points). Path 3 is the original option in LEED version 4, which achieved three (3) points.

Path 4: Meet requirements of Path 3 and incorporate building reuse and/or salvage materials into the project's structure and enclosure for the proposed design. Demonstrate reductions compared with a baseline building of at least 20% reduction for global warming potential and demonstrate at least 10% reduction in two additional impact categories listed below (4 points).

The baseline building for comparison must be of comparable size, function, orientation and operating energy performance to the proposed design in the LCA study. The as-designed building is modeled with the types and quantities of materials that have been currently specified for the building.

For Paths 2, 3, and 4 above, no impact category assessed as part of the LCA may increase by more than 5% compared with the baseline building. The impact categories targeted for reduction are:

Impact Categories:

- Global Warming Potential (Embodied Carbon, CO2e)
- Depletion of Stratospheric Ozone
- Acidification of Land and Water
- Eutrophication
- Formation of Tropospheric Ozone
- Depletion of Non-Renewable Energy Resources
- Biogenic Carbon Storage is reported, but not included in the total embodied carbon calculations.

3. Methodology

Whole-Building LCA Tool:

The assessment has been carried out with One Click LCA software. The software holds 11 third party certifications and complies with over 30 certifications and standards for Life Cycle Assessment and Life Cycle Costing, including all versions of LEED and BREEAM. The software includes curated and verified global and local databases. The up to date list of integrated databases can be found here: https://www.oneclicklca.com/support/faq-and-guidance/documentation/database/.

One Click LCA has been third party verified by ITB for compliancy with the following LCA standards: EN 15978, ISO 21931–1 and ISO 21929, and data requirements of ISO 14040 and EN 15804. The full compliancy documentation is available at https://www.oneclicklca.com/support/faq-and-guidance/documentation/compliancy-and-certifications/.

ITB is a certification organization and a Notified Body (EC registration nr. 1488) to the European Commission designated for construction product certification. Polish Accreditation Board assures the independence and impartiality of ITB services (Accreditation Certificates are: AB 023, AC 020, AC 072, AP 113). ITB activities are conducted in accordance to the requirements of the following assurance standards: ISO 9001, ISO/IEC 27001, ISO/IEC 17025, EN 45011, and ISO/IEC 17021.

The tool supports CML characterization methodology as well as TRACI characterization methodology. All of the datasets in the tool comply with ISO 14040/14044 and most part also EN 15804 standard.

Scope:
The wbLCA system boundary included the building's structure and enclosure. Structural elements include frame and floors inclusive of fireproofing and concrete encasement. Enclosure includes all materials from the exterior cladding to the interior sheathing, inclusive of insulation. Roof assemblies include the entire assembly inclusive of membranes, insulation, and vapor barriers. The building will utilize fly ash and slag in the concrete per the Eastern Region NRMCA standard as a substitute for Portland Cement for all 3000, 4000, and 5000 psi concrete.

The system boundary excludes: interior finishes on the walls (e.g. paints), flooring finishes, and ceiling finishes; non-structural interior partitions; interior stairs; railings; Mechanical/Electrical/Plumbing (MEP) equipment; site elements (such as the exterior ramps); fire detection systems; elevators; parking lots; site improvements (such as pavements and curbs); and landscaping (such as landscaping and the green roof).

More specific information regarding the modeled systems specific to this project can be found in the Project Description section below.

System Boundary:
- The service life of the model will be 60 years to fully account for material replacement.
- The life cycle inventory data sets comply with ISO 14044; and
- The assessment is cradle to grave including modules A1-A, A4, B2-B5, and C2-C4. The scope excludes module A5 (installation), B1 (use), B2 (maintenance), B6 (operational energy), B7 (operational water use), and module D.

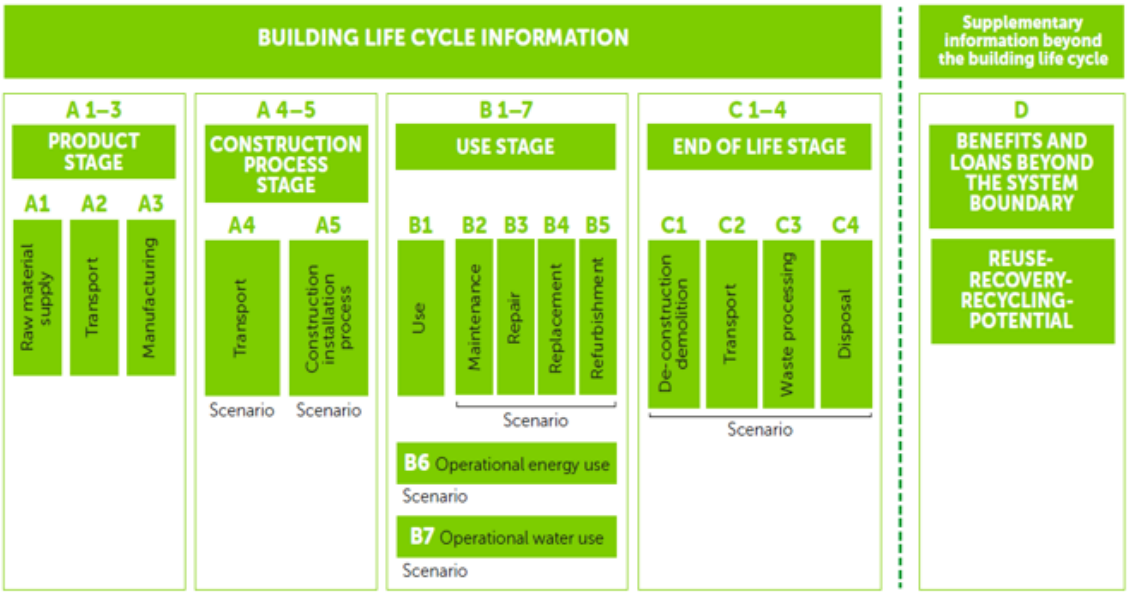


Illustration: Building Life Cycle Information and life cycle stages

wbLCA Process

TGE received the 100% Construction Documents drawings, specifications, and Revit models of NewCAL. To conduct this comparative assessment, the requirements and parameters of the LEED version 4.1 Materials and Resources Credit, Building Life Cycle Impact Reduction, Option 2 wbLCA were followed, including:

- Reviewing project documents received from the design team, including 100% Construction Documents architectural and structural drawings and specifications [and exterior wall takeoffs if used] for the design.
- Reviewing 100% Construction Documents Revit models received from the design team for conformance to the contract documents, including one architectural model and one structural model of the design.
- Holding a conference call with the design team to clarify any questions on the architectural and structural designs.
- Assigning each construction material within the two Revit models to materials in the OneClick LCA database, referencing the architectural and structural drawings, specifications, and submittals as needed.
- Generating output reports via OneClick LCA

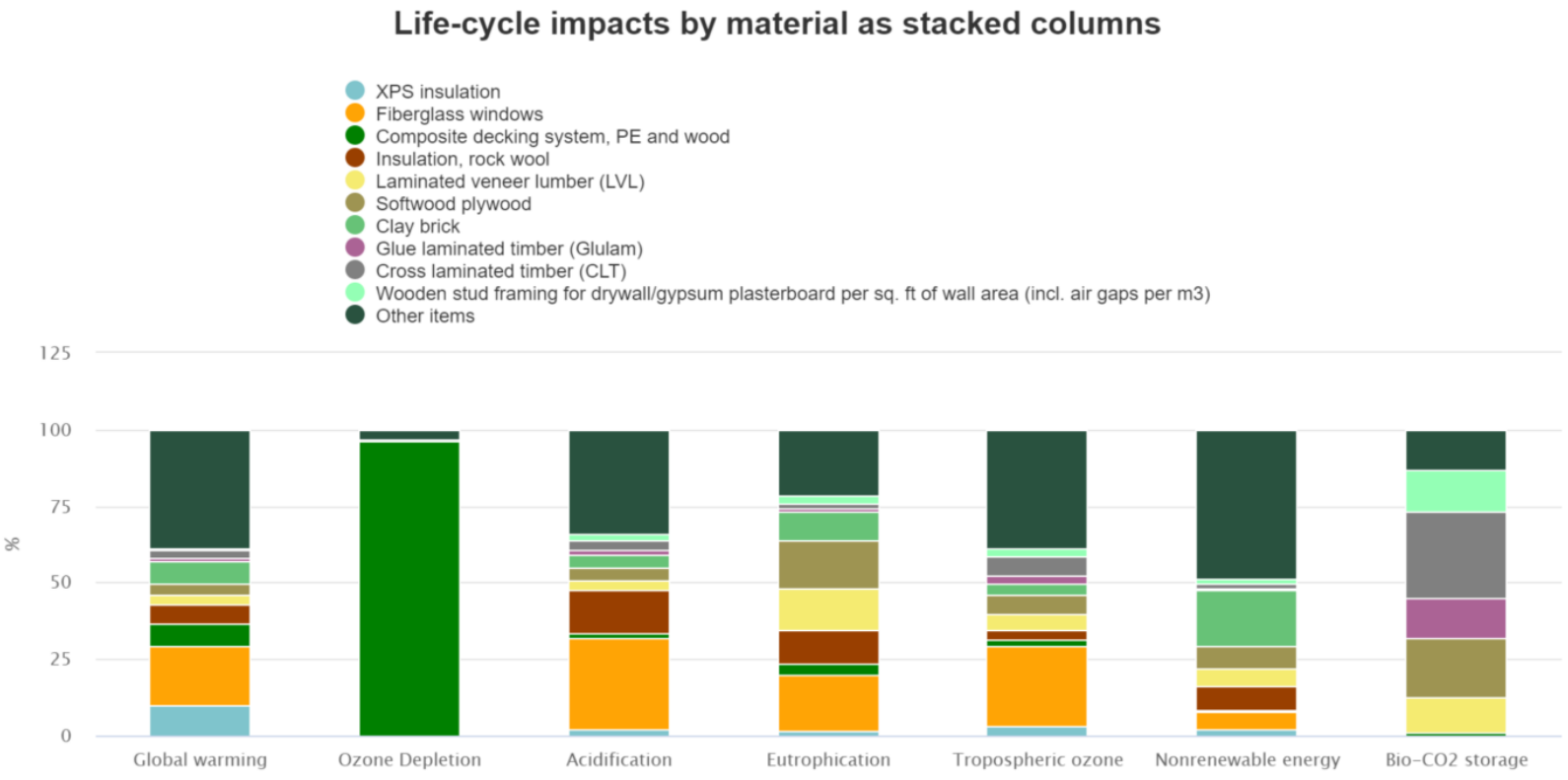
The OneClick LCA models were generated by exporting then changing the definitions of the modeled Revit construction materials within OneClick LCA to reflect the materials considered in the baseline and proposed design. In the absence of specific transportation data, we used OneClick LCA's default material transportation distances for all building materials.
After assigning all materials and running the OneClick LCA model, the software output PDF files that reported the wbLCA results per the TRACI 2.1 (Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts) impact assessment method. TRACI is an impact assessment method developed by the U.S. Environmental Protection Agency.

II. RESULTS

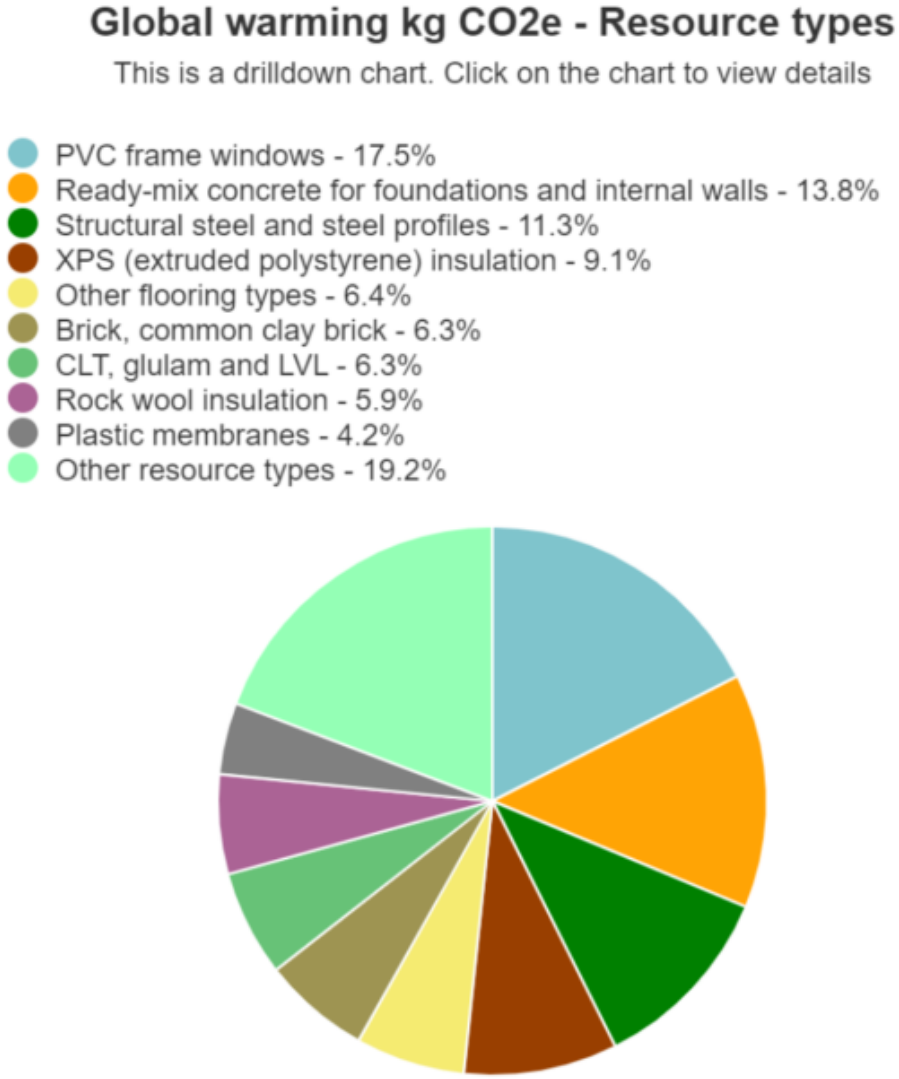
Total Impact of Final LCA Model + Comparison to Baseline (Cradle to Grave)

	Result category	Global warming kg CO_2e	Ozone Depletion kg CFC11e	Acidification kg SO_2e	Eutrophication kg Ne	Formation of tropospheric ozone kg O3e	Depletion of nonrenewable energy MJ	Biogenic carbon storage kg CO_2e bio	
A1-A3	Construction Materials	634,417.31 | -47 %	1.02 | -0.6 %	3,185.86 | -32 %	784.56 | -22 %	45,269.44 | -37 %	5,444,327.43 | -24 %	469,602.12 | +600 %	Details
A4	Transport to the building site	32,169.46 | -65 %	0.01 | -64 %	92.66 | -48 %	23.33 | -64 %	2,073.49 | -29 %	617,461.98 | -59 %		Details
B3	Repair								Details
B4-B5	Material replacement and refurbishment	153,851.13 | 0 %	1.84 | 0 %	739.66 | 0 %	128.61 | 0 %	10,311.69 | 0 %	974,504.46 | 0 %		Details
C1-C4	End of life	47,907.86 | -4.9 %	0 | -38 %	133.25 | +17 %	144.2 | +170 %	2,389.91 | +81 %	165,298.64 | -42 %		Details
	Total	**868,345.76**	**2.87**	**4,151.42**	**1,080.7**	**60,044.54**	**7,201,592.51**	**469,602.12**	
	Comparing total results with: 5 - Final LCA - Baseline								
	5 - Final LCA - Baseline Total	1,491,358.67	2.89	5,729.03	1,249.47	85,912.94	9,874,889.28	67,198.71	
	5 - Final LCA compared with 5 - Final LCA - Baseline	**-42 %**	**-0.7 %**	**-28 %**	**-14 %**	**-30 %**	**-27 %**	**+600 %**	
	Results per denominator								
	Gross Internal Floor Area (ASHRAE) 32000.0 sq ft	27.14	0	0.13	0.03	1.88	225.05	14.68	

Contribution of Each Material per Impact Category (Ignore Bio-CO2 Storage)



% of Total Embodied Carbon Per Building Material Type (Cradle to Grave)



Top 10 Most Contributing Specific Materials (Cradle to Gate)

No.	Resource	Cradle to gate impacts (A1-A3)	Of cradle to gate (A1-A3)
1.	Fiberglass windows, 1.5m x 1.3 m, 40 mm frame thickness, 1.42 m2 glazing area, 60.50 kg/m2	74 tonnes CO_2e	11.7 %
2.	Ready-mix concrete, 4000 psi, 27.6 Mpa	63 tonnes CO_2e	10.0 %
3.	Hollow structural steel sections, 487 lbs./ft.3	54 tonnes CO_2e	8.5 %
4.	XPS insulation, L=0.0276 W/mK, R=1 m2K/W, 27.6 mm 0.744 kg/m2, 26.9 kg/m3	52 tonnes CO_2e	8.2 %
5.	Clay brick, 2120 kg/m3	51 tonnes CO_2e	8.0 %
6.	Insulation, rock wool, 4-4.3 m2K/W per 1 in thickness, 2.5-7.1in, 4 lb/ft3	49 tonnes CO_2e	7.7 %
7.	Hot-rolled structural steel sections, North American industry average, per m3, 7800 kg/m3	43 tonnes CO_2e	6.7 %
8.	Ready-mix concrete, 3000 psi, 20.7 Mpa	36 tonnes CO_2e	5.6 %
9.	Softwood plywood, 9.5 mm, 484 kg/m3, 7% moisture content	27 tonnes CO_2e	4.3 %
10.	Aluminium frame curtain wall system, 1.5m x 1.6m, 35.6 kg/m2	26 tonnes CO_2e	4.1 %

III . INPUTS

Key Material Assumptions

The below table includes the key material assumptions specified in the LCA. One-Click relies on proprietary data from databases such as Gabi and Ecoinvent as well as Environmental Product Declarations (EPDs). When EPDs were used in the LCA this reference is included in parentheses (industry average materials) and brackets [Product Specific EPD].

Baseline Building Assumptions

Material Category	Assumption	Detail
Concrete	SCMs (Supplementary Cementing Materials	NRCMA industry, eastern region average fly ash and slag content across whole building.
	Mixes	3000 psi NWC for footings concrete [NRMCA EPD] 4000 psi NWC for all SOG, foundation walls, piers, and pilasters concrete [NRMCA EPD] 5000 psi NWC for all exterior slabs, above grade walls, and round concrete columns encasements [NRMCS EPD]
	Type	Normal-weight concrete mix [NRMCA EPD]
	Lifetime	All concretes set to building lifetime (60 years).
	Reinforcement	Rebar reinforcement captured in metal category.
Metals	Structural Steel	Hot-rolled structural steel sections (AISC industry average)
	Steel Floor and Roof Deck	Steel roof and floor deck, 22-16 gauge (industry average)
	Welded Wire Fabric	Welded wire mesh concrete reinforcement (industry average)
	Steel Reinforcement	Reinforcement steel (rebar), generic, 97% recycled content (typical, industry average)
Roof System	Roof Assemblies' Materials	TPO single ply waterproofing roof membrane [Carlisle SynTec EPD] ToughRock® Fireguard C Panel [Georgia Pacific EPD] STYROFOAM BRAND ST-100 [DuPont EPD] Bituthene® 3000 [GCP EPD] Plywood (industry average) Ultrabatt rockwool insulation [Thermafiber EPD]

		Hot-dip galvanized steel sheets (industry average) Only counting the insulation since the metal deck and reinforced concrete are accounted for in the concrete and steel totals from the structural engineer.
	Roof Shingles	Fiberglass asphalt shingle roofing system (Asphalt Roofing Manufacturers Association EPD)
	Wood Deck	Composite decking system, PE and wood [Fiber Composites EPD]
Wall System	Interior Walls	2x4 & 2x6 wooden stud framing for drywall/gypsum plasterboard, 16 inch stud spacing (industry average)
	Exterior Wall Assemblies' Materials	Precast concrete, architectural wall panel (industry average) STYROFOAM BRAND ST-100 [DuPont EPD] Non permeable sheet (NPS) wall membrane, Perm-A-Barrier® (PAB) NPS [GCP EPD] This was supposed to be VPS, but no EPD was available for that type of membrane, so the closest option was chosen. Plywood (industry average) ToughRock® Fireguard C Panel [Georgia Pacific EPD] Ultrabatt rockwool insulation [Thermafiber EPD] TPO single ply waterproofing roof membrane [Carlisle SynTec EPD] Stucco was used on the project, but no relevant EPD was available, so it was not included in this analysis.
	FCP	Fibre cement boards (industry average)
	Brick	Clay brick (OneClick LCA EPD)
	Exterior Stone Wall	Natural stone cladding, 88.78 kg/m2 (Natural Stone Institute EPD)
Glazing Systems	Curtain Wall	Aluminium storefront framing systems Trifab™ 451UT, Trifab™ [Kawneer EPD] Aluminium frame curtain wall system, 1600 UT 1 [Kawneer EPD]

	Fenestration	300 Series Tilt and Turn, 300 Series Fixed, 325 Series Awning/Casement, 325 Series Fixed, 400 Series [Inline EPD] Triple glazed IGUs with argon gas and fiberglass frames were used on the project, but no relevant EPDs were available for either separately, so a combined EPD was used in their place.
	Doors	Steel door (industry average) Aluminum framed exterior doors were also used on the project, but no relevant EPDs were available, so they were not included in this analysis.

Proposed Building Assumptions

Material Category	Assumption	Detail
Concrete	SCMs (Supplementary Cementing Materials	NRCMA industry, eastern region average fly ash and slag content across whole building.
	Mixes	3000 psi NWC for footings concrete [NRMCA EPD] 4000 psi NWC for all SOG, foundation walls, piers, and pilasters concrete [NRMCA EPD] 5000 psi NWC for all exterior slabs, above grade walls, and round concrete columns encasements [NRMCS EPD]
	Type	Normal-weight concrete mix [NRMCA EPD]
	Lifetime	All concretes set to building lifetime (60 years).
	Reinforcement	Rebar reinforcement captured in metal category.
Metals	Structural Steel	Hot-rolled structural steel sections (AISC industry average) Hollow structural steel sections (AISC industry average)
	Steel Floor and Roof Deck	Steel roof and floor deck, 22-16 gauge (industry average)
	Welded Wire Fabric	N/A
	Steel Reinforcement	Reinforcement steel (rebar), generic, 97% recycled content (typical, industry average)
Timber	LVL Beams	Laminated veneer lumber (LVL), 445 mm, 548 kg/m3, 6% moisture content (American Wood Council, Canadian Wood Council EPD)
	Glulam	Glue laminated timber (Glulam), 544 kg/m3, 12% (± 3%) moisture content (One Click LCA) Actual product specified for project is the Weyerhaeuser PSL Glulam product.
	CLT	Cross laminated timber (CLT), 481 kg/m3, 12% (± 3%) moisture content (One Click LCA) Softwood plywood, 9.5 mm, 484 kg/m3, 7% moisture content (American Wood Council, Canadian Wood Council) - For floor toppings. Gypcrete floor toppings were used in this project, but no relevant EPD was available, so it was not included in this analysis.
	Dimension Lumber	Softwood lumber, kiln-dried and planed, 19 mm, 460 kg/m3, 15% moisture content (American Wood Council, Canadian Wood Council) Prefabricated truss from softwood for open web floor/roof framing, 417 kg/m3, 95.7%

		softwood lumber, 3.6% LVL, 0.1% plywood, < 0.1% OSB, 0.4% metal connector plates (Quebec Wood Export Bureau (2020))
Roof System	Roof Assemblies' Materials	TPO single ply waterproofing roof membrane [Carlisle SynTec EPD] ToughRock® Fireguard C Panel [Georgia Pacific EPD] STYROFOAM BRAND ST-100 [DuPont EPD] Bituthene® 3000 [GCP EPD] Plywood (industry average) Ultrabatt rockwool insulation [Thermafiber EPD] Hot-dip galvanized steel sheets (industry average) Only counting the insulation since the metal deck and reinforced concrete are accounted for in the concrete and steel totals from the structural engineer.
	Roof Shingles	Fiberglass asphalt shingle roofing system (Asphalt Roofing Manufacturers Association EPD)
	Wood Deck	Composite decking system, PE and wood [Fiber Composites EPD]
Wall System	Interior Walls	2x4 & 2x6 wooden stud framing for drywall/gypsum plasterboard, 16 inch stud spacing (industry average)
	Exterior Wall Assemblies' Materials	Precast concrete, architectural wall panel (industry average) STYROFOAM BRAND ST-100 [DuPont EPD] Non permeable sheet (NPS) wall membrane, Perm-A-Barrier® (PAB) NPS [GCP EPD] This was supposed to be VPS, but no EPD was available for that type of membrane, so the closest option was chosen. Plywood (industry average) ToughRock® Fireguard C Panel [Georgia Pacific EPD] Ultrabatt rockwool insulation [Thermafiber EPD]

		TPO single ply waterproofing roof membrane [Carlisle SynTec EPD] Stucco was used on the project, but no relevant EPD was available, so it was not included in this analysis.
	FCP	Fibre cement boards (industry average)
	Brick	Clay brick (OneClick LCA EPD)
	Exterior Stone Wall	Natural stone cladding, 88.78 kg/m2 (Natural Stone Institute EPD)
Glazing Systems	Curtain Wall	Aluminium storefront framing systems Trifab™ 451UT, Trifab™ [Kawneer EPD] Aluminium frame curtain wall system, 1600 UT 1 [Kawneer EPD]
	Fenestration	300 Series Tilt and Turn, 300 Series Fixed, 325 Series Awning/Casement, 325 Series Fixed, 400 Series [Inline EPD] Triple glazed IGUs with argon gas and fiberglass frames were used on the project, but no relevant EPDs were available for either separately, so a combined EPD was used in their place.
	Doors	Steel door (industry average) Aluminum framed exterior doors were also used on the project, but no relevant EPDs were available, so they were not included in this analysis.

V. CONCLUSION

Based on the NewCAL Revit models (dated 23-0522 & 23-0622) provided by the project design team, the new construction of the NewCAL building is estimated to have a total embodied carbon impact of 868,345.76 kg CO2e (868.34 MTCO2e).

Detailed results of the analysis can be found under ‘Section II-Results’ of this report. Key material assumptions are summarized under ‘Section III-Inputs’. The wbLCA indicates that the fiberglass windows, hollow structural steel, the 4000 psi ready-mix concrete, and the XPS insulation have the highest impact on the total embodied carbon for the new construction. Section II of this report also summarizes the complete top ten contributing materials to the embodied carbon impact of the project.
The wbLCA indicates that the optimization strategy to use structural timber instead of structural steel in most of the structural frame of the building resulted in a 42% reduction. A majority of this reduction came from the A1-A3 stages due the significant decrease in structural steel and concrete used in the project. You'll also notice that the biggest percent reduction (not kg reduction) came from the A4 stage (transportation to the building site). This was due to the significant weight

reduction in total materials brought to the site. Less weight that needs to be transported means less fuel that needs to be used to transport this weight and therefore less carbon emissions.

You'll notice that this decision had a significant impact on the top contributing materials in the project. You would normally exclusively see structural steel and concrete as the top 2 contributing materials by a wide margin, but in the NewCAL project, since the embodied carbon impact of the timber frame is that much lower than a steel frame, it allowed for other materials to take the top spots like the fiberglass windows and XPS insulation.

VI. Appendix: LCA Data

The following data points have been used as sources for this assessment. All data used complies with ISO 14040 and 14044 and is drawn from One Click LCA database and has been verified following the BRE-verified data qualification methodology by LCA data specialists.

Resource name	Country	Product	Density	Year	Environment Data Source	Standard	EPD number	EPD program	Manufacturer	Product Category Rules (PCR)	Notes about PCR	Technical specification	Upstream database	Verification
Aluminium frame curtain wall system	[northAmerica]	1600 1, 1600 2, 1600 3, 1600 4, 1600 5, 1600 SS, 1600 UT 1, 1600 UT 2, 1620/1620 SSG, 1630 SS IR, 2250 IG, 2250 LR, 7500 and Clearwall Curtain Wall Systems		2015	EPD TRADITIONAL CURTAIN WALL ALUMINUM CURTAIN WALL SYSTEMS	ISO 14040	47868332121.105.1	UL Environment	Kawneer	PCR Cradle to Gate Window, September 2015	Only with EN15804	1.5m x 1.6m, 35.6 kg/m2	GaBi	verified
Aluminium storefront framing systems	[northAmerica]	Trifab™ VersaGlaze™ 450/451/451T, Trifab™ 400, Trifab™ 451UT, Trifab™ 601/601T/601UT, EnCORE™, IR500/501, IR501T/501UT, InFrame™		2021	EPD TRIFAB™ FRAMING SYSTEMS AND STOREFRONT FRAMING SYSTEMS	EN15804+A1	4789733794.107.1	UL Environment	Kawneer	EPD Part B: Requirements on the EPD for Self supporting façade elements based on glazed curtain walls (IBU, V1.7, 04.01.2019) (IBU, 2019)	Only with EN15804	36.1 kg/m2	GaBi	verified
Clay brick	[USA, canada]		2120.0	2020	EPD U.S.–Canada Industrywide Clay Brick	EN15804+A1	EPD10447	NSF	Acme Brick Company, Belden Brick Company, Bowerston Shale Company, Brampton Brick, Inc., Endicott Clay Products Co., General Shale, Inc., Glen-Gery Corporation, Hebron Brick Company, Lee Brick & Tile Company, Meridian Brick LLC, Meridian Brick Canada Ltd., Pine Hall Brick, Inc., Statesville Brick Company	PCR for Clay Brick, Clay Brick Pavers and Structural Clay Tile	Only with EN15804	2120 kg/m3	ecoinvent	verified
Composite decking system, PE and wood	[northCarolina, idaho, USA]	Concordia (Symmetry & Horizon), Sanctuary, ArmorGuard/Veranda, Good Life, Perspective		2021	EPD Composite Decking Systems	ISO 14040	SCS-EPD-07180	SCS Global	Fiber Composites	ISO 21930:2017. Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services.	Only with EN15804	average weight: 22.04 kg/m2	ecoinvent	verified
Cross laminated timber (CLT)	[LOCAL]		481.0	2023	One Click LCA	EN15804+A1, EN15804+A2	-	One Click LCA	One Click LCA	EN15804+A1	-	481 kg/m3, 12% (± 3%) moisture content	ecoinvent	internalonly
Fiberglass asphalt shingle roofing system	[northAmerica]			2016	EPD Asphalt Shingle Roofing System Asphalt Roofing Manufacturers Association (ARMA)	EN15804+A1	4787168709.101.1	UL Environment	Asphalt Roofing Manufacturers Association (ARMA)	ASTM PCR Asphalt shingles, built-up asphalt membrane roofing and modified bituminous membrand roofing, 2014	Only with EN15804	12.7 kg/m2	GaBi	verified
Fiberglass windows	[ontario, canada]	300 Series Tilt and Turn, 300 Series Fixed, 325 Series Awning/Casement, 325 Series Fixed, 400 Series		2021	EPD Inline Fiberglass Windows	EN15804+A1	EPD 266	ASTM	Inline	ISO 21930: 2017	Only with EN15804	1.5m x 1.3 m, 40 mm frame thickness, 1.42 m2 glazing area, 60.50 kg/m2	ecoinvent	verified
Fibre cement boards	[LOCAL]		1300.0	2019	One Click LCA	EN15804+A1	-	One Click LCA		EN15804+A1	-	1300 kg/m3 (81.16 lbs/ft3)	ecoinvent	internalonly
Glass-mat gypsum boards, fire and moisture resistant, for exterior walls	[USA, canada, mexico]	1/2 DensGlass, 1/2 DensElementTM	767.7165354330709	2016	EPD for 1/2 inch DensGlass® Gypsum Sheathing and 1/2 inch DensElementTM Sheathing	ISO 14040	EPD-046	ASTM	Georgia-Pacific Gypsum LLC	ASTM International, PCR for North American Glass Mat Gypsum Panels – Gypsum PCR-2016: v1	Only with EN15804	12.7 mm (1/2 inch), 9.75 kg/m2 (1.997 lb/ft2), 768 kg/m3	ecoinvent	verified
Glue laminated timber (Glulam)	[LOCAL]		544.0	2023	One Click LCA	EN15804+A1, EN15804+A2	-	One Click LCA	One Click LCA	EN15804+A1	-	544 kg/m3, 12% (± 3%) moisture content	ecoinvent	internalonly
Gypsum board with glass mat facing	[USA, canada]	ToughRock® Fireguard C Panel		2020	EPD Georgia-Pacific Gypsum EPD for 1/2 ToughRock® Fireguard C® Panel	ISO 14040	EPD10310	NSF	Georgia-Pacific Gypsum	PCR Gypsum Boards – Gypsum PCR-2019: v1.	Only with ISO14040	1/2 in (12.7 mm), 2.12 lb/ft2 (10.4 kg/m2)	ecoinvent	verified
Gypsum board with glass mat facing	[USA, canada]	DensGlass®		2020	EPD 1/2 in DensGlass® Sheathing Panel	ISO 14040	EPD10358	NSF	Georgia-Pacific Gypsum	PCR Gypsum Boards – Gypsum PCR-2019: v1.	Only with ISO14040	1/2 in (12.7 mm), 2.04 lb/ft2 (9.95 kg/m2)	ecoinvent	verified
Hollow structural steel sections	[USA]		7800.0	2016	EPD Fabricated hollow structural sections American Institute of Steel Construction Steel Tube Institute	ISO 14040	4786979051.103.1	UL Environment	AISC, STI	SCS PCR for Designated Steel Construction Products (2015)	Only with ISO14040	487 lbs./ft.3	GaBi	verified
Hot-dip galvanized steel sheets	[LOCAL]		7850.0	2019	One Click LCA	EN15804+A1	-	One Click LCA		EN15804+A1	-	recommended sheet steel thickness range: 0.4-3.0 mm (0.015-0.12 in), zinc coating: 20 µm (787.4 µin) (0.28kg/m2 / 0.057 lbs/ft2 sheet steel)	ecoinvent	internalonly

Resource name	Country	Product	Density	Year	Environment Data Source	Standard	EPD number	EPD program	Manufacturer	Product Category Rules (PCR)	Notes about PCR	Technical specification	Upstream database	Verification
Hot-rolled structural steel sections, North American industry average, per m3	[northAmerica]		7800.0	2021	EPD FABRICATED HOT-ROLLED STRUCTURAL SECTIONS AMERICAN INSTITUTE OF STEEL CONSTRUCTION	EN15804+A1	4789556099.102.1	UL Environment	American Institute of Steel Construction (AISC)	PCR Part B: Designated Steel Construction Product EPD Requirements (UL Environment, V2.0, 08.26.2020)	Only with EN15810	7800 kg/m3	GaBi	verified
Insulation, rock wool	[USA]	Ultrabatt	64.07385	2014	EPD Thermafiber Mineral Wool Insulation	ISO 14040	4786077032.104.1	UL Environment	Thermafiber	PCR for Building Envelope Thermal Insulation v1.2	Only with ISO14040	4-4.3 m2K/W per 1 in thickness, 2.5-7.1in, 4 lb/ft3	USLCI	verified
Laminated veneer lumber (LVL)	[USA, canada]		548.0	2020	EPD North American Laminated Veneer Lumber	ISO 14040	4788424634.105.1	UL Environment	American Wood Council, Canadian Wood Council	UL Environment: Product Category Rules for Building-Related Products and Services Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Project Report, v3.2 Part B: Structural and Architectural Wood Products EPD Requirements, v1.0	Only with EN15804	445 mm, 548 kg/m3, 6% moisture content	ecoinvent	verified
Natural stone cladding	[canada, USA]			2022	EPD Industry-wide Type III EPD Exterior Dimension Stone Cladding	EN15804+A1	NSI – 20221101 – 003	-	Natural Stone Institute	ULE PCR Part B: Cladding Product Systems EPD requirements v2.0, 2021	-	88.78 kg/m2	ecoinvent	verified
Non permeable sheet (NPS) wall membrane	[tennessee, illinois, USA]	Perm-A-Barrier® (PAB) NPS		2022	EPD PERM-A-BARRIER® (PAB) Air Barrier System	ISO 14040	EPD10786	NSF	GCP Applied Technologies	PCR ASTM International Water-Resistive and Air Barriers	Only with EN15804	0.56 kg/m2	GaBi	verified
Precast concrete, architectural wall panel	[northAmerica]		2400.0	2015	Architectural and Insulated Wall Panel Industry Wide, National Precast Concrete Association 2015	ISO 14040	EPD-016	ASTM		ASTM PCR for Preparing an EPD For Precast Concrete	Only with EN15804		USLCI	verified
Prefabricated truss from softwood for open web floor/roof framing	[quebec, canada]		417.0	2019	EPD Prefabricated light wood frame open web floor truss	EN15804+A1	1725-6769, v. 1.2	CSA Group	Quebec Wood Export Bureau (2020)	PCR Structural and Architectural Wood Products. Version 2. June 2015.	Only with EN15804	417 kg/m3, 95.7% softwood lumber, 3.6% LVL, 0.1% plywood, < 0.1% OSB, 0.4% metal connector plates	ecoinvent	verified
Ready-mix concrete	[maine, vermont, newHampshire, connecticut, rhodeIsland, newYork, pennsylvania, westVirginia, virginia, maryland, newJersey, delaware, massachusetts, USA]		2400.0	2022	NRMCA Member National and Regional LCA Benchmark (Industry Average) Report – V 3.2, updated 2022	ISO 14040	-	NRMCA	Industry average ready-mix concrete for Eastern region USA NRMCA (2022)	-	-	3000 psi, 20.7 Mpa	ecoinvent	verified
Ready-mix concrete	[maine, vermont, newHampshire, connecticut, rhodeIsland, newYork, pennsylvania, westVirginia, virginia, maryland, newJersey, delaware, massachusetts, USA]		2400.0	2022	NRMCA Member National and Regional LCA Benchmark (Industry Average) Report – V 3.2, updated 2022	ISO 14040	-	NRMCA	Industry average ready-mix concrete for Eastern region USA NRMCA (2022)	-	-	4000 psi, 27.6 Mpa	ecoinvent	verified
Ready-mix concrete	[maine, vermont, newHampshire, connecticut, rhodeIsland, newYork, pennsylvania, westVirginia, virginia, maryland, newJersey, delaware, massachusetts, USA]		2400.0	2022	NRMCA Member National and Regional LCA Benchmark (Industry Average) Report – V 3.2, updated 2022	ISO 14040	-	NRMCA	Industry average ready-mix concrete for Eastern region USA NRMCA (2022)	-	-	5000 psi, 34.5 Mpa	ecoinvent	verified
Reinforcement steel (rebar), generic	[LOCAL]		7850.0	2022	One Click LCA	EN15804+A1, EN15804+A2	-	One Click LCA	One Click LCA 2022	EN15804+A1	-	97% recycled content (typical), A615	ecoinvent	internalonly
Reinforcement steel (rebar), generic	[LOCAL]		7850.0	2018	One Click LCA	EN15804+A1	-	One Click LCA		EN15804+A1	-	97% recycled content (typical), A615	ecoinvent	internalonly
Rubberized asphalt and polyethylene waterproofing membranes, self-adhesive	[tennessee, USA]	Bituthene® 3000		2022	EPD BITUTHENE® Post Applied Waterproofing	ISO 14040	EPD10784	NSF	GCP Applied Technologies	PCR ASTM International Water-Resistive and Air Barriers	Only with EN15804	60 mil (1.5 mm), 1.85 kg/m2	GaBi	verified

Resource name	Country	Product	Density	Year	Environment Data Source	Standard	EPD number	EPD program	Manufacturer	Product Category Rules (PCR)	Notes about PCR	Technical specification	Upstream database	Verification
Softwood lumber, kiln-dried and planed	[USA, canada]		460.0	2020	EPD North American Softwood Lumber	ISO 14040	4788424634.102.1	UL Environment	American Wood Council, Canadian Wood Council	UL Environment: Product Category Rules for Building-Related Products and Services Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Project Report, v3.2 Part B: Structural and Architectural Wood Products EPD Requirements, v1.0	Only with EN15804	19 mm, 460 kg/m3, 15% moisture content	ecoinvent	verified
Softwood plywood	[USA, canada]		484.0	2020	EPD North American Softwood Plywood	ISO 14040	4788424634.103.1	UL Environment	American Wood Council, Canadian Wood Council	UL Environment: Product Category Rules for Building-Related Products and Services Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Project Report, v3.2 Part B: Structural and Architectural Wood Products EPD Requirements, v1.0	Only with EN15804	9.5 mm, 484 kg/m3, 7% moisture content	ecoinvent	verified
Steel door	[USA]		1185.369	2015	Quartz 2015	ISO 14040	CP127	Quartz		LCIA: TRACI 2.1, GWP IPCC 2013	LCIA: TRACI 2.1, GWP IPCC 2013	86x36x1.34in	GaBi	verified
Steel roof and floor deck	[northAmerica]		7800.0	2015	Steel roof and floor deck, Steel Deck Institute 2015	ISO 14040	4786052957.101.1	UL Environment	Steel Deck Institute	SCS PCR for Designated Steel Construction Products, v1.0 May 2015	Only with EN15804	22-16 gauge	GaBi	verified
TPO Single ply waterproofing roof membrane (mechanically fastened)	[northAmerica]		931.758530183727	2016	EPD TPO Single Ply Roofing Membrane (Mechanically Fastened) Carlisle SynTec Systems	EN15804+A1	4787408569.102.1	UL Environment	Carlisle SynTec Systems	PCR for Single Ply Roofing Membranes. ASTM International.	Only with EN15804	60 mils: 1.42 kg/m2	GaBi	verified
Wooden stud framing for drywall/gypsum plasterboard per sq. ft of wall area (incl. air gaps per m3)	[northAmerica]			2013	North American Softwood Lumber, American and Canadian Wood Councils 2013	ISO 14040	13CA24184.102.1	UL Environment	American Wood Council, Canadian Wood Council	FP Innovations PCR Structural and Architectural Wood Products, Version 1, November 8, 2011 (2011)	Only with EN15804	2x6 in, 16 in spacing, headers incl. for 8 ft wall height	USLCI	verified
Wooden stud framing for drywall/gypsum plasterboard per sq. ft of wall area (incl. air gaps per m3)	[northAmerica]			2013	North American Softwood Lumber, American and Canadian Wood Councils 2013	ISO 14040	13CA24184.102.1	UL Environment	American Wood Council, Canadian Wood Council	FP Innovations PCR Structural and Architectural Wood Products, Version 1, November 8, 2011 (2011)	Only with EN15804	2x4 in, 16 in spacing, headers incl. for 8 ft wall height	USLCI	verified
XPS insulation	[idaho, illinois, missouri, USA]	STYROFOAM BRAND ST-100	26.9	2021	EPD STYROFOAMTM BRAND ST-100 PRODUCTS	EN15804+A1	4789868895.101.1	UL Environment	DuPont	PCR Part B: Building Envelope Thermal Insulation EPD Requirements (UL V2.0, 2018)	Only with EN15804	L=0.0276 W/mK, R=1 m2K/W, 27.6 mm 0.744 kg/m2, 26.9 kg/m3	GaBi	verified

	Result category	Global warming kg CO_2e	Ozone Depletion kg CFC11e	Acidification kg SO_2e	Eutrophication kg Ne	Formation of tropospheric ozone kg O3e	Depletion of nonrenewable energy MJ	Biogenic carbon storage kg CO_2e bio	
A1-A3	Construction Materials	634,417.31 | -47 %	1.02 | -0.6 %	3,185.86 | -32 %	784.56 | -22 %	45,269.44 | -37 %	5,444,327.43 | -24 %	469,602.12 | +600 %	Details
A4	Transport to the building site	32,169.46 | -65 %	0.01 | -64 %	92.66 | -48 %	23.33 | -64 %	2,073.49 | -29 %	617,461.98 | -59 %		Details
B3	Repair								Details
B4-B5	Material replacement and refurbishment	153,851.13 | 0 %	1.84 | 0 %	739.66 | 0 %	128.61 | 0 %	10,311.69 | 0 %	974,504.46 | 0 %		Details
C1-C4	End of life	47,907.86 | -4.9 %	0 | -38 %	133.25 | +17 %	144.2 | +170 %	2,389.91 | +81 %	165,298.64 | -42 %		Details
	Total	**868,345.76**	**2.87**	**4,151.42**	**1,080.7**	**60,044.54**	**7,201,592.51**	**469,602.12**	
	Comparing total results with: 5 - Final LCA - Baseline								
	5 - Final LCA - Baseline Total	1,491,358.67	2.89	5,729.03	1,249.47	85,912.94	9,874,889.28	67,198.71	
	5 - Final LCA compared with 5 - Final LCA - Baseline	-42 %	-0.7 %	-28 %	-14 %	-30 %	-27 %	+600 %	
	Results per denominator								
	Gross Internal Floor Area (ASHRAE) 32000.0 sq ft	27.14	0	0.13	0.03	1.88	225.05	14.68	