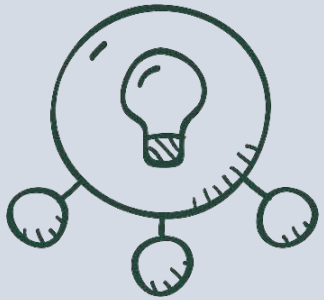
Embodied Carbon Network | 2019 Webinar Series

EMBODIED CARBON IN THE BUILT ENVIRONMENT: SESSION 5 – Using WBLCA to Reduce Embodied Carbon within LEED and Beyond

November 8, 2019

Network Overview

Communication and knowledge building platform

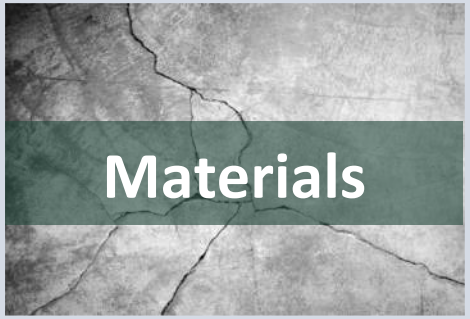


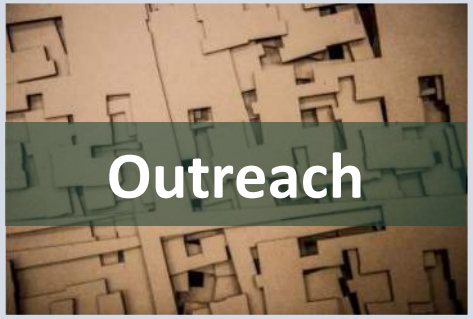
1108 members from industry, nonprofits, governments, academia

Common mission to phase out emissions from buildings and construction materials

ECN Focus Groups

10 Focus Groups





CARBON LEADERSHIP FORUM

Inspire, Inform and Enable Low Carbon Construction

MAGNUSSON KLEMENCIC ASSOCIATES
Structural + Civil Engineers

MITHŪN

STOPWASTE
at home • at work • at school

Carbon Innovations

THE RUSSELL FAMILY FOUNDATION

The American Institute of Architects

ARUP

CARBON CURE

CENTRAL
Stronger, Cleaner, Greener Concrete.
A U.S. CONCRETE COMPANY

Interface

KIERAN TIMBERLAKE

Orca
Optimal Ready-Mixed Concrete Aggregates
Distributed by Eagle Rock Aggregates Inc.

Sellen

SKANSKA

Thornton Tomasetti

WAP SUSTAINABILITY CONSULTING

we

bassetti architects

CALLISONRTKL

kpff

LeMessurier

OWENS CORNING

PCS Structural Solutions

SIMPSON GUMPERTZ & HEGER

tk1sc

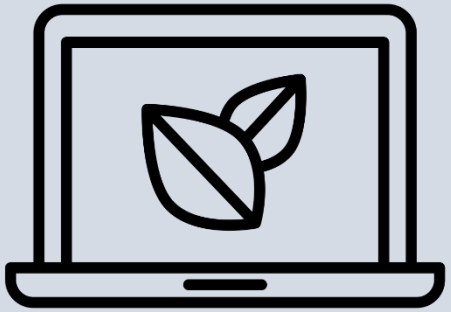
URBAN FABRICK

walter p moore

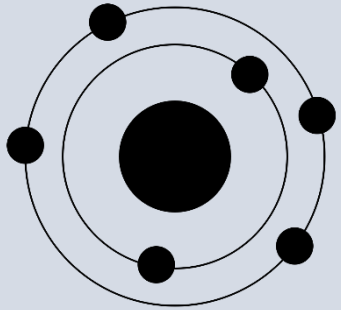
ADRIAN SMITH + GORDON GILL | AIA SEATTLE | AMBIENT ENERGY | ARKIN TILT | BRIGHTWORKS | CLIMATE EARTH | COUGHLIN PORTER LUNDEEN | KATERRA | LMN ARCHITECTS | LUND OPSAHL | NATIONAL READY MIXED CONCRETE CO | NRMCA | SHKS | SIEGEL & STRAIN ARCHITECTS | WRNS STUDIO

Series Overview

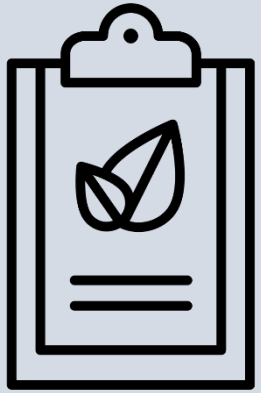
Research, case studies, strategies to measure and reduce embodied carbon



Six online sessions



Subject matter experts



AIA CE Credits

Disclaimer

Webinar Series Disclaimer

This session is provided as part of the Embodied Carbon Network 2019 Webinar Series. We invite guest speakers to share their knowledge and insight on topics related to carbon emissions attributed to building materials. The series aims to introduce topics that lead participants to think and talk about building industry strategies for reducing carbon emissions.

Mention of trade names or commercial products does not constitute endorsement or recommendation for use. Please note the opinions, ideas, or data presented by speakers in this series do not represent members of the Embodied Carbon Network or constitute endorsement by the Network.

Logistics

- 15-minute Q&A session after presentations
- To receive AIA continuing education credit: send your AIA member number to info@embodiedcarbonnetwork.org
- To access past webinar recordings, visit: www.embodiedcarbonnetwork.org/resources
- Save the Date!
    - Upcoming Materials Focus Group call - Dec 6th at 9am PST
    - Upcoming webinar: Session 6 - LCA Data and Tools – Dec 13th at 9am PST

Webinar Overview

San Francisco Airport WBLCA Case Study using Tally

Raphael Sperry
Associate
Arup

Office Building WBLCA Case Study using One Click LCA

Anthony Pak
Principal | LCA Consultant
Priopta

Webinar Overview

Concrete Mix LCA and Case Studies for LEED v4.1

Baha Sadreddin
High Performance Design Specialist
ZGF

Setting up the Baseline for Building Enclosure and Structure

Victoria Herrero-Garcia
Sustainability Consultant, WBLCA Analyst
Ambient Energy

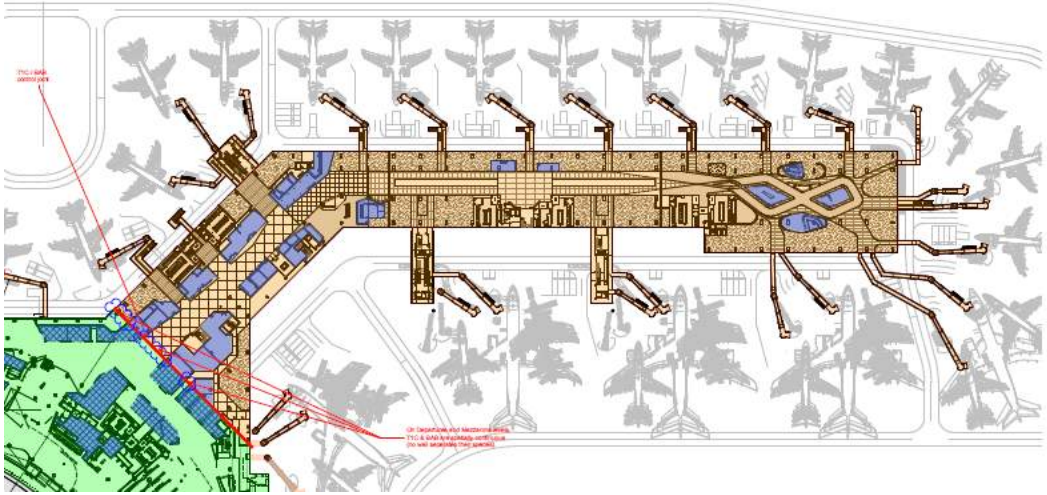
SFO Boarding Area B – Whole Building LCA

Raphael Sperry, AIA, LEED AP BD&C ID&C, WELL AP
Associate | Sustainability
Arup | San Francisco

raphael.sperry@arup.com

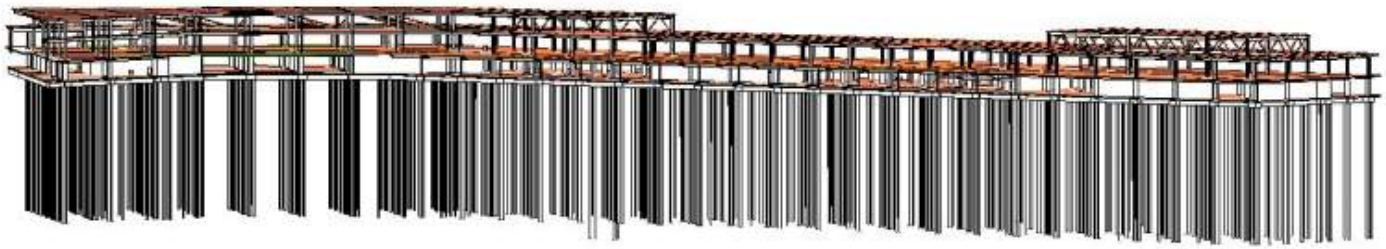
ARUP

SFO Boarding Area B



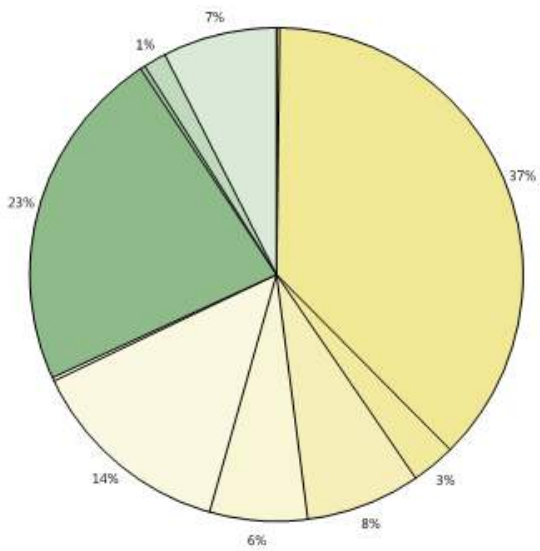
Area: ~500,000 square feet
Cost : ~ $1 Billion
Schedule: 2015 - 2022

100% SD LCA – Structure Only Tally Analysis

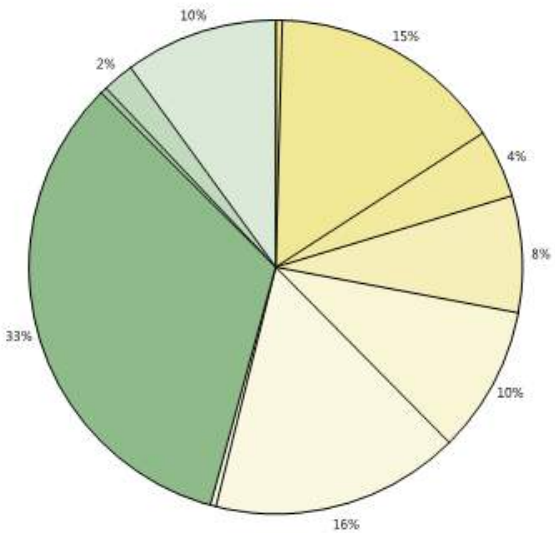


View of building structure at 100%SD

Results per CSI Division, itemized by Material



Global Warming Potential



Primary Energy Demand

Legend

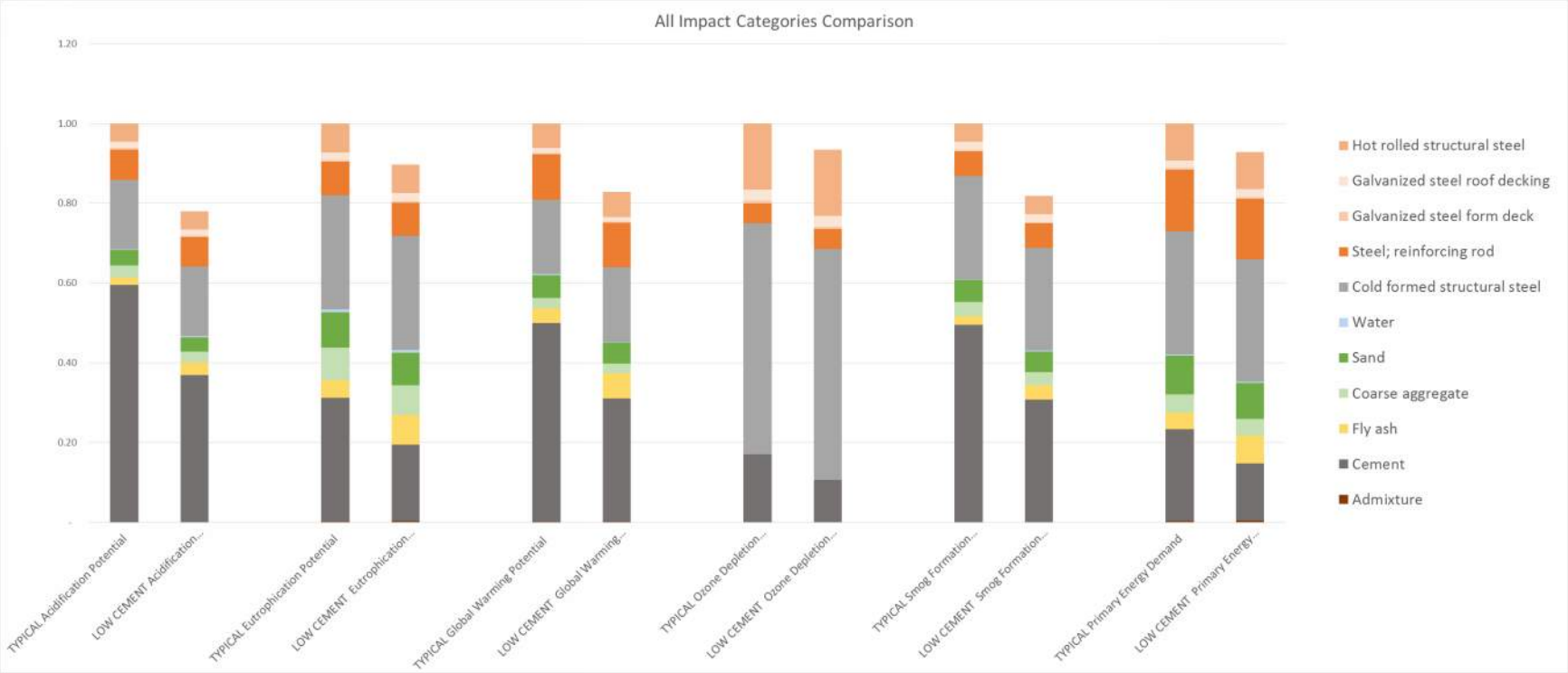
03 - Concrete

- Admixture
- Cement
- Coarse aggregate
- Expanded shale
- Expanded slag
- Fly ash
- Glass fibers
- Perlite
- Sand
- Steel, reinforcing rod
- Water

05 - Metals

- Cold formed structural steel
- Galvanized steel form deck
- Galvanized steel roof decking
- Hot rolled structural steel

100% SD LCA – Structure Only
Tally Analysis

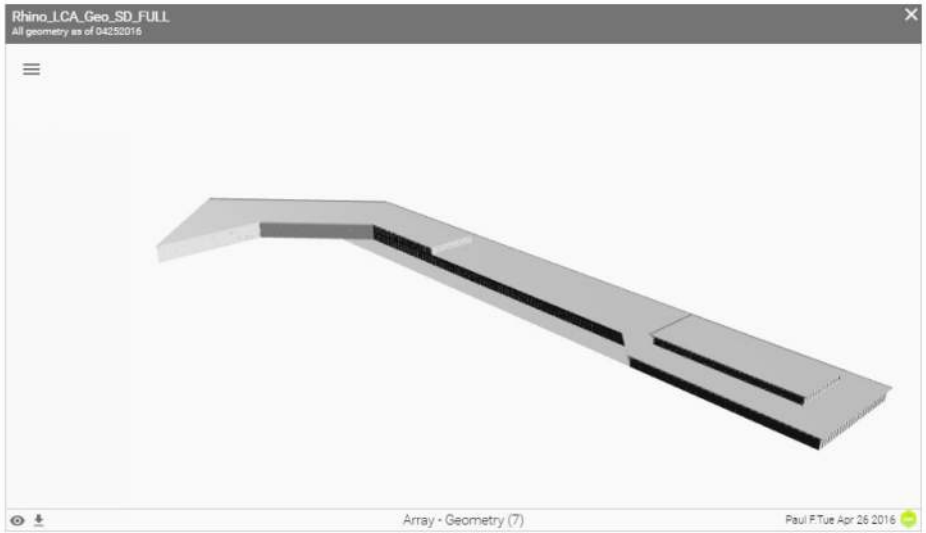


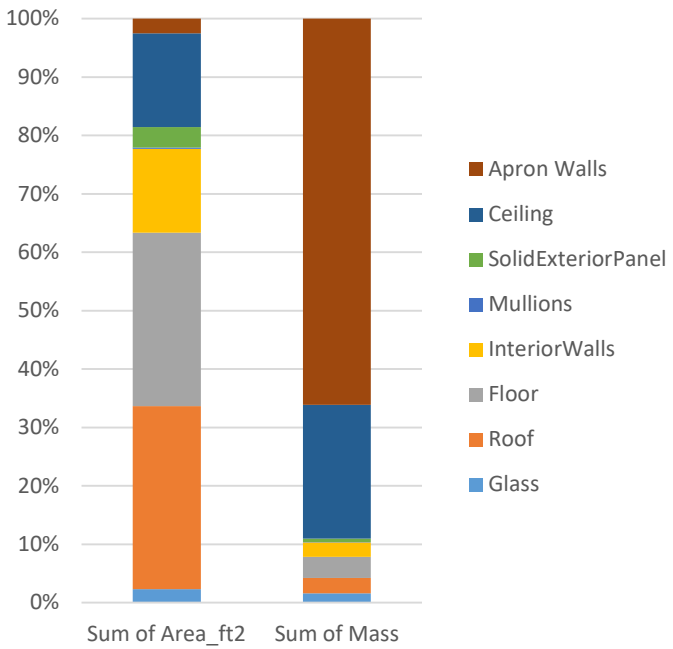
Comparison of whole structure using Typical and Low-cement concrete mixes; steel structure unchanged
(Tally results exported to Excel for comparison)

100% SD – Nonstructural materials

Sometimes a Revit model is not available in SD…

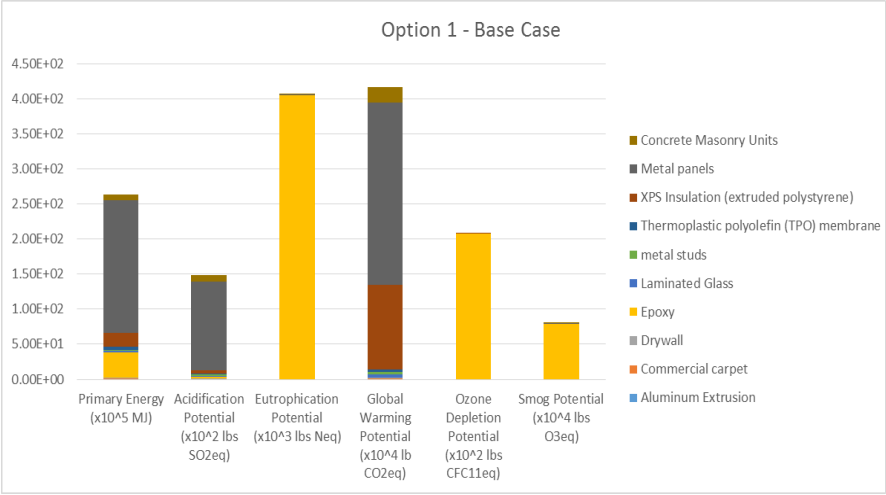
we exported envelope material takeoffs from a Rhino model in SD



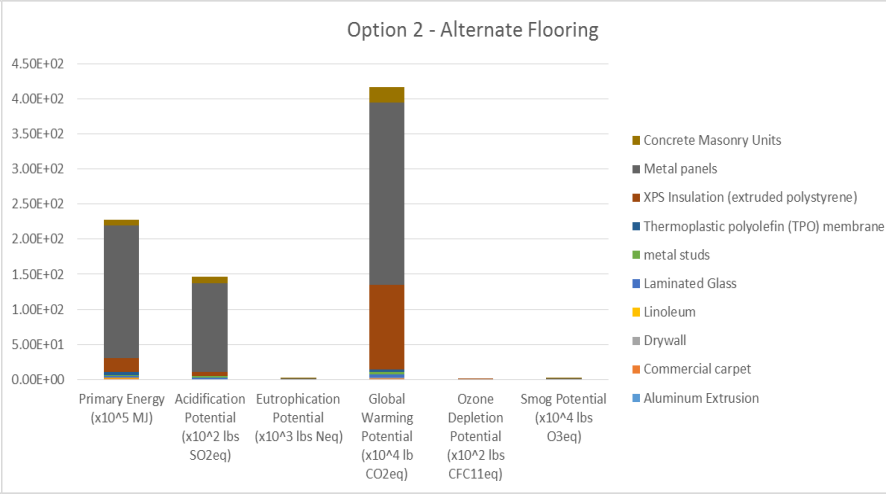


100% SD – Nonstructural materials
Quartz database analysis

Sometimes a Revit model is not available in SD… in this case, using a consistent data set is essential



Epoxy terrazzo flooring



Linoleum flooring

100% CD LCA – Low Cement Concrete

CENTRAL

Mix # 3FAE75Q2

Material Code	Description	Source Supplier	Design Quantity (lbs/cy)	Volume
Cement	ASTM C150	Lehigh Permanente	[illegible]	[illegible]
Water	ASTM C94	Potable Residence	[illegible]	[illegible]
Fly Ash	ASTM C618 Class F	SEMC Foss Cement	[illegible]	[illegible]
Coarse Aggregate	ASTM C33 #57	Hanson Plant 94 - Cruz	[illegible]	[illegible]
Fine Aggregate	ASTM C33 Fine Agg	Hanson Plant 92	[illegible]	[illegible]
Water	ASTM C1602	Central Concrete Central Concrete	[illegible]	[illegible]
Admixture	C494 TYPE A - 9218	BASF - Cleveland	[illegible]	
Admixture	C494 Type A/F - Polyheed	BASF - Cleveland	[illegible]	
		Air Target	[illegible]	[illegible]
		Totals	[illegible]	[illegible]

Fiber Reach	ASTM C494 Type B & D	[illegible]
Fiber Set	ASTM C494 Type C	[illegible]

CENTRAL

Mix # 361112C1

Material Code	Description	Source Supplier	Design Quantity (lbs/cy)	Volume
Cement	ASTM C150	Lehigh Permanente	[illegible]	[illegible]
Fly Ash	ASTM C618 Class F	SEMC Foss Cement	[illegible]	[illegible]
Coarse Aggregate	ASTM C33 #57	Hanson Plant 94 - Cruz	[illegible]	[illegible]
Fine Aggregate	ASTM C33 Fine Agg	Hanson Plant 92	[illegible]	[illegible]
Admixture	C494 TYPE A - 9218	BASF - Cleveland	[illegible]	
Water	ASTM C1602	Central Concrete Central Concrete	[illegible]	[illegible]
		Air Target	[illegible]	[illegible]
		Totals	[illegible]	[illegible]

Fiber Reach	ASTM C494 Type B & D	[illegible]
Fiber Set	ASTM C494 Type C	[illegible]

100% CD LCA – Assign Tally Materials

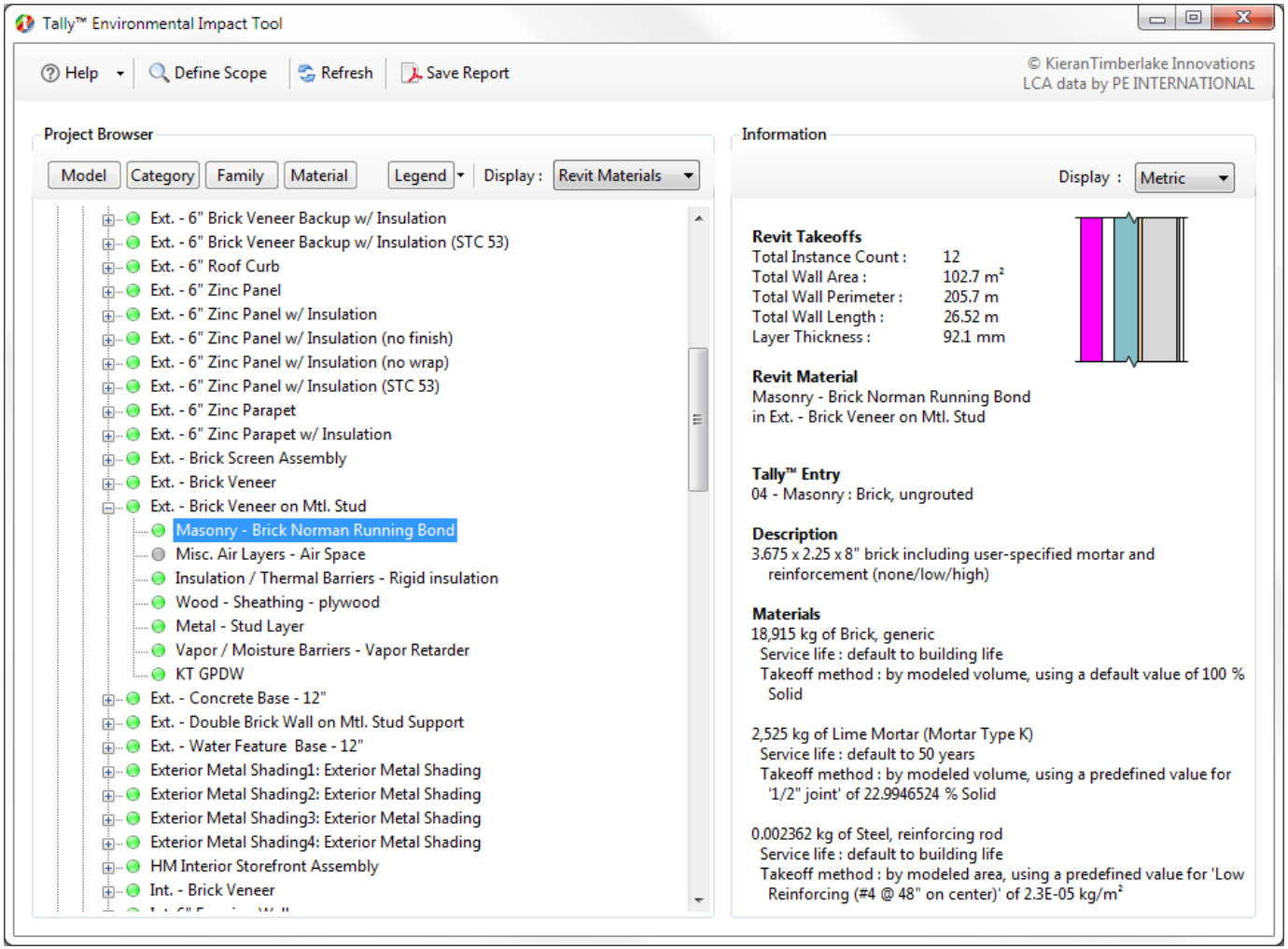
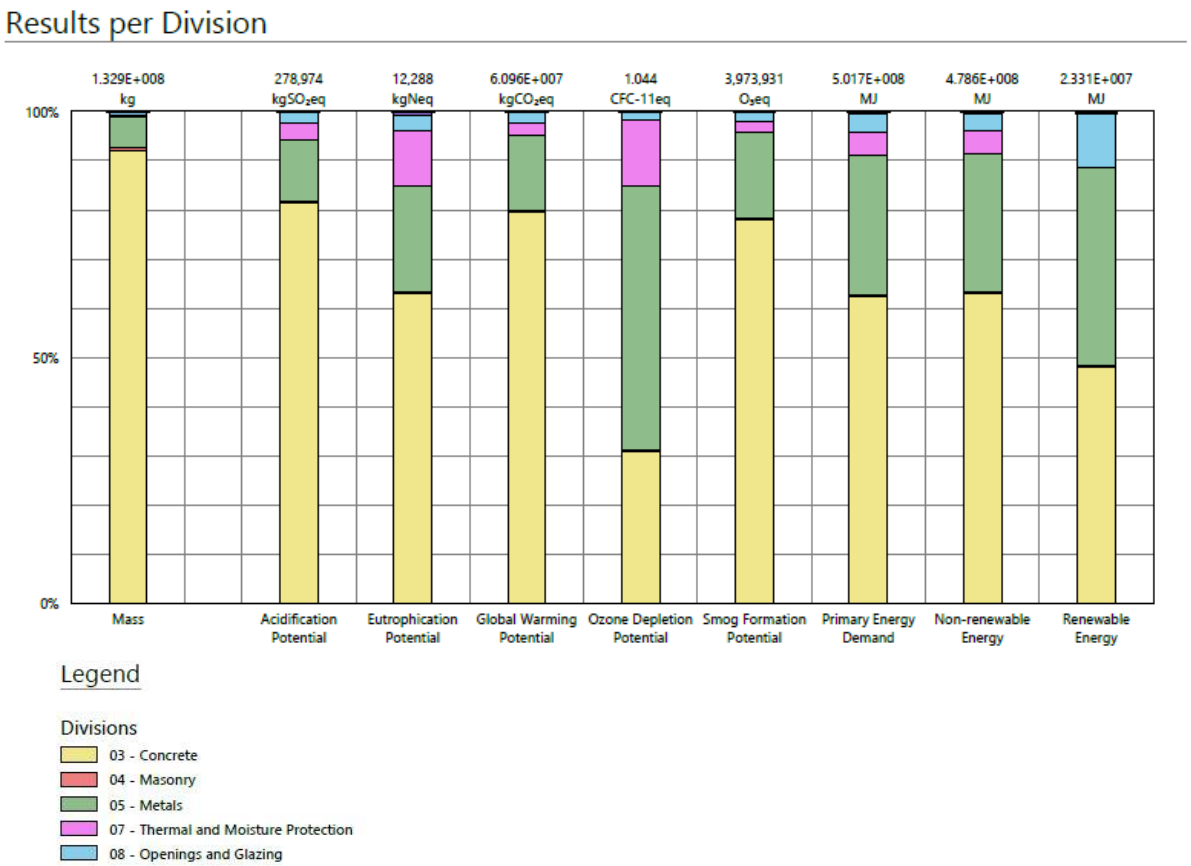
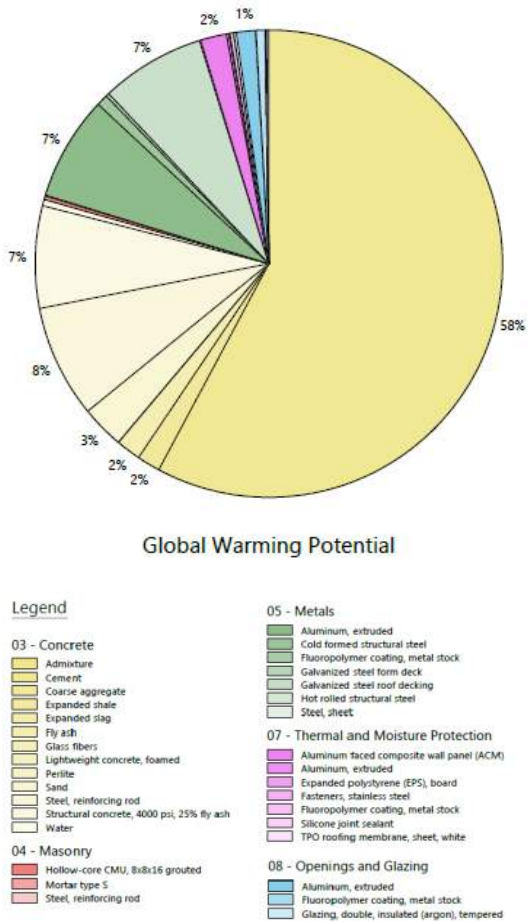


image: Autodesk

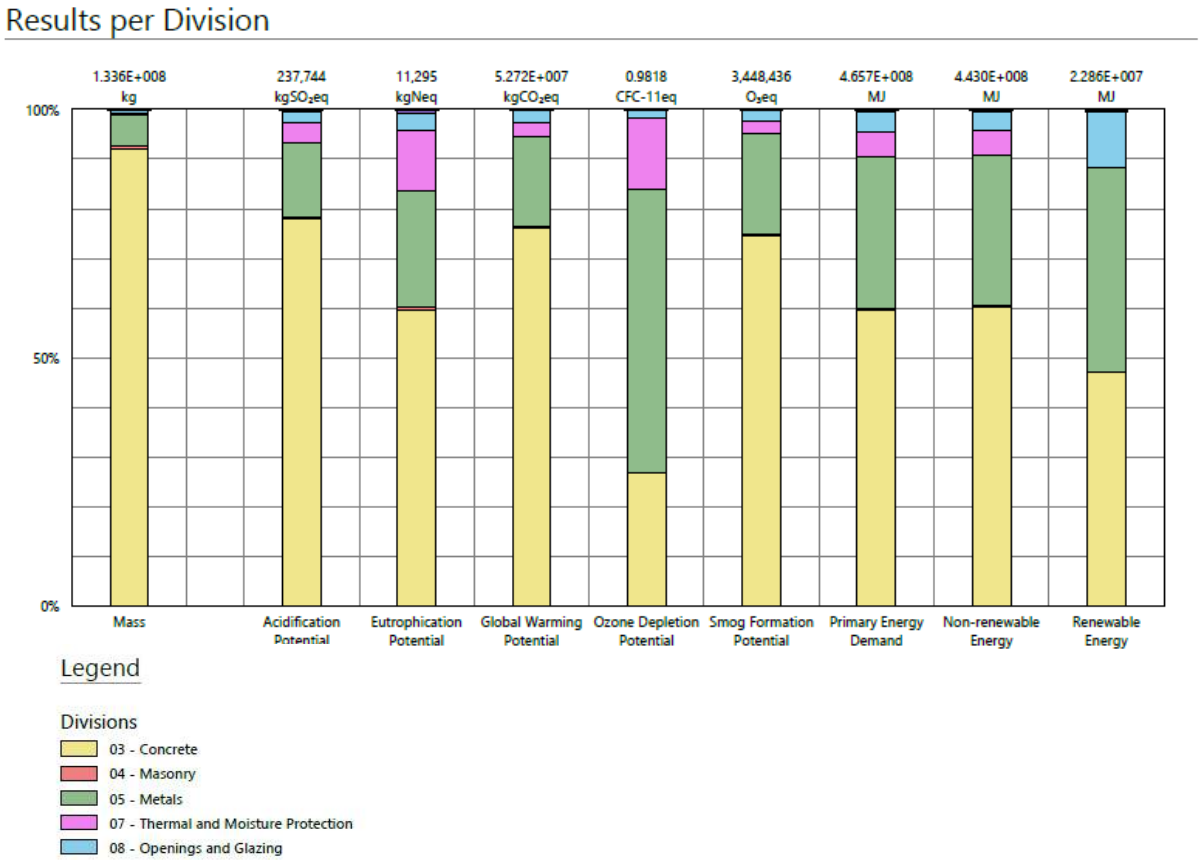
100% CD LCA – Structure and Enclosure Tally Analysis: Baseline Case

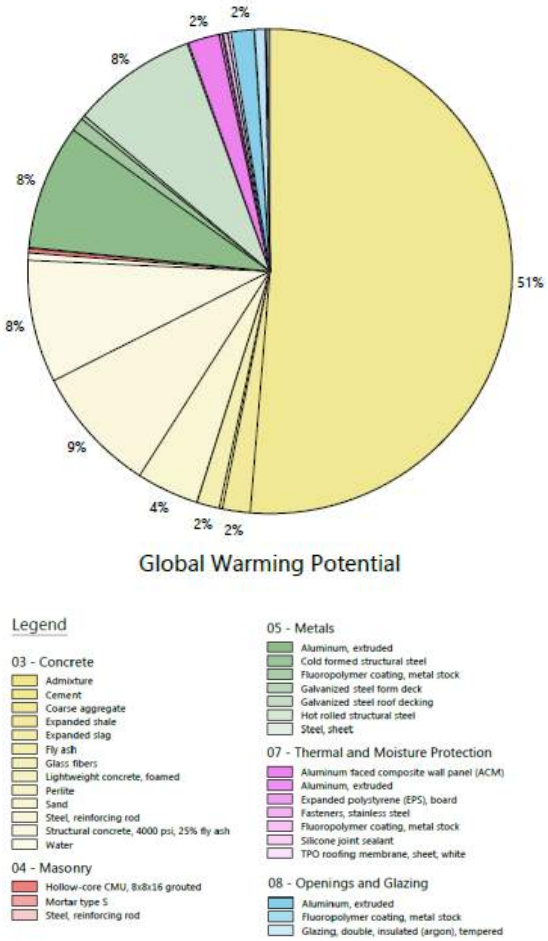




Baseline case Tally output

100% CD LCA – Structure and Enclosure Tally Analysis: Design Case

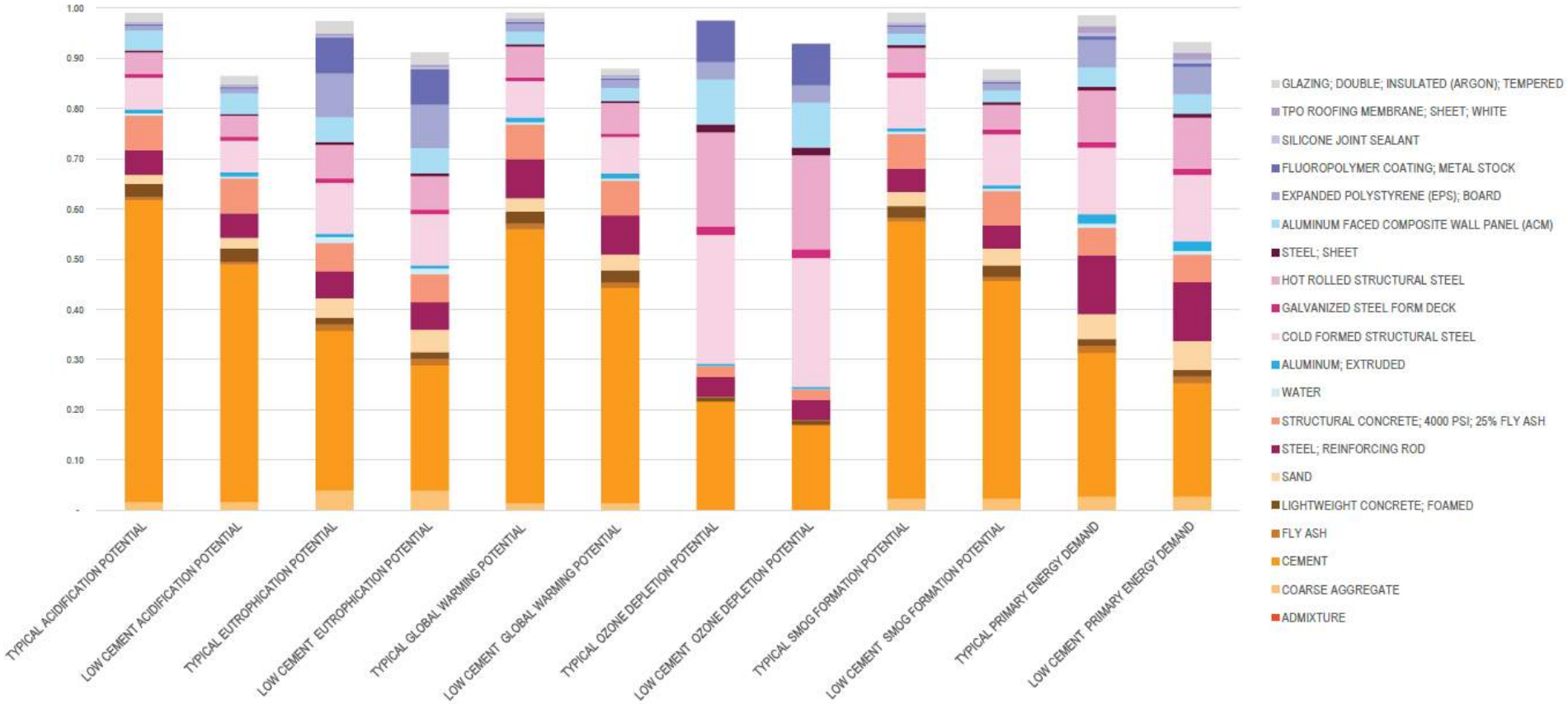




Design case Tally output

100% CD WBLCA – Tally

It can be hard to use the Design Options feature of Revit to get Tally to show side by side reports…



100% CD WBLCA – Tally

It can be hard to use the Design Options feature of Revit to get Tally to show side by side reports…

Column1	Acidification Potential	Eutrophication Potential	Global Warming Potential	Ozone Depletion Potential	Smog Formation Potential	Primary Energy Demand	Non-renewable Energy Demand	Renewable Energy Demand	Mass
	(kgSO2eq)	(kgNeq)	(kgCO2eq)	(CFC-11eq)	(kgO3eq)	(MJ)	(MJ)	(MJ)	(kg)
Baseline (typical cement mix)	320,092	15,564	69,647,095	1	4,555,735	602,722,891	576,889,241	25,928,986	139,714,746
As-Designed (low-GWP concrete mixes)	280,400	14,649	61,930,455	1	4,051,094	571,850,604	545,971,939	25,971,372	139,887,038
Design compared to baseline	**-12%**	**-6%**	**-11%**	**-5%**	**-11%**	**-5%**	**-5%**	**0%**	**0%**

Thank you!

Raphael Sperry, AIA, LEED AP BD&C ID&C, WELL AP
Associate | Sustainability
Arup | San Francisco

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ARUP

Office Building pursuing LEED Gold

Modelled with Revit model and One Click LCA

Anthony Pak

Principal

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PRIOPTA

Source of Impact Reductions

1) Concrete Mixes with higher %SCM

Element	Baseline	Proposed
Foundation Slab	25 MPa 10 GU Benchmark	25 MPa 15 GU air
Foundation Footings	35 MPa 10 GU Benchmark	35 MPa 30 GU air
Parkade Floor Slabs	35 MPa 10 GU Benchmark	35 MPa 30 GU air
Above Grade Floor Slabs	35 MPa 10 GU Benchmark	35 MPa 25 GU
Columns (P6-L2)	50 MPa 10 GU Benchmark	50 MPa 35 GU air
Columns (L2-Roof)	35 MPa 10 GU Benchmark	35 MPa 25 GU
Shear Walls (P6-L2)	40 MPa 10 GU Benchmark	40 MPa 30 GU air
Shear Walls (L2-Roof)	30 MPa 10 GU Benchmark	30 MPa 25 GU
Stairs	50 MPa 10 GU Benchmark	50 MPa 30 GU air
Exterior Walls	35 Mpa 10 GU Benchmark	35 Mpa 25 GU air
Parkade Walls	35 MPa 10 GU Benchmark	35 MPa 30 GU air
Roof	35 MPa 10 GU Benchmark	35 MPa 25 GU air

2) Post Tensioned (PT) Slabs

Compared to similar past project, post tensioned slabs compared to conventionally reinforced slabs of similar spans, loading, and strength specifications:

11” conventional = 9” PT
15” conventional = 12” PT

No increase in cement content in concrete mixes for PT slabs

Environmental Product Declarations (EPD)

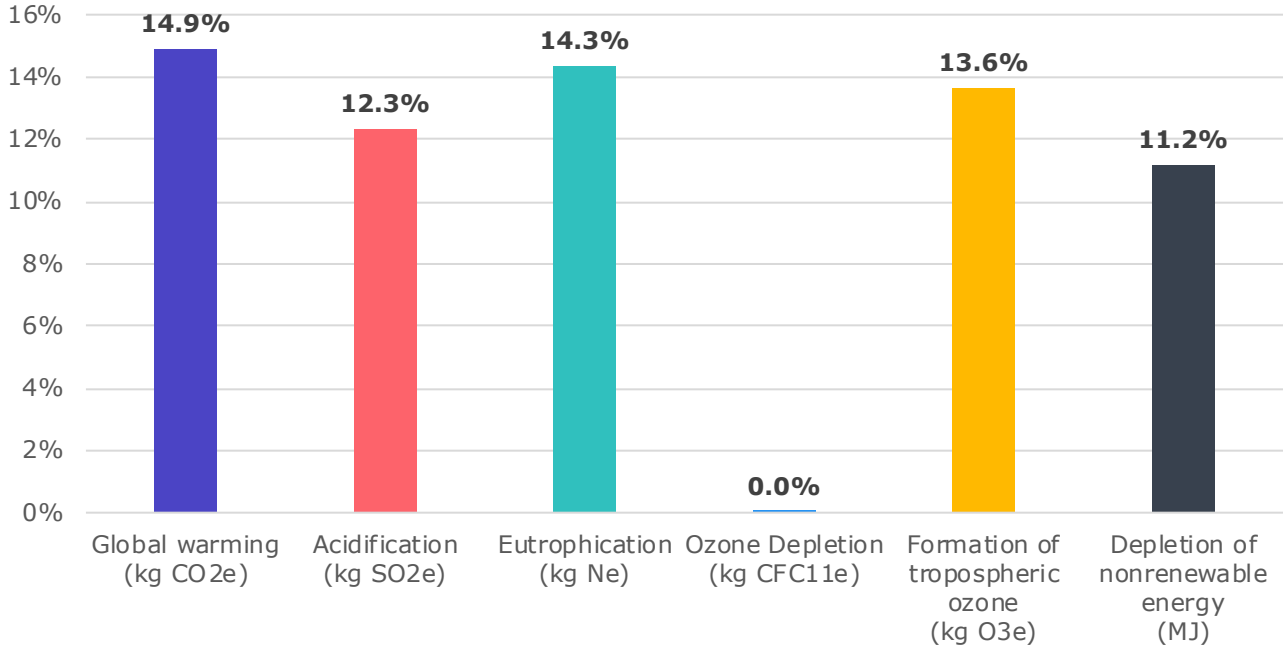
Legend
No EPD available. Generic LCI data.
Industry Average EPD
Manufacturer Specific EPD (May not be what is specified)

Select relevant North American industry average EPDs instead of generic material datapoints from One Click LCA where available.

Adjust default concrete transportation distances from 200km to 40km.

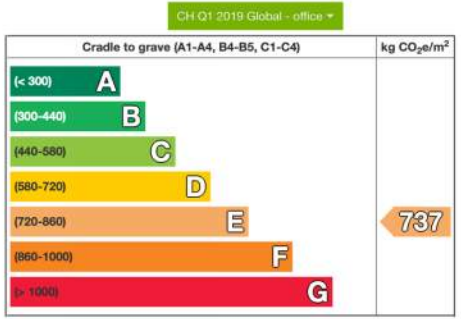
Resource name	Country	Product	Density	Date	Environment Data Source	Standard	EPD number	EPD program	Manufacturer	PCR	Notes about PCR	Technical specification	Upstream database
Aggregate (crushed gravel), generic	[LOCAL]		1,600	2016	One Click LCA	EN15804	-	One Click LCA		EN15804			ecoinvent
Air and water barrier system, mechanically fastened	[USA]	Tyvek		2017	EPD Tyvek® Fluid Applied Weather Barrier Systems	ISO14044	4787001 0016.101.1	UL Environment	DuPont	UL Part A v1.3 & Part B joint compound EPD requirements (2016)	Only with ISO14040	0.184 lbs/ft2	GaBi
Aluminum facade, cold-rolled plate	[North America]		2,753	2014	Cold-Rolled Aluminum Plates, Aluminum Association 2014	EN15804	4786001 2004.101.1	UL Environment	Aluminum Association	Products of Aluminum and Aluminum Alloys (BIL: July 2012)	Only with EN15804	2685-2840 kg/m3	GaBi
Asphalt, generic	[LOCAL]		2,358	2016	One Click LCA	EN15804	-	One Click LCA		EN15804		5/95/95 bitumen-aggregate ratio	ecoinvent
Carpet	[USA]		577	2015	Quartz 2015	ISO14044	CP152	Quartz		LCIA: TRACI 2.1, GWP IPCC 2013	LCIA: TRACI 2.1, GWP IPCC 2013	0.69m	GaBi
Concrete masonry unit, normal-weight	[canada]		2,250	2016	EPD Normal-weight and light-weight concrete masonry units as manufactured by members of the Canadian Concrete Masonry Producers Association (CCMPA)	ISO14044	EPD-043	ASTM	CCMPA	PCR ASTM International, for Preparing an Environmental Product Declaration for Manufactured Concrete and Concrete Masonry Products	Only with ISO14040	T: 90/145/190/140/190 mm, 390/mi/190 mm, 2000 kg/m3	ecoinvent, USLCI
EPS insulation	[USA]			2017		ISO14044	4787215 8161.101.1	UL Environment	EPS Industry Alliance	UL PCR: Building Envelope Thermal and Mechanical Insulation v1.4 2016	Only with ISO14044	Sample: 0.0401 W/mK, t = 4.01 centimeter (1.58 in), RB = 1.m²K/W (R-value 5.68)	ecoinvent
Float glass, single pane, generic	[LOCAL]		2,500	2016	One Click LCA	EN15804	-	One Click LCA		EN15804		8 - 12 mm, 10 kg/m2 (for 4 mm), 2500 kg/m3	ecoinvent
Glass wool blowing insulation	[USA]	Johnson Ultra Blowing Wool Insulation	9	2013	Johnson Ultra Blowing Wool Insulation, Knauf Insulation 2013	ISO14044	4786001 8364.101.1	UL Environment	Knauf Insulation	PCR Building Envelope Thermal Insulation v1.2 (UL 2013)	Only with ISO14044	R19	GaBi
Gypsum board with glass mat sheathing	[USA, canada]		1,716	2016	EPD Gypsum Association Industry Average EPD for Glass Mat Gypsum Panels	ISO14044	EPD-038	ASTM	Gypsum Association	PCR ASTM International, Product Category Rules for Preparing an Environmental Product Declaration for Glass Mat Gypsum Panels, August 2016	Only with ISO14040	1/2in, 2.25 lb/ft2	ecoinvent, USLCI
Gypsum board, wallboard, type X, 0.625 inch (16 mm)	[north America]		640	2014	North American Gypsum Boards, Typical (5/8 Type X), Gypsum Association 2014	ISO14044	EPD(USA) 01/2014	EPInnovations	Gypsum Association	PCR for North American Gypsum Boards, Gypsum PCR-2013 v1 (EPInnovations 2013)	Only with ISO14044 TRACI 2.1 units only	1/4in	ecoinvent
Hollow structural steel sections	[USA]		7,800	2016	EPD Fabricated hollow structural sections American Institute of Steel Construction Steel Tube Institute	ISO14044	4786871 9001.101.1	UL Environment	AISC, STI	North American PCR for Designated Steel Construction Products (BCS, 2015)	Only with ISO14040	4X7 lbs./ft3	GaBi
ISO foam insulation	[north America]	Thermax insulation	41	2014	Tuff-R and Thermax Insulation, Rmax 2014	ISO14044	4786101 5271.101.1	UL Environment	Dow	Product Category Rules for preparing an environmental product declaration (EPD) for Product Group: Building Envelope Thermal Insulation	Only with EN15804	0.5-4.25in	ecoinvent
Liquid-applied moisture barrier	[USA]		993	2015	Quartz 2015	ISO14044	CP082	Quartz		LCIA: TRACI 2.1, GWP IPCC 2013	LCIA: TRACI 2.1, GWP IPCC 2013	0.04in	GaBi
Mill finished aluminum extrusions	[USA, canada]		2,703	2016	EPD Aluminum Extrusions	EN15804	112403 57.101.1	UL Environment	Aluminum Extruders Council (AEC)	Requirements on the EPD for windows and doors (BIL: V1.7, 06.11.2014),	Only with EN15804		GaBi
PVC waterproofing roof membrane, single-ply	[USA, canada]	Sure-Flex PVC Roofing Membrane	1,260	2016	Sure-Flex PVC Membrane, Carlisle 2016	ISO14044	EPD0240	ASTM	Carlisle SynTec Systems	PCR for Preparing an EPD for Single-Ply Roofing Membranes	Only with EN15804	50 mil, 0.22 lbs/ft2	USLCI
PVC polyester waterproofing roof membrane, single-ply	[north America]		1,118	2014	Single-ply polyester reinforced roofing membranes, CPA 2014	ISO14044	EPD-035	ASTM	Chemical Fabrics and Film Association	ASTM, Product Category Rules for Preparing and Environmental Product Declaration for Single-Ply Roofing Membrane, November 2013	Only with EN15804 TRACI 2.1 units only	40 mil	USLCI
Panels	[canada]	Cinder gray	1,300	2016	EPD CASMA SLABS AND BOULEVARD PAVERS	ISO14044	7163-3648	CSA Group	Permacon	PCR for Segmental Concrete Paving Products. ASTM International April, 2015 to March, 2020	Only with EN15804	1.19 sq. m, T min 3.86 in, 2300 kg/m3	ecoinvent
Primary structural steel frame components	[USA]		7,833	2016	Primary structural steel frame components, MBMA 2016	ISO14044	4786171 4398.101.1	UL Environment	MBMA	SCS Global Services (2015). North American Product Category Rule for Designated Steel Construction Products. V1.0	Only with EN15804		USLCI
Ready-mix concrete	[canada]		2,400	2012	EPD READY-MIXED CONCRETE CRMCA Member Industry-Wide EPD for Canadian	EN15804	EPD190-R2	NSF	CRMCA	(PCR) for ISO 14025 Type III Environmental Product Declarations (EPDs) for Concrete Version 1.1 dated December 4, 2012.	Only with EN15804	21MPa OU cem. with air ent. 15-20% SA	USLCI
Ready-mix concrete	[canada]		2,400	2012	EPD READY-MIXED CONCRETE CRMCA Member Industry-Wide EPD for Canadian	EN15804	EPD190-R2	NSF	CRMCA	(PCR) for ISO 14025 Type III Environmental Product Declarations (EPDs) for Concrete Version 1.1 dated December 4, 2012.	Only with EN15804	35MPa OU cem. with air ent. 30-40% FA	USLCI
Ready-mix concrete	[canada]		2,400	2012	EPD READY-MIXED CONCRETE CRMCA Member Industry-Wide EPD for Canadian	EN15804	EPD190-R2	NSF	CRMCA	(PCR) for ISO 14025 Type III Environmental Product Declarations (EPDs) for Concrete Version 1.1 dated December 4, 2012.	Only with EN15804	35MPa OU cem. with air ent. 25-34% SC	USLCI
Ready-mix concrete	[canada]		2,400	2012	EPD READY-MIXED CONCRETE CRMCA Member Industry-Wide EPD for Canadian	EN15804	EPD190-R2	NSF	CRMCA	(PCR) for ISO 14025 Type III Environmental Product Declarations (EPDs) for Concrete Version 1.1 dated December 4, 2012.	Only with EN15804	35MPa OU cem. without air ent. 25-34% SC	USLCI
Ready-mix concrete	[canada]		2,400	2012	EPD READY-MIXED CONCRETE CRMCA Member Industry-Wide EPD for Canadian	EN15804	EPD190-R2	NSF	CRMCA	(PCR) for ISO 14025 Type III Environmental Product Declarations (EPDs) for Concrete Version 1.1 dated December 4, 2012.	Only with EN15804	10MPa OU cem. with air ent. 35-50% SC	USLCI
Ready-mix concrete	[canada]		2,400	2012	EPD READY-MIXED CONCRETE CRMCA Member Industry-Wide EPD for Canadian	EN15804	EPD190-R2	NSF	CRMCA	(PCR) for ISO 14025 Type III Environmental Product Declarations (EPDs) for Concrete Version 1.1 dated December 4, 2012.	Only with EN15804	15MPa OU cem. without air ent. 25-34% SC	USLCI
Ready-mix concrete	[canada]		2,400	2012	EPD READY-MIXED CONCRETE CRMCA Member Industry-Wide EPD for Canadian	EN15804	EPD190-R2	NSF	CRMCA	(PCR) for ISO 14025 Type III Environmental Product Declarations (EPDs) for Concrete Version 1.1 dated December 4, 2012.	Only with EN15804	35MPa OU cem. with air ent. 30-40%FA/SA	USLCI
Ready-mix concrete	[canada]		2,400	2012	EPD READY-MIXED CONCRETE CRMCA Member Industry-Wide EPD for Canadian	EN15804	EPD190-R2	NSF	CRMCA	(PCR) for ISO 14025 Type III Environmental Product Declarations (EPDs) for Concrete Version 1.1 dated December 4, 2012.	Only with EN15804	50MPa OU cem. with air ent. 35-40% FA	USLCI
Reinforcement steel bar	[north America]		7,850	2017	EPD Fabricated Steel Reinforcement	ISO14044	EPD-076	ASTM	CRSI	North American Product Category Rule for Designated Steel Construction Products	Only with ISO14040	490 lb/ft3	GaBi
Rock wool insulation panels, unfaced, generic	[LOCAL]		50	2016	One Click LCA	EN15804	-	One Click LCA		EN15804		1 = 0.0343 W/mK, 50 kg/m3 (applicable for densities: 25-50 kg/m3)	ecoinvent
Safety glass	[north America]	Keralite F, Keralite L, Keralite Select F, Keralite Select L	2,584	2014	Keralite Fire Rated Safety Glass Cerame, Vetrotech 2014	ISO14044	4786041 4398.101.1	UL Environment	Vetrotech Saint-Gobain	LIMA PCR for Flat Glass - UN CPC 3711	Only with EN15804	1/2 and 5/16 in, 12 2/3 lb/ft2	GaBi
Softwood plywood	[north America]		491	2012	North American Softwood Plywood, American and Canadian Wood Councils 2012	ISO14025	12CA24 584.101.3	UL Environment	American Wood Council Canadian Wood Council	PCR for preparing an Environmental Product Declaration for North American Structural and Architectural Wood Products, Version 1, November 8, 2011 (FP Innovations 2011)	Bogarde (15) separated	715.79 kg/m3	USLCI
Solid sheet steel for studs, industry average US and CN	[north America]		7,843	2015	EPD industry-wide Cold-formed Steel Studs and Track manufactured in U.S. and Canada	ISO14044	SCS-EPD-03018	SCS Global	SBI	North American Product Category Rule for Designated Steel Construction Products, v1.0	Only with EN15804 TRACI 2.1 units only	19 S/8in-14in x19, 1/4in x 5ft 1/2in x0.0188in x 1/24in	USLCI
Steel framing systems, solid	[north America]	Dietrich, Joists, Footwalls, Vipersteel	7,850	2015	Steel Framing Systems, Marino Ware 2015	ISO14044	4786791 5523.101.1	UL Environment	Marino Ware	North American PCR for Designated Steel Construction Products (SCS, 2015)	Only with EN15804		GaBi
Steel roof and floor deck	[north America]		7,850	2016	Steel roof and floor deck, Steel Deck Institute 2016	ISO14044	4786011 2892.101.1	UL Environment	Steel Deck Institute	SCS PCR for Designated Steel Construction Products, v1.0 May 2016	Only with EN15804	22-16 gauge	GaBi
Steel stud framing for drywall@gypsum-placterboard per sq. meter of wall area (incl. air gaps per m3)	[USA]		34	2012	LCA based on NRB, data for steel product, primary structural, beams and columns, at plant (U.S. Life Cycle Inventory Database 2012)	ISO14044	-	-			Only with EN15804	C-profile: 2 1/2 x 1 - 1/5 inch, gauge 25, 10 ft height x 24 inch (60 cm) spacing	USLCI
Steel stud framing for drywall@gypsum-placterboard per sq. meter of wall area (incl. air gaps per m3)	[USA]		82	2012	LCA based on NRB, data for steel product, primary structural, beams and columns, at plant (U.S. Life Cycle Inventory Database 2012)	ISO14044	-	-			Only with EN15804	C-profile: 6 x 3 inch, gauge 20, 10 ft height x 16 inch (40 cm) spacing	USLCI
Steel stud framing for drywall@gypsum-placterboard per sq. meter of wall area (incl. air gaps per m3)	[USA]		58	2012	LCA based on NRB, data for steel product, primary structural, beams and columns, at plant (U.S. Life Cycle Inventory Database 2012)	ISO14044	-	-			Only with EN15804	C-profile: 6 x 3 inch, gauge 20, 10 ft height x 24 inch (60 cm) spacing	USLCI
Steel stud framing for drywall@gypsum-placterboard per sq. meter of wall area (incl. air gaps per m3)	[USA]		33	2012	LCA based on NRB, data for steel product, primary structural, beams and columns, at plant (U.S. Life Cycle Inventory Database 2012)	ISO14044	-	-			Only with EN15804	C-profile: 3-5/8 x 1 - 1/5 inch, gauge 25, 10 ft height x 24 inch (60 cm) spacing	USLCI
Steel stud framing for drywall@gypsum-placterboard per sq. meter of wall area (incl. air gaps per m3)	[USA]		47	2012	LCA based on NRB, data for steel product, primary structural, beams and columns, at plant (U.S. Life Cycle Inventory Database 2012)	ISO14044	-	-			Only with EN15804	C-profile: 3-5/8 x 1 - 1/5 inch, gauge 25, 10 ft height x 16 inch (40 cm) spacing	USLCI
Steel stud framing for drywall@gypsum-placterboard per sq. meter of wall area (incl. air gaps per m3)	[USA]		34	2012	LCA based on NRB, data for steel product, primary structural, beams and columns, at plant (U.S. Life Cycle Inventory Database 2012)	ISO14044	-	-			Only with EN15804	C-profile: 4 x 2 inch, gauge 25, 10 ft height x 24 inch (60 cm) spacing	USLCI
Steel swing door	[canada]			2017	EPD AMBICO Steel Door	ISO14044	EPD-040	ASTM	Ambico	Underwriters Laboratory Product Category Rule (PCR) for Preparing an Environmental Product Declaration (EPD) for Product Group Commercial Steel Doors and/or Steel Frames, Version (March 10, 2016)	Only with ISO14040	1x7 ft, 1-3/4in	ecoinvent, USLCI
Steel, structural, beams and columns	[USA]		7,850	2012	LCA based on NRB, data for steel product, primary structural, beams and columns, at plant (U.S. Life Cycle Inventory Database 2012)	ISO14044	-	-		NRB	Only with EN15804		USLCI
Thermally improved aluminum extrusions (profiles), not finished	[USA, canada]		2,703	2016	EPD Thermally Improved Aluminum Extrusions	EN15804	112403 57.101.1	UL Environment	Aluminum Extruders Council (AEC)	Requirements on the EPD for windows and doors (BIL: V1.7, 06.11.2014),	Only with EN15804		GaBi

Proposed Building Reductions –

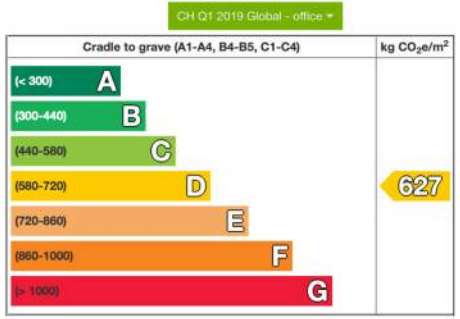


Carbon Heroes Embodied Carbon Benchmark
(kgCO2e/m2)

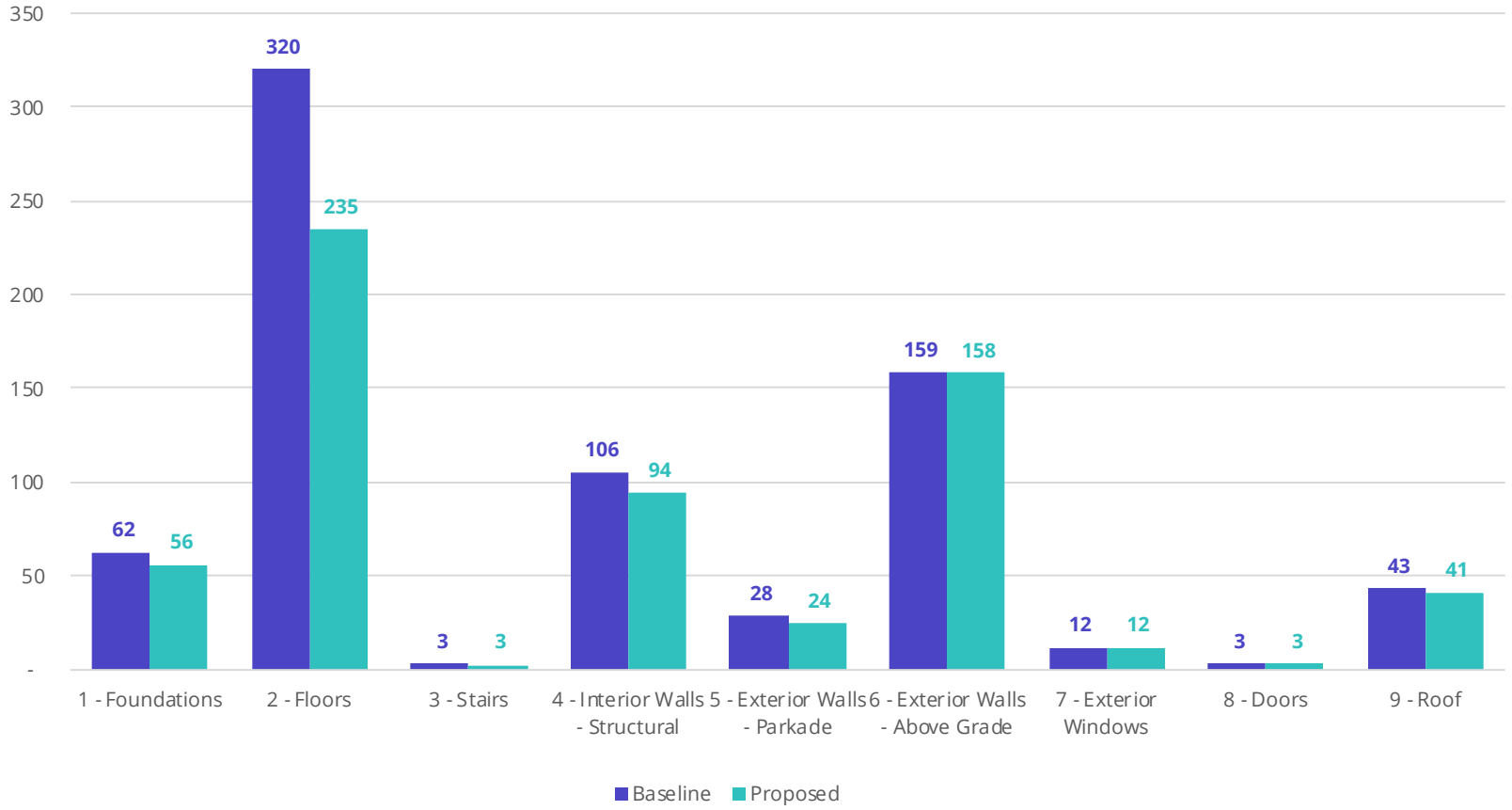
Baseline Building



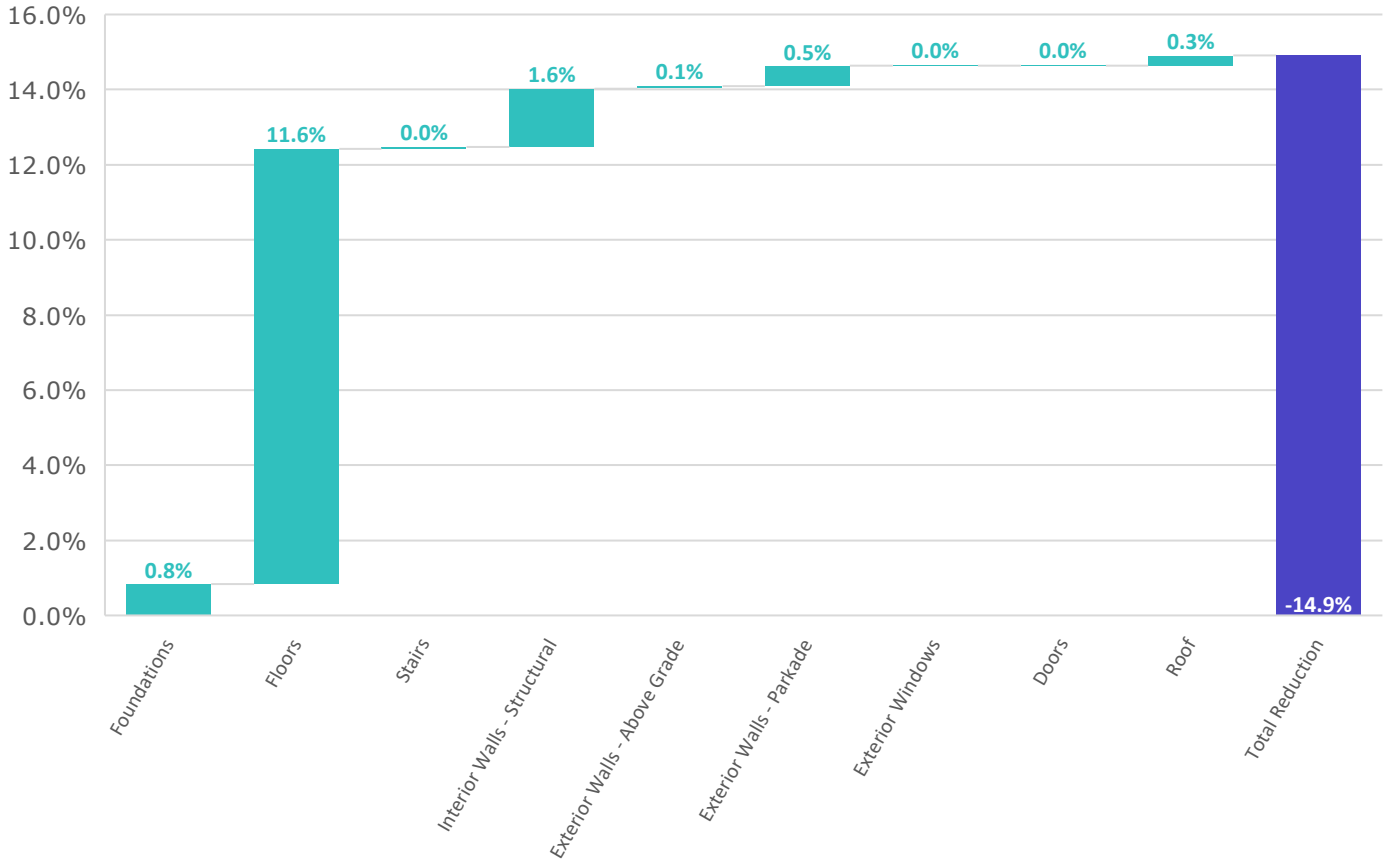
Proposed Building



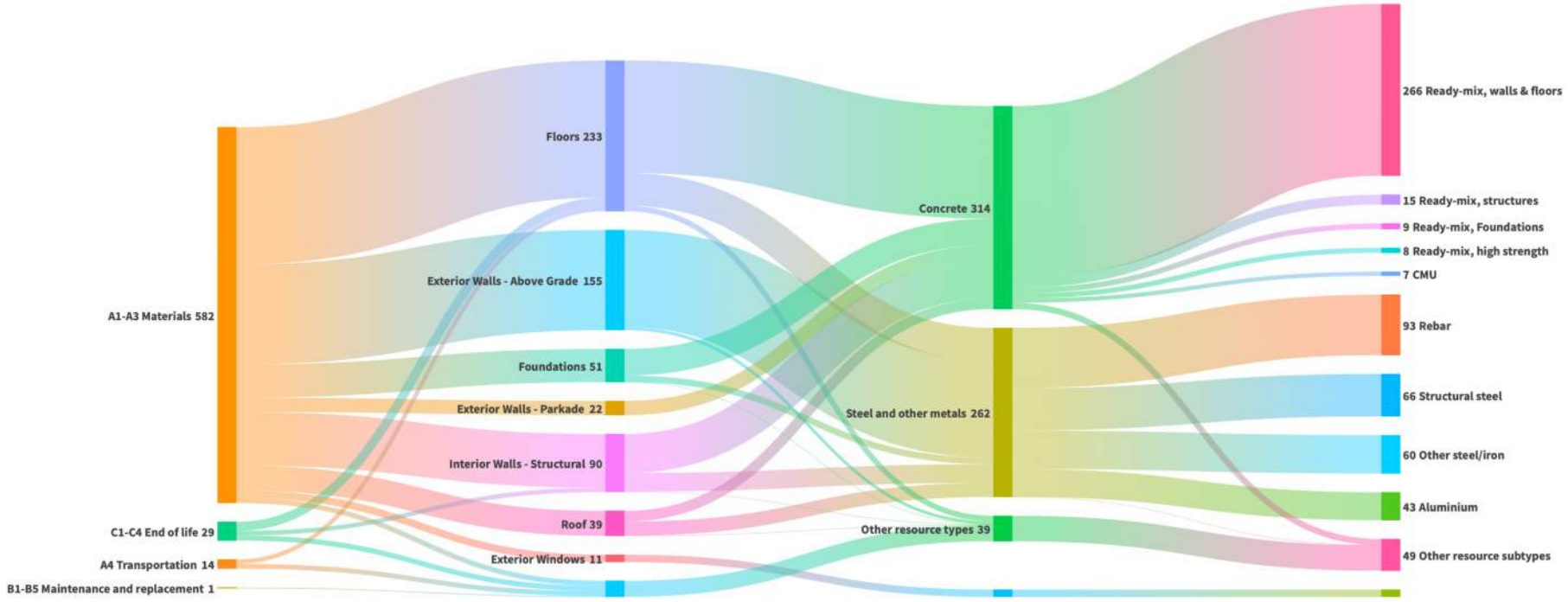
GWP by Assembly ($kgCO_2e/m^2$)



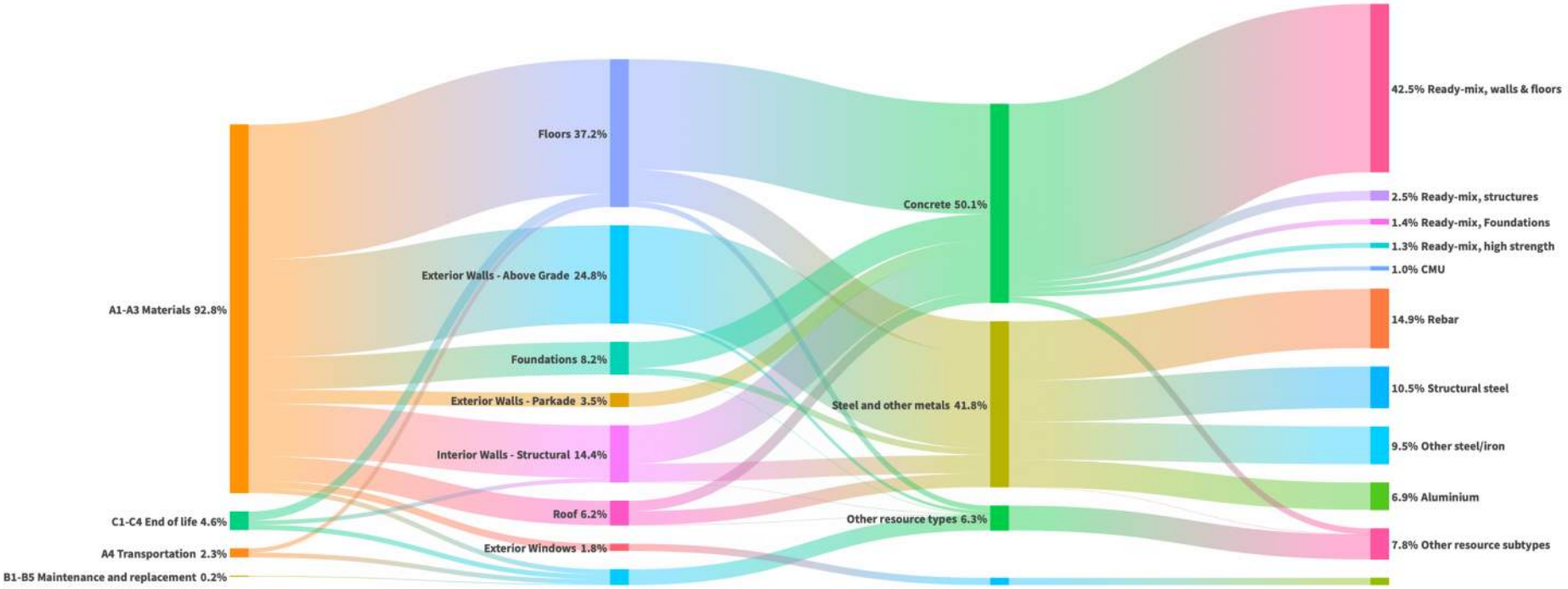
GWP – Breakdown of Reductions



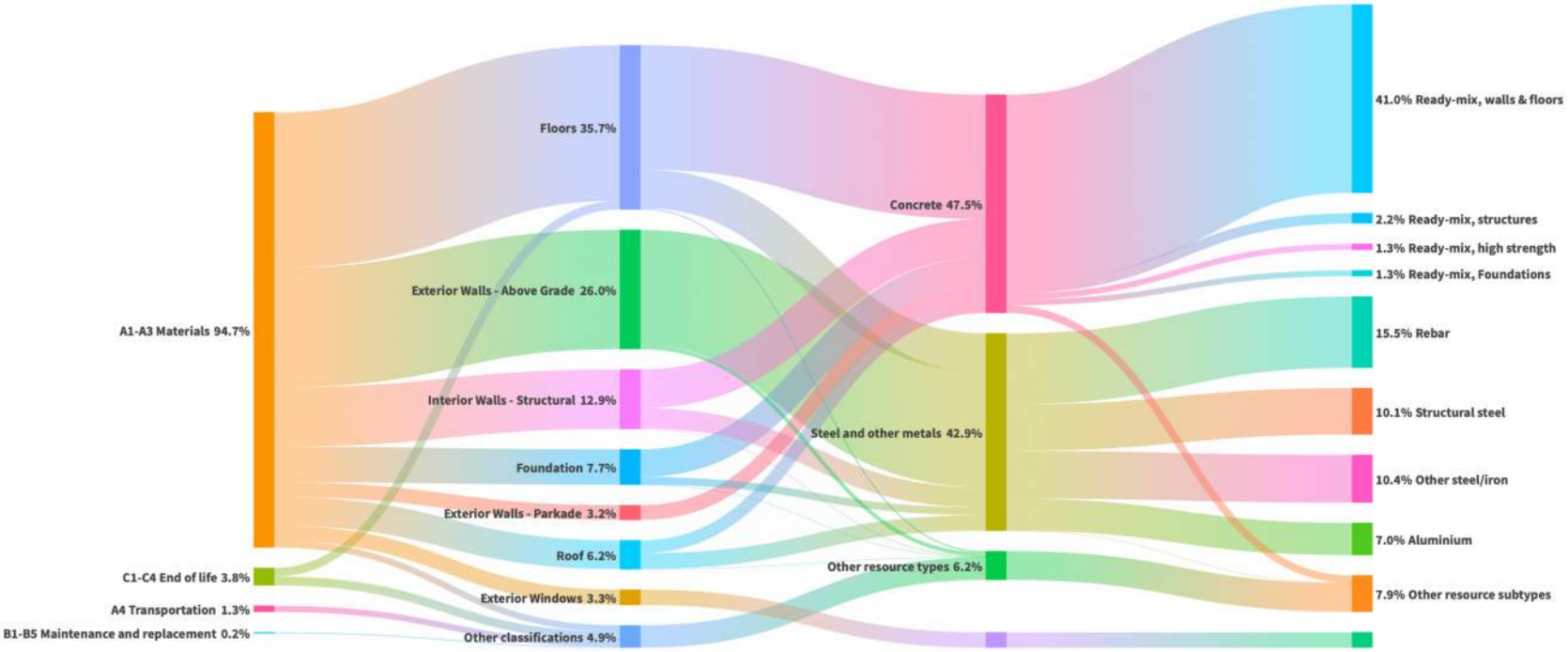
Global Warming Potential - Proposed
(kg CO_2e/m^2)



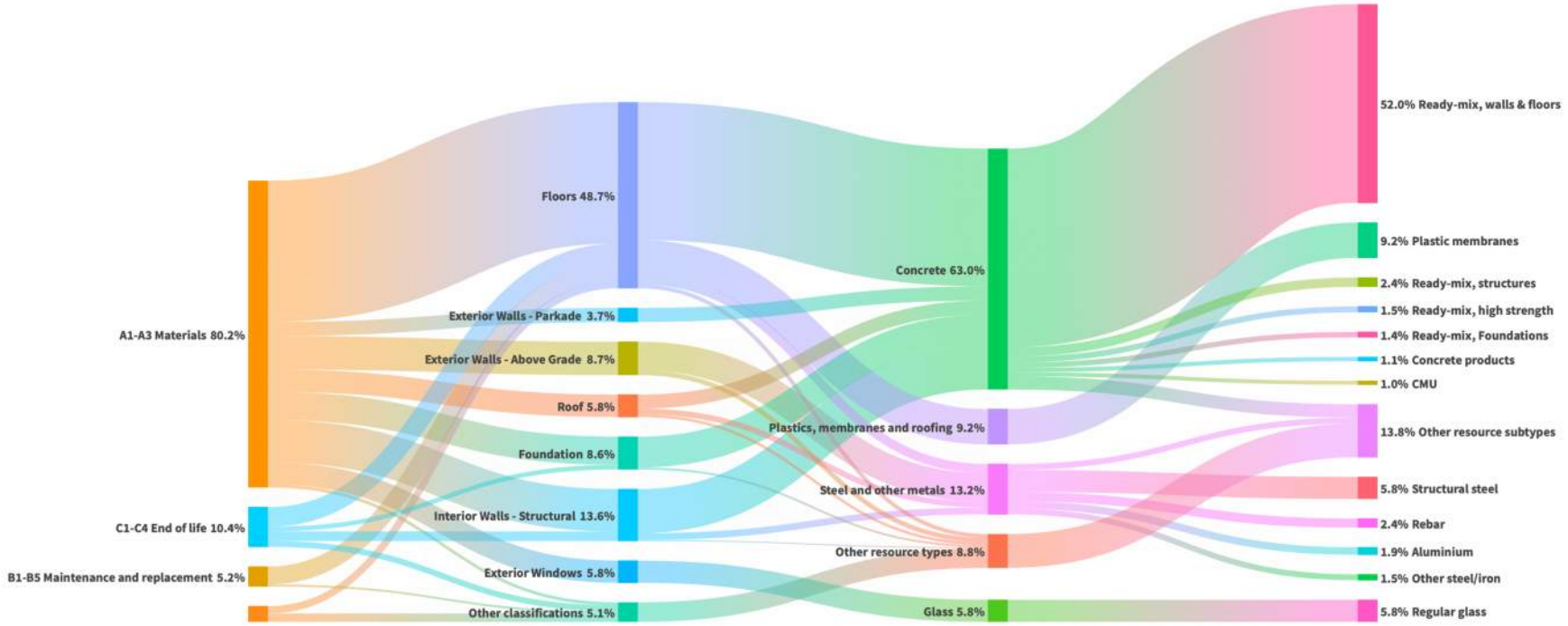
Global Warming Potential



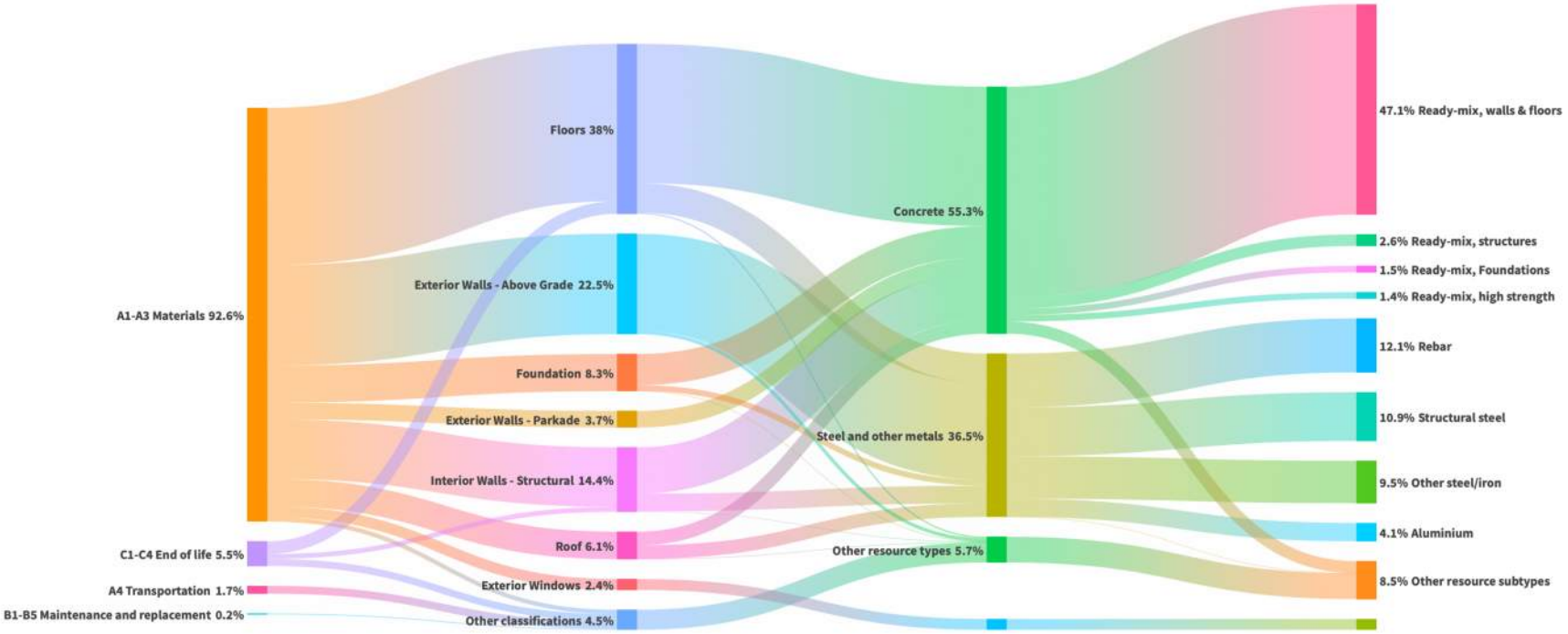
Acidification Potential



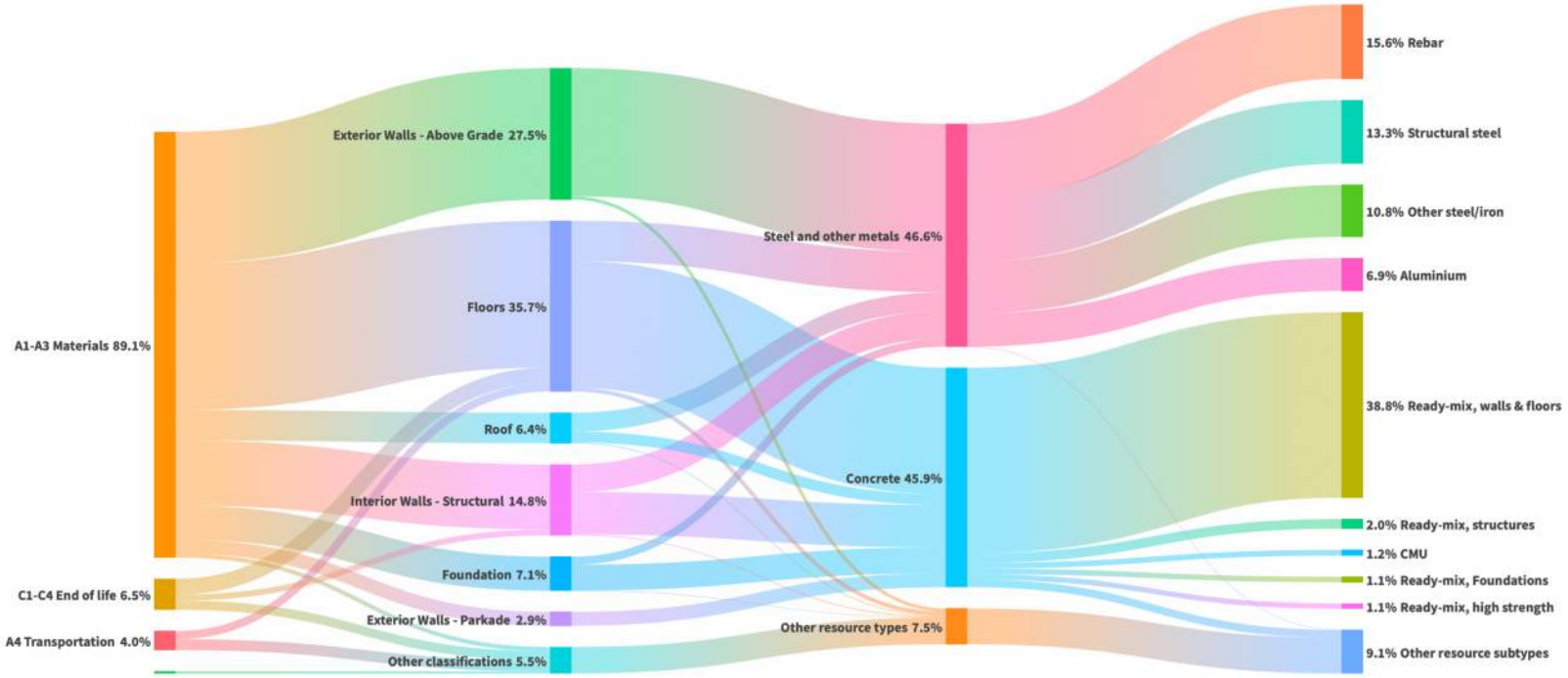
Eutrophication Potential



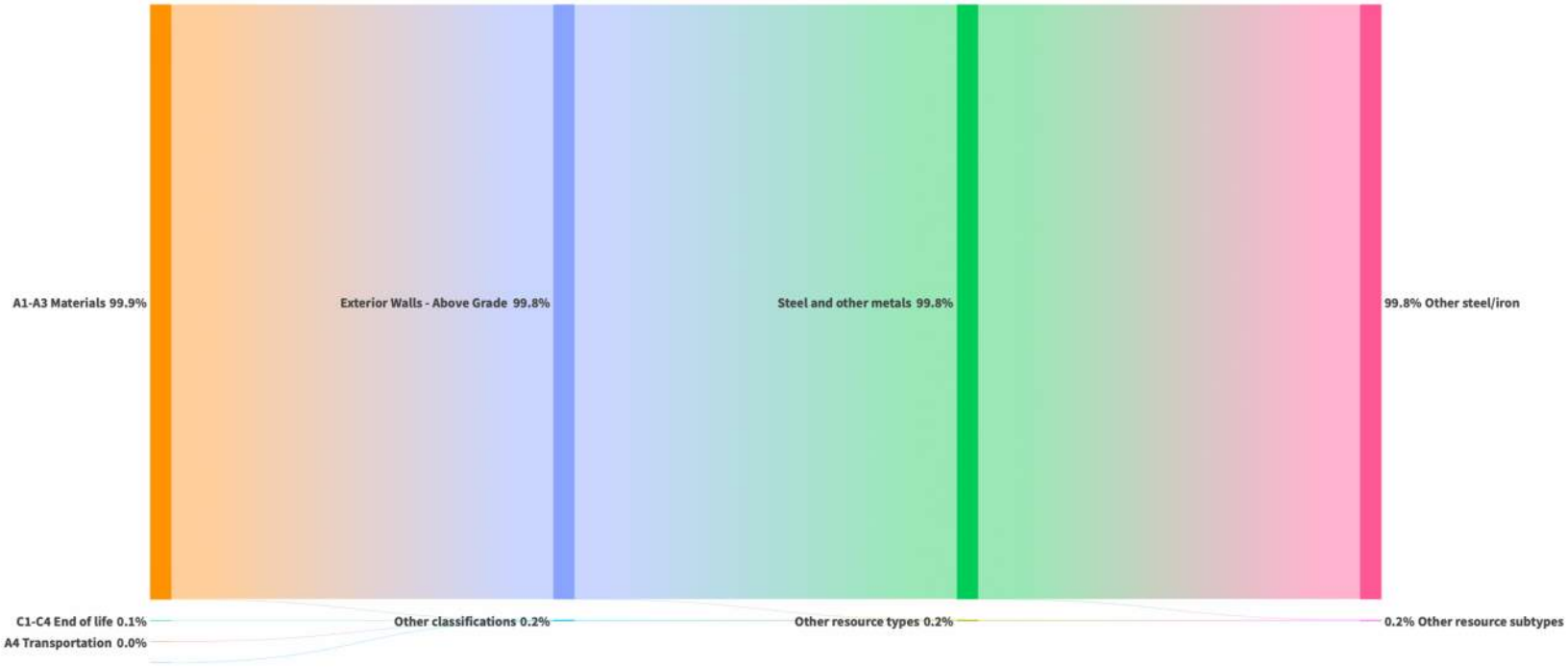
Smog Formation Potential



Non-Renewable Energy Use



Ozone Depletion Potential



Thank You

Anthony Pak

Principal

anthony@priopta.com

PRIOPTA

WBLCA Workflow and Concrete

Baha Sadreddin

High-Performance Design Specialist

ZGF Architects

ZGF

ZIMMER GUNSUL FRASCA ARCHITECTS LLP

Why LCA?

Total global CO2 emissions

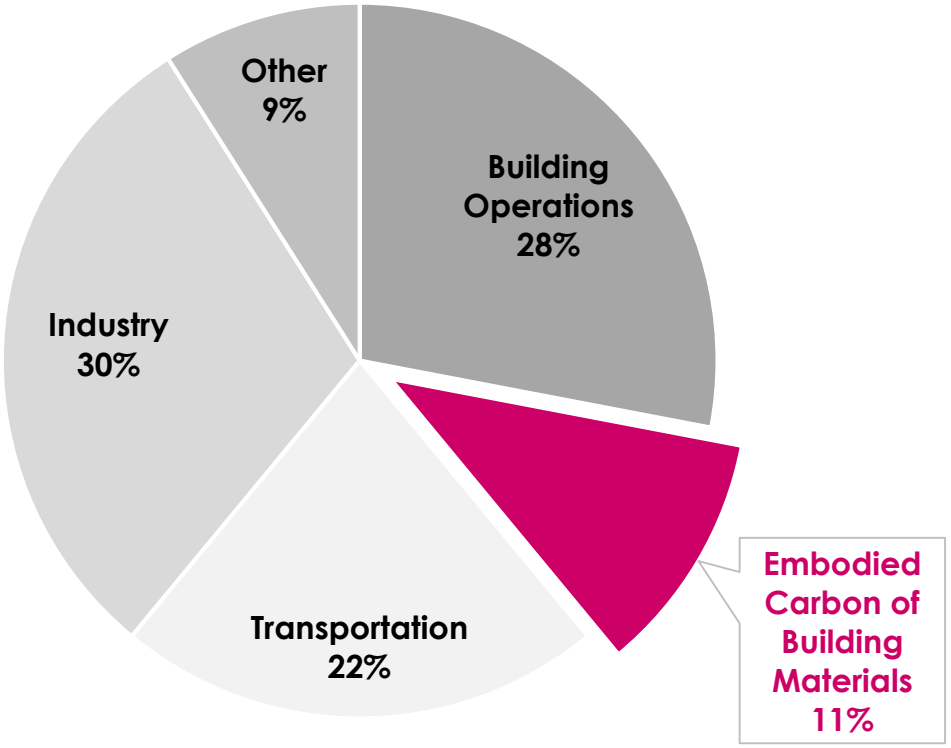
Building operations

= 28% of global GHG emissions

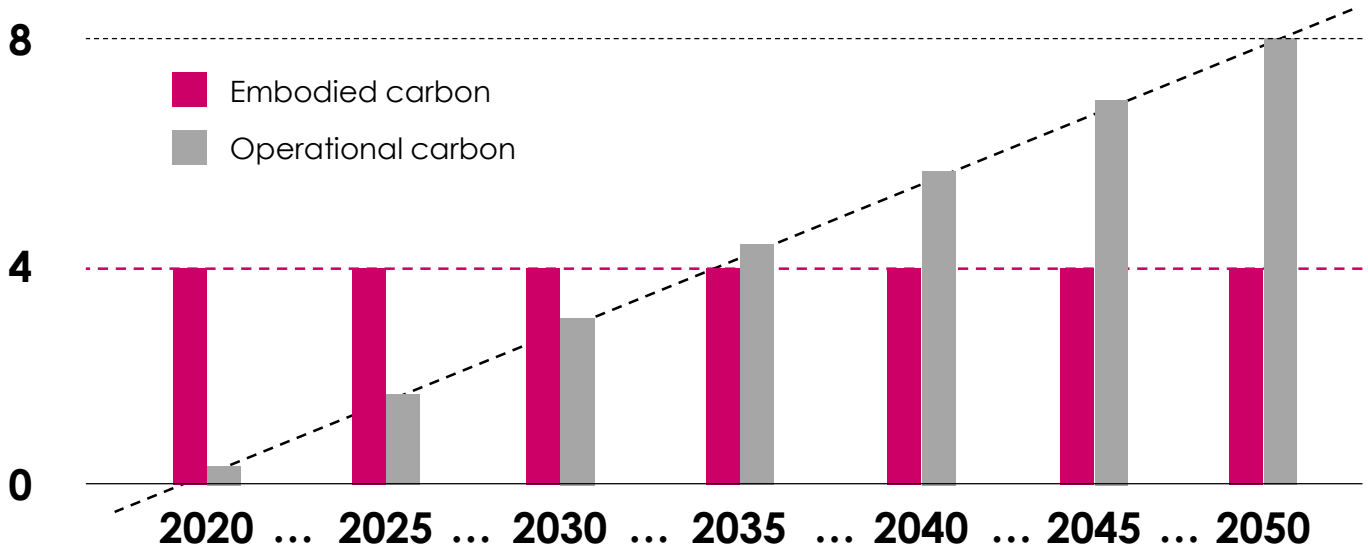
Embodied carbon of building materials

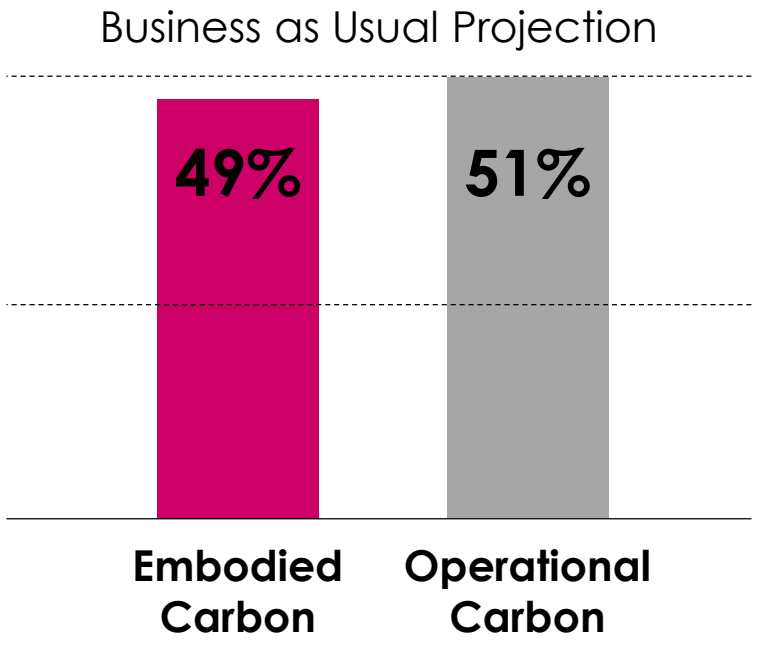
= 11% of global GHG emissions

Global Co2 Emissions by Sector



Source: original graphic from Architecture 2030, UN Environment Global Status Report 2017





Annual New Construction Carbon Emissions 2020-2050
billion tons of co2/yr

Source: original graphic from Architecture 2030, UN Environment Global Status Report 2017

Embodied carbon

is as important as

operational carbon.

LEED v4.1

Offers four paths to achieve credit.

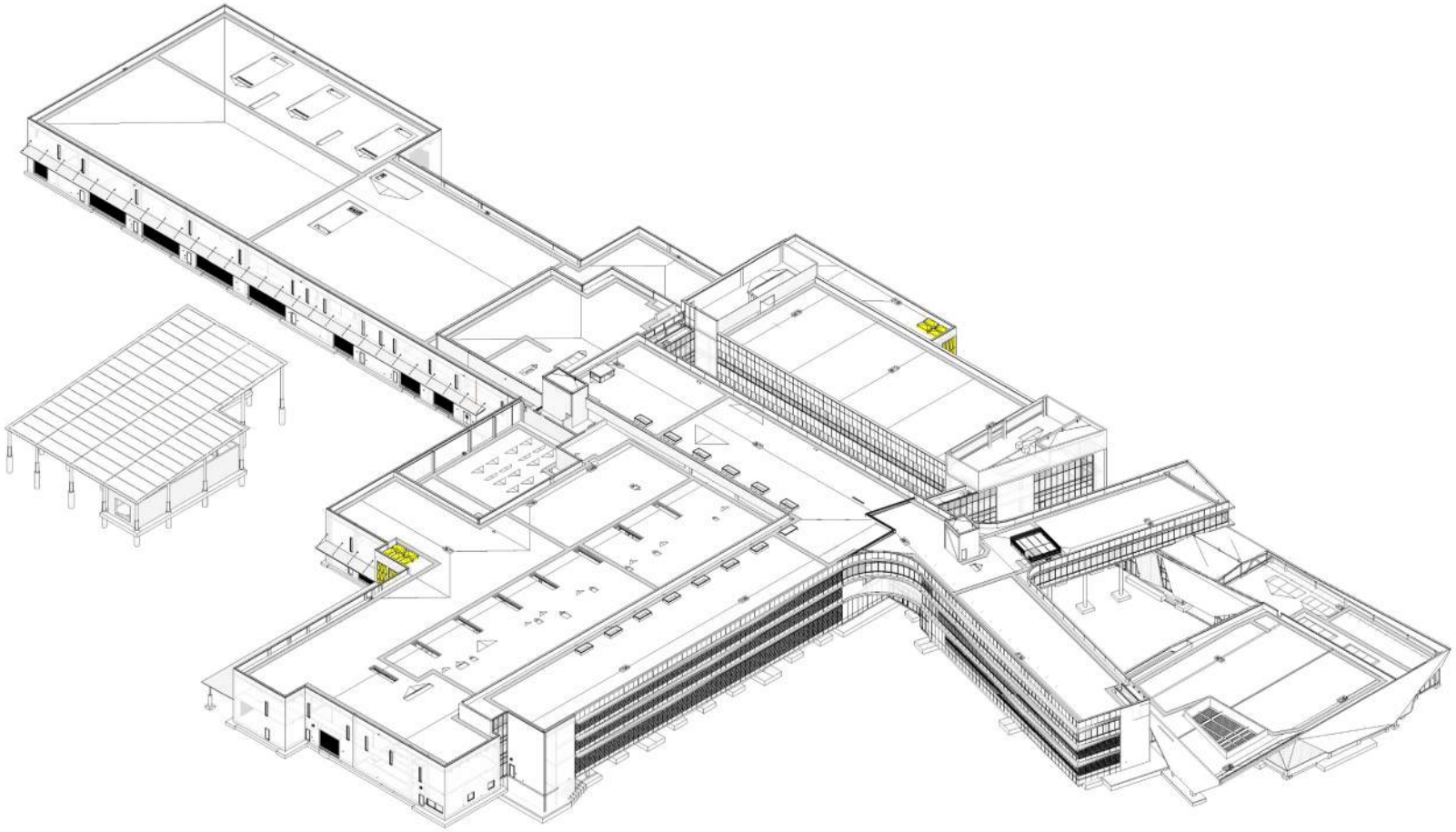
1. Conduct an **LCA (1 point).**
2. **5%** reduction **(2 points).**
3. **10%** reduction **(3 points).**
4. **20%** reduction + building **reuse** and/or salvaged materials **(4 points).**

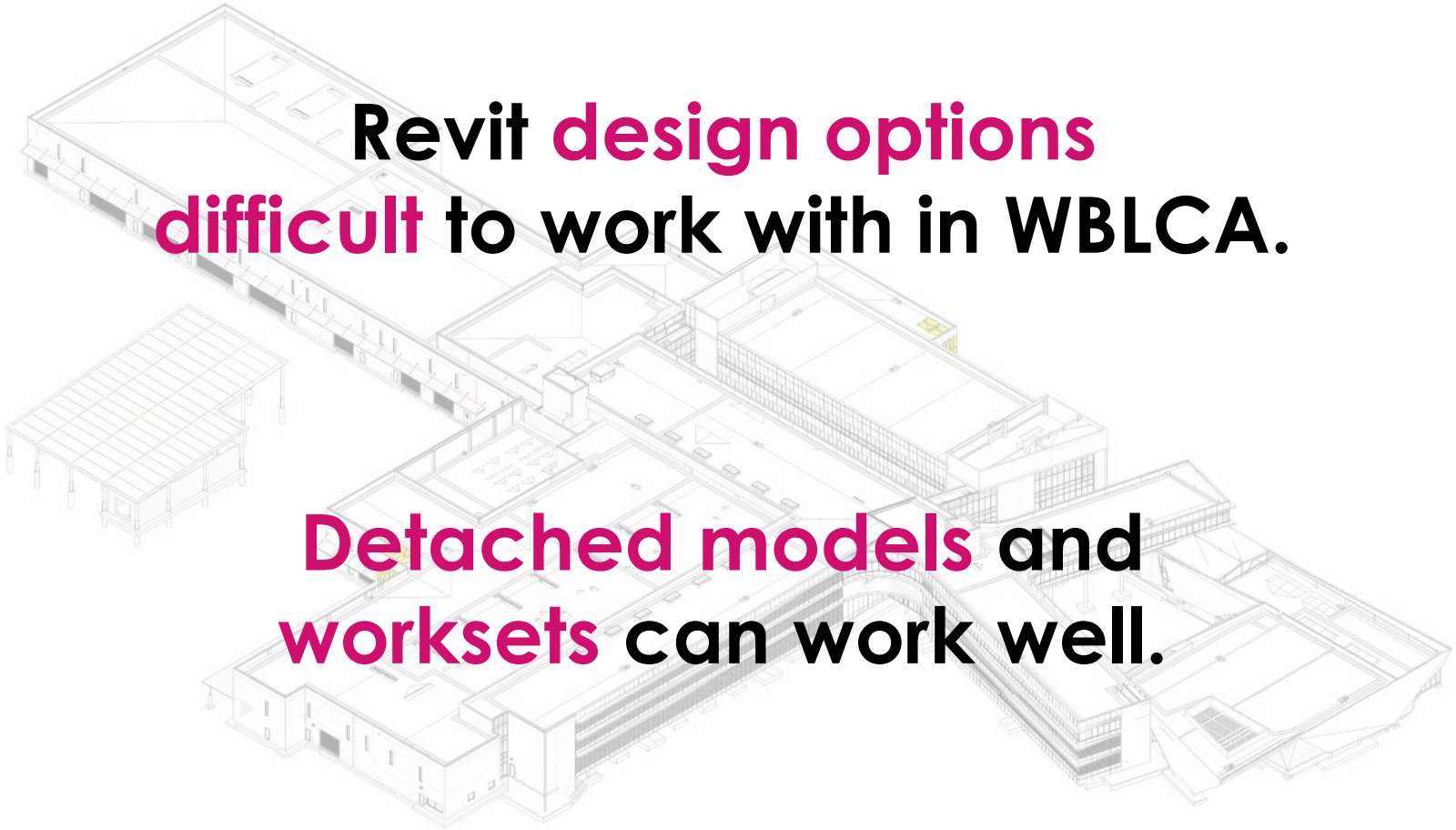
Workflow through case studies

California Air Resources Board

ZNE Office and Lab Building

420,000 sf

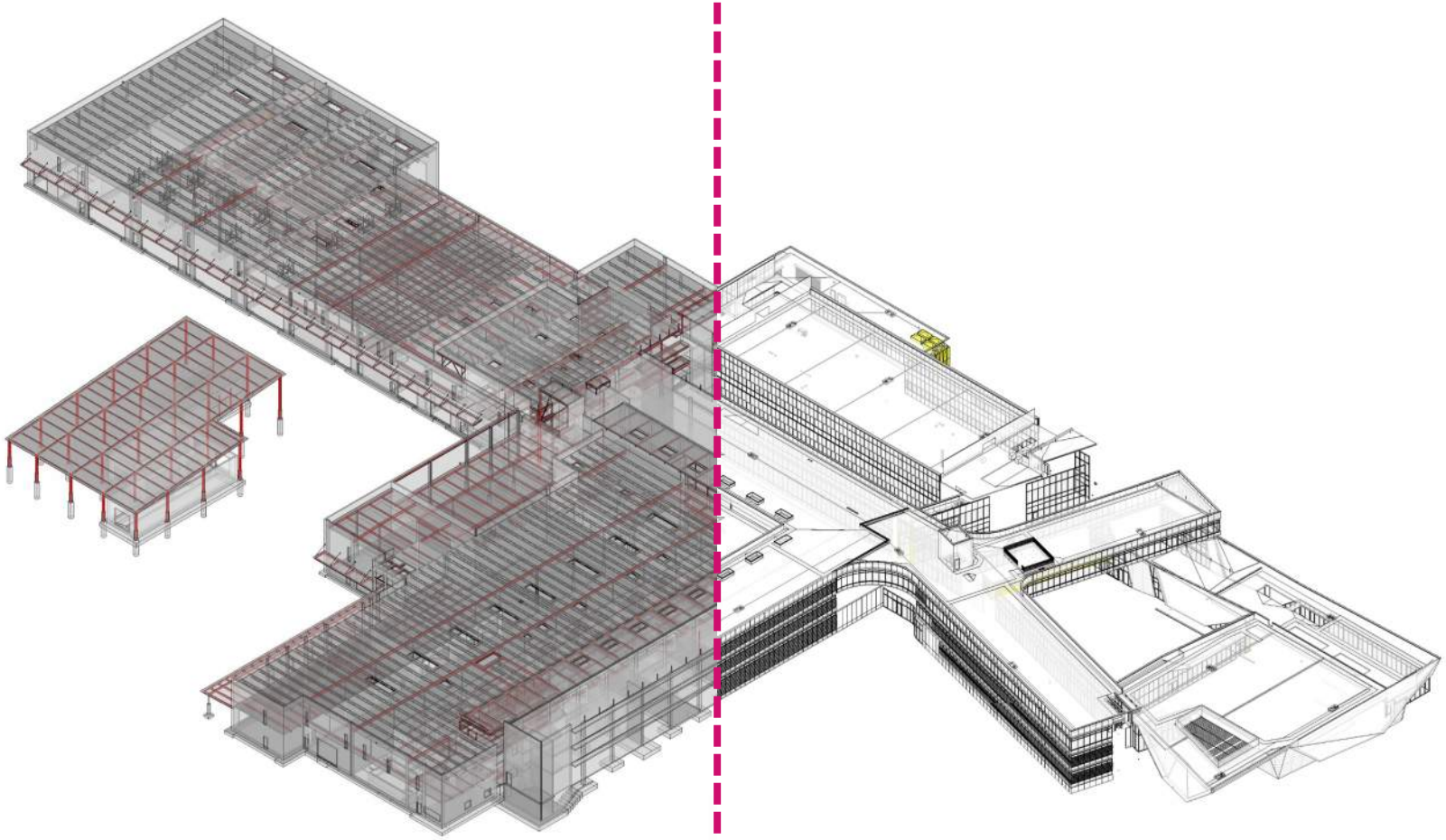




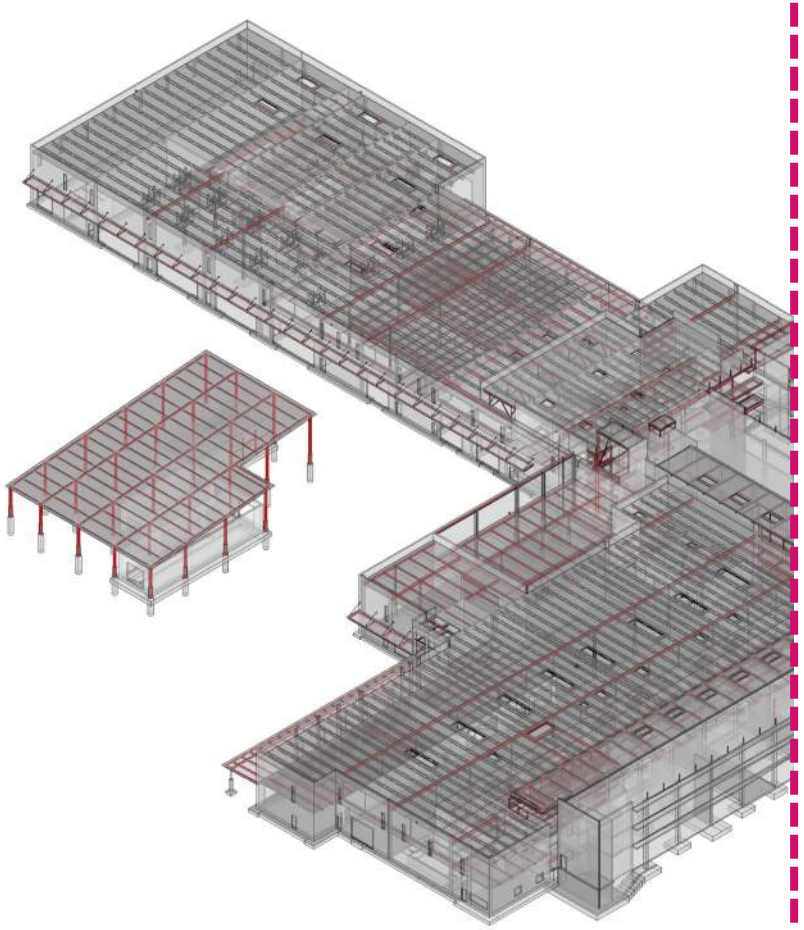
Revit design options difficult to work with in WBLCA.

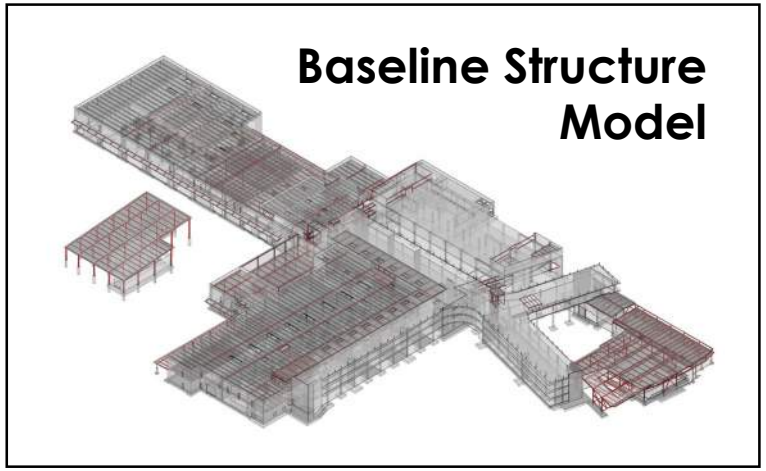
Detached models and worksets can work well.

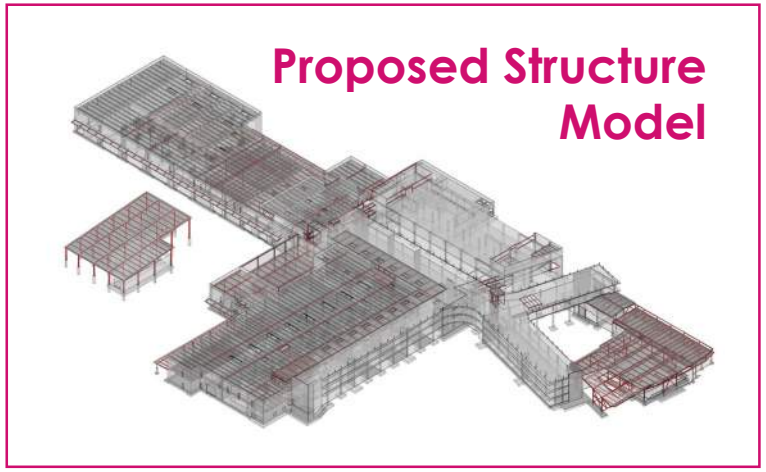
Structure | Enclosure

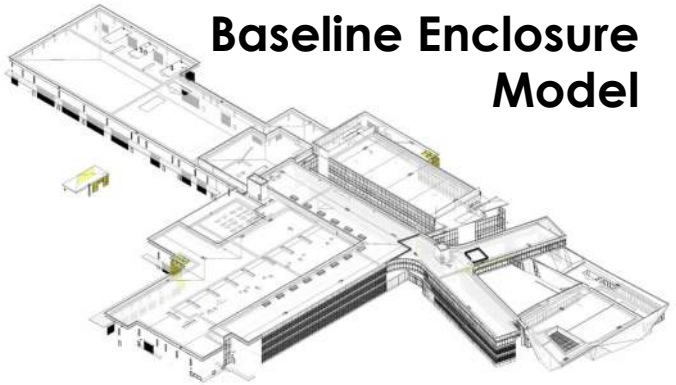


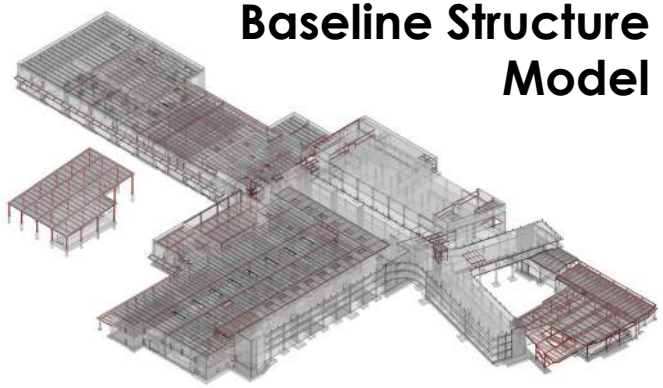
Structure

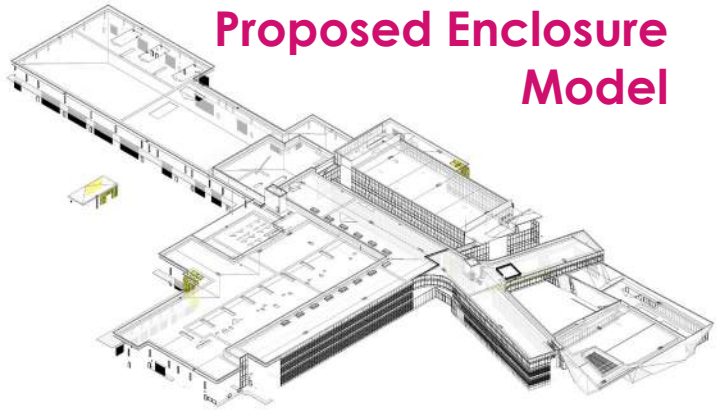


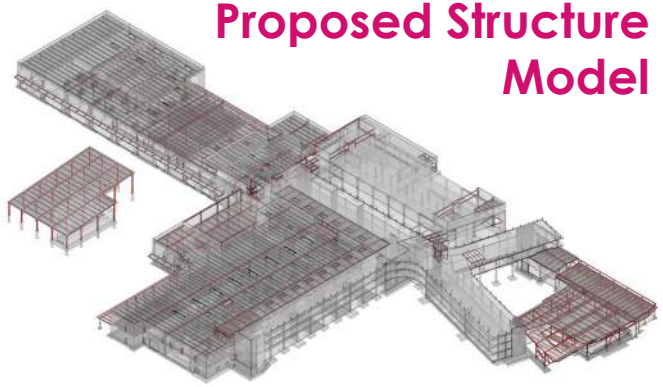


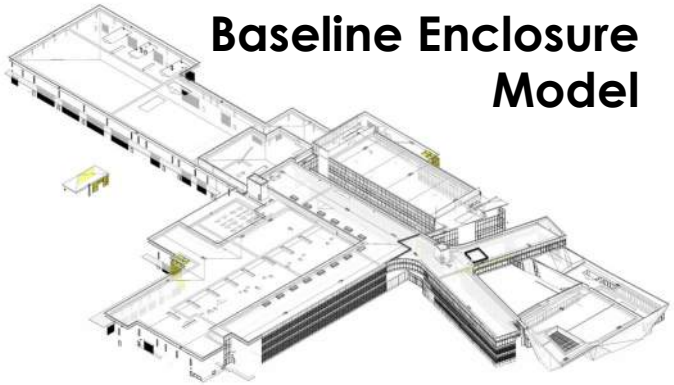



Baseline Enclosure Model

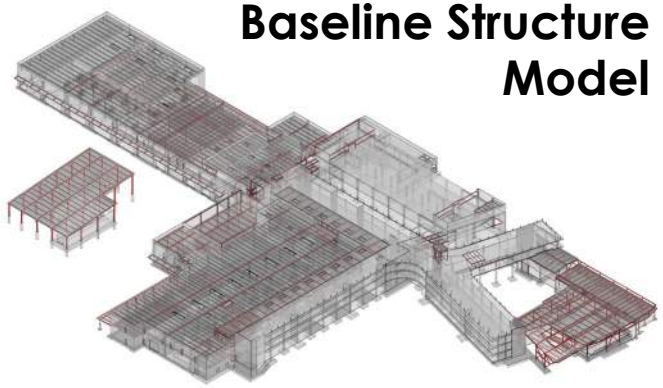

Baseline Structure Model

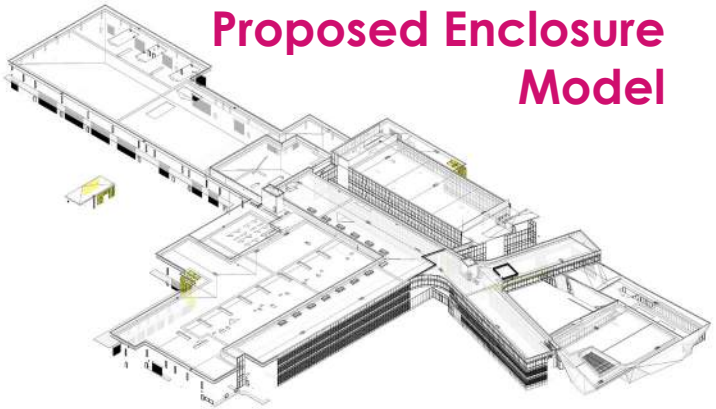

Proposed Enclosure Model


Proposed Structure Model

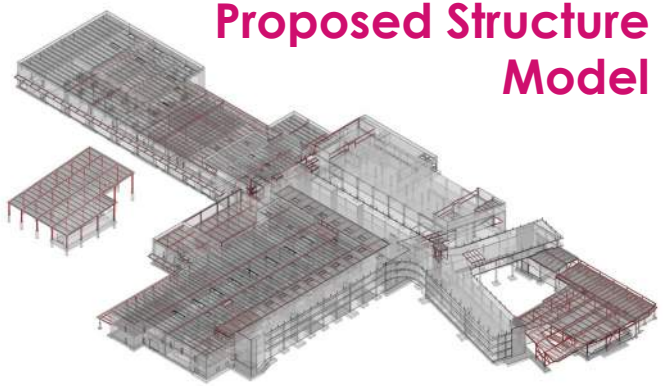


LEED Baseline





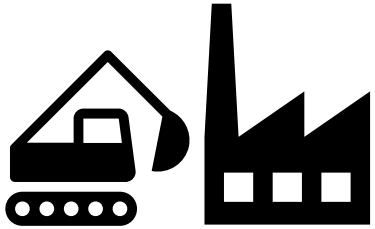
LEED Proposed



Identify and optimize/replace

high impact materials

through LCA of the baseline model



Product stage

Extraction, Transport, Manufacturing

Transportation stage

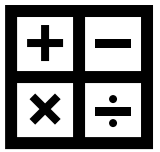
To site

Maintenance & replacement

Expected service life

End of life stage

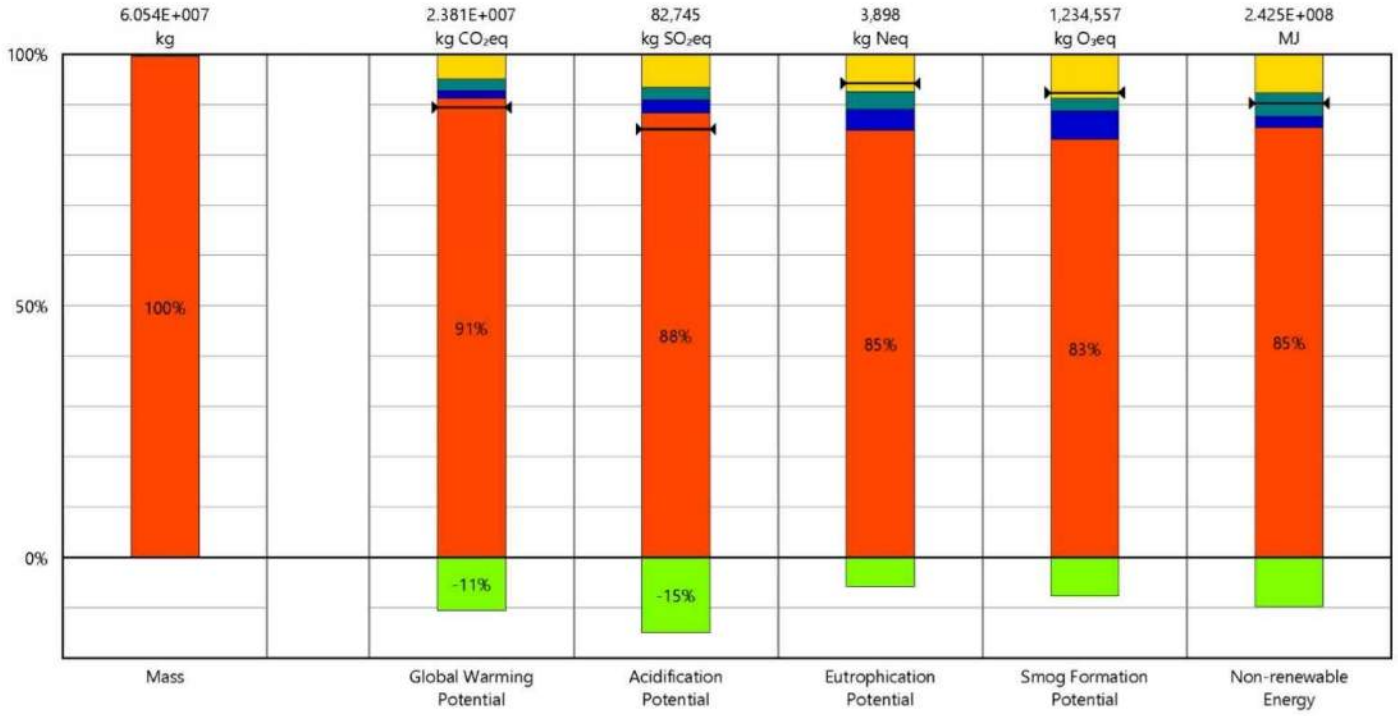
Demolition, Recycling, Disposal



Module D

Benefits & loads beyond sys boundary

Results per Life Cycle Stage



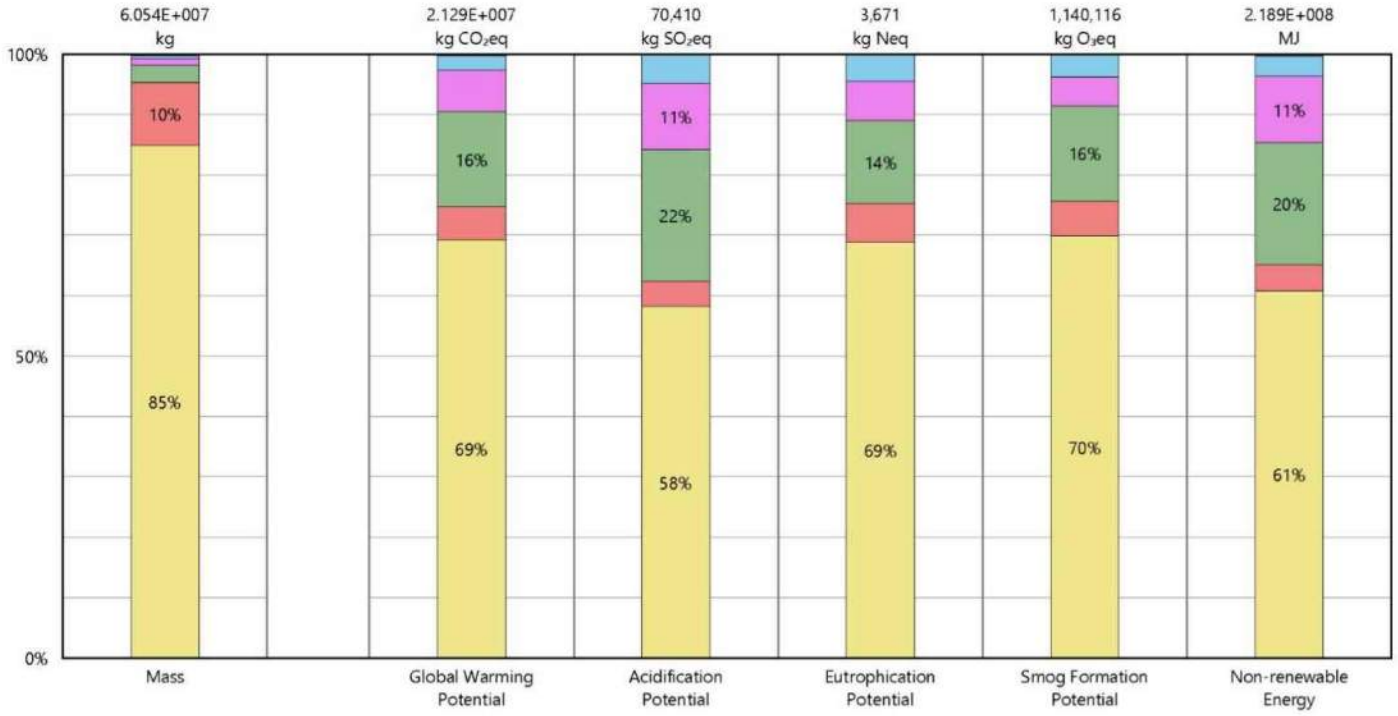
Legend

Net value (impacts + credits)

Life Cycle Stages

- Product [A1-A3]
- Transportation [A4]
- Maintenance and Replacement [B2-B5]
- End of Life [C2-C4]
- Module D [D]

Results per Division

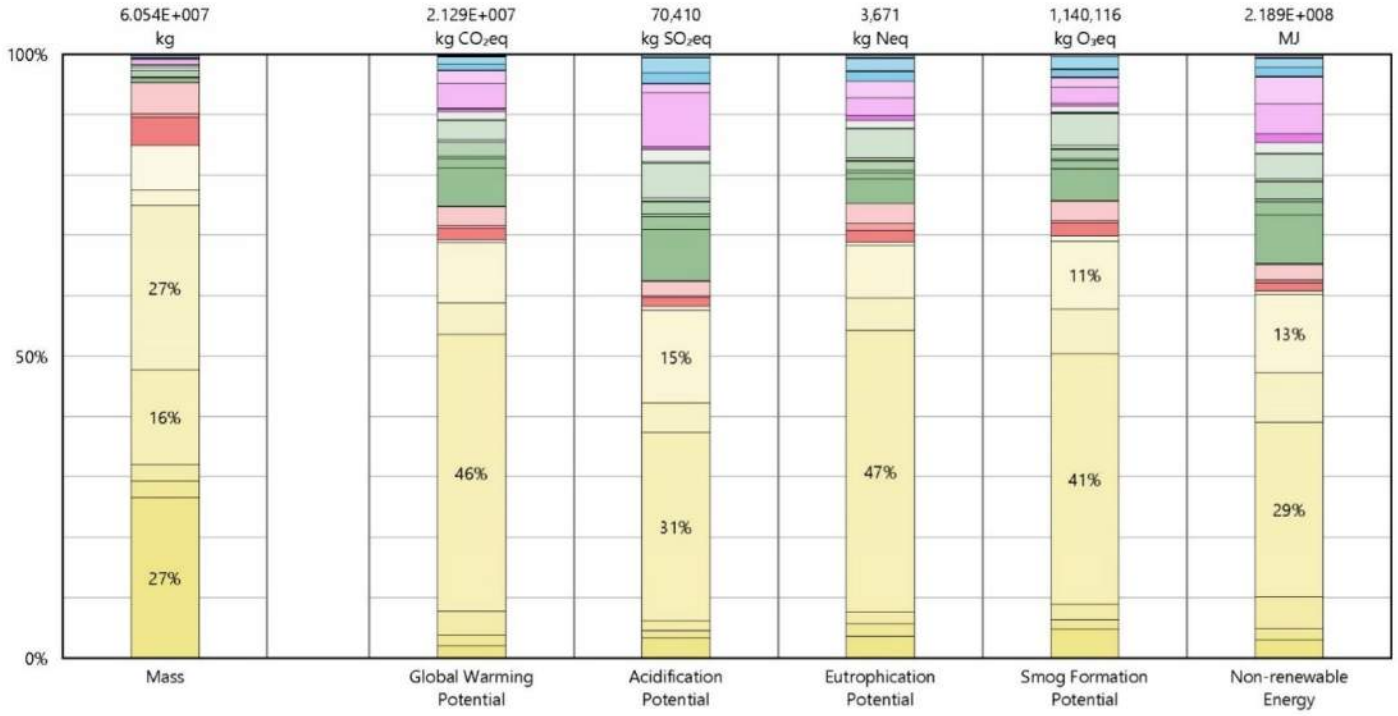


Legend

Divisions

- 03 - Concrete
- 04 - Masonry
- 05 - Metals
- 07 - Thermal and Moisture Protection
- 08 - Openings and Glazing
- 09 - Finishes

Results per Division, itemized by Material

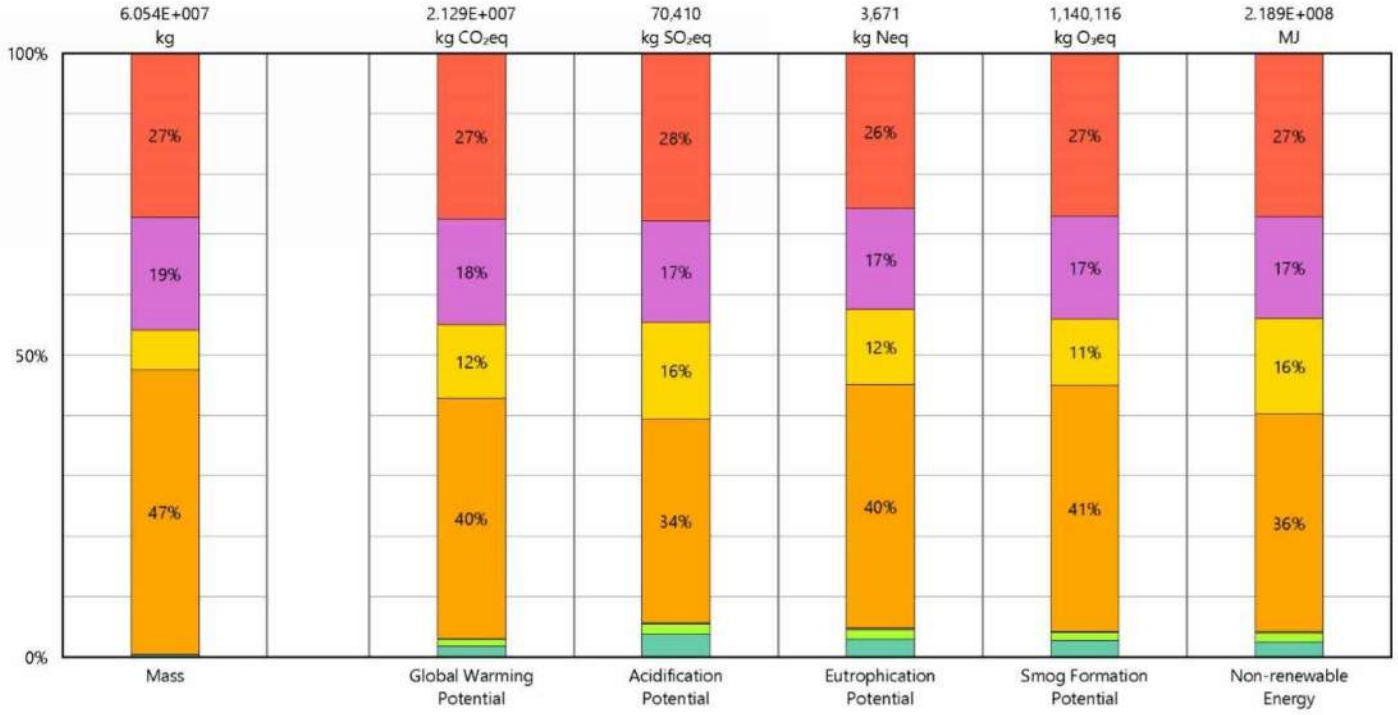


Legend

03 - Concrete

- Coarse aggregate
- Fly ash
- Perlite
- Portland cement, PCA - EPD
- Sand
- Steel, reinforcing rod
- Water

Results per Revit Category

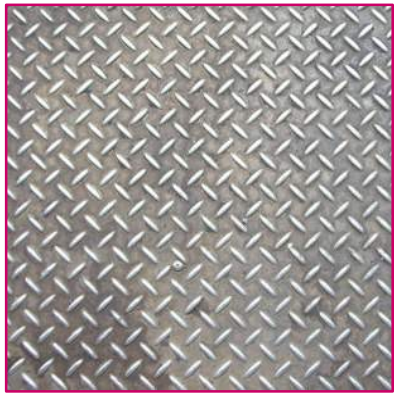


Legend

Revit Categories

- Ceilings
- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Structure
- Walls
- Windows

Identify, optimize, replace
high impact materials.



Steel/Metals

Insulation

Wood

Concrete

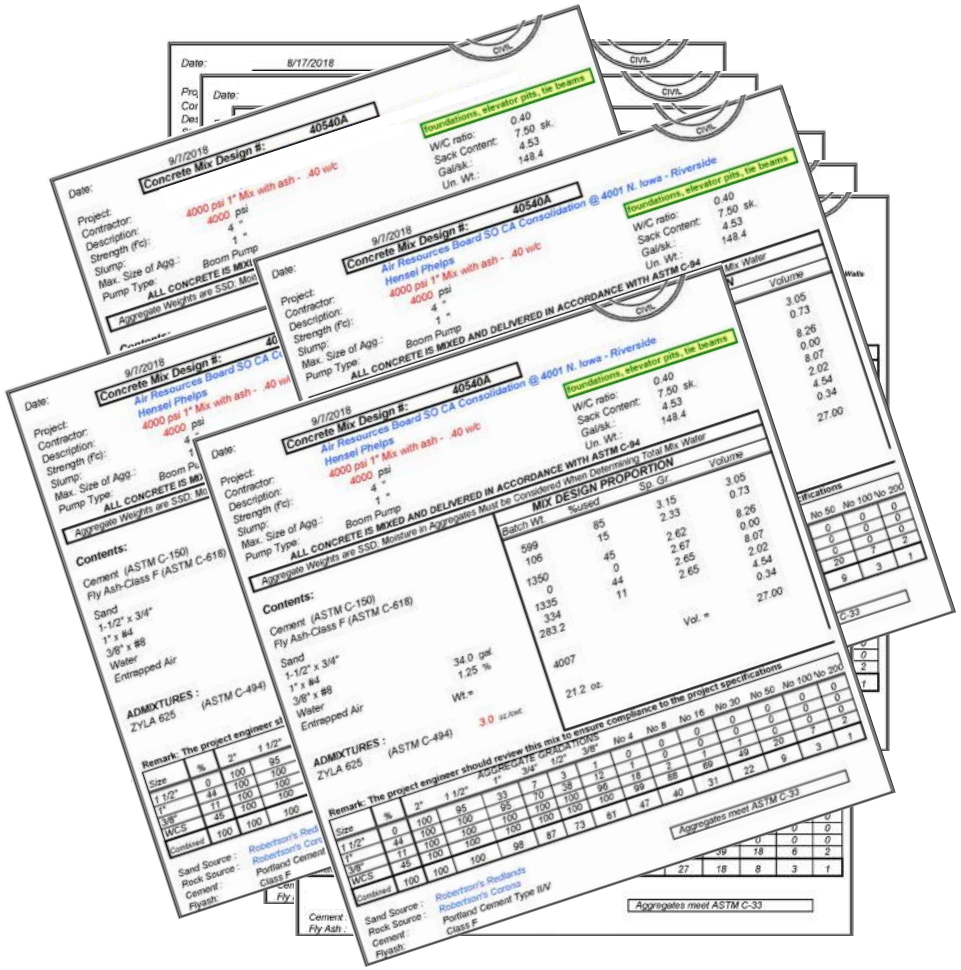
- **If the cement industry was a country by itself, it would be the 3rd largest contributor to GHG emissions after only the U.S. and China.**

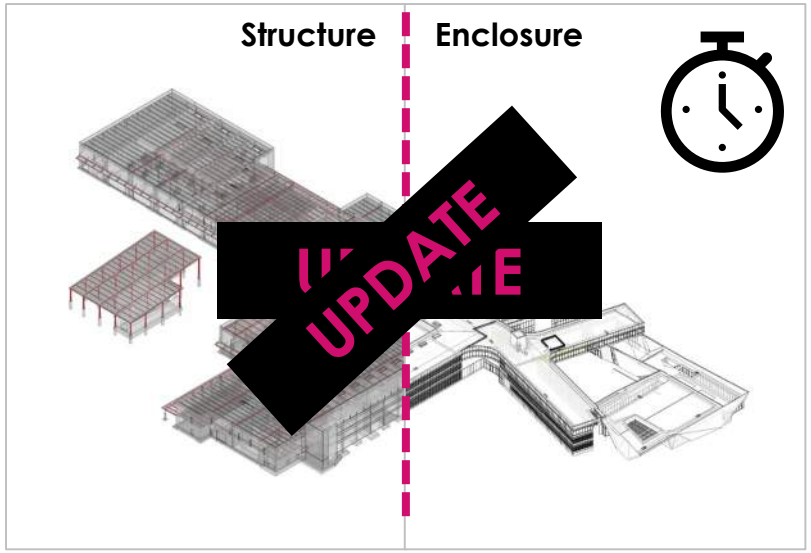
U.S.

China

~~Concrete~~

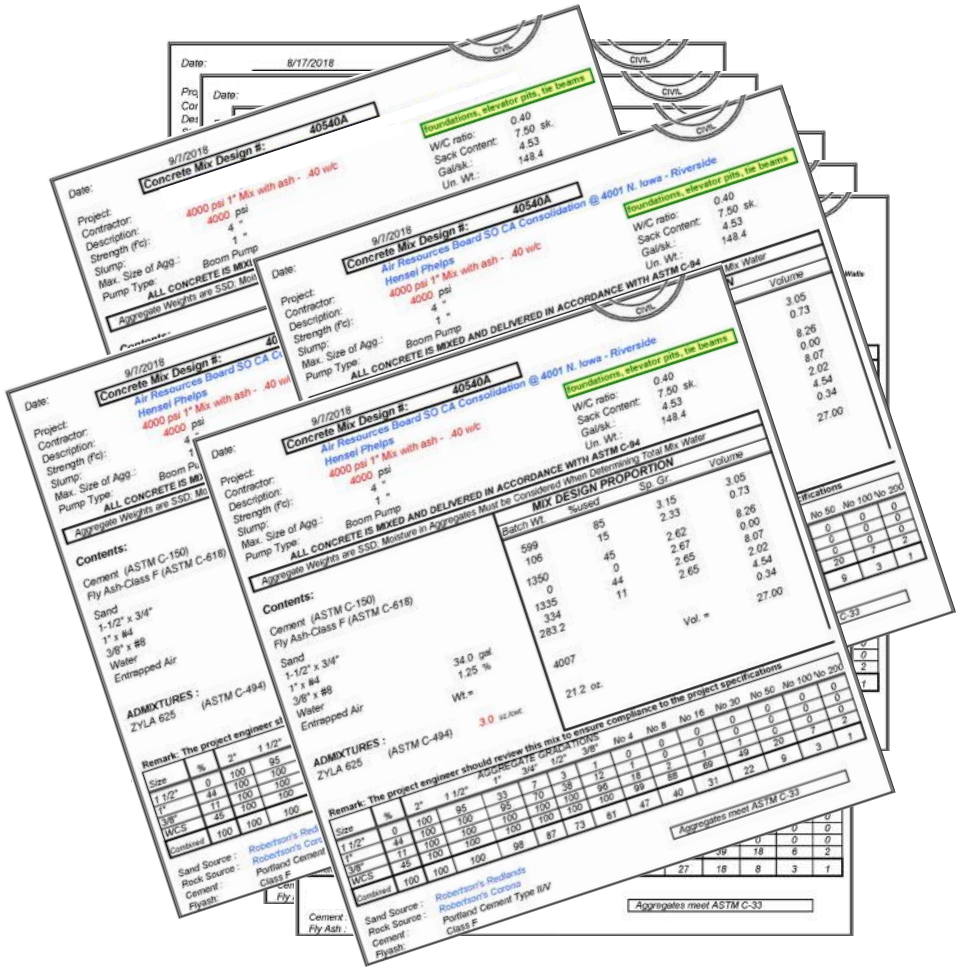
Mass timber

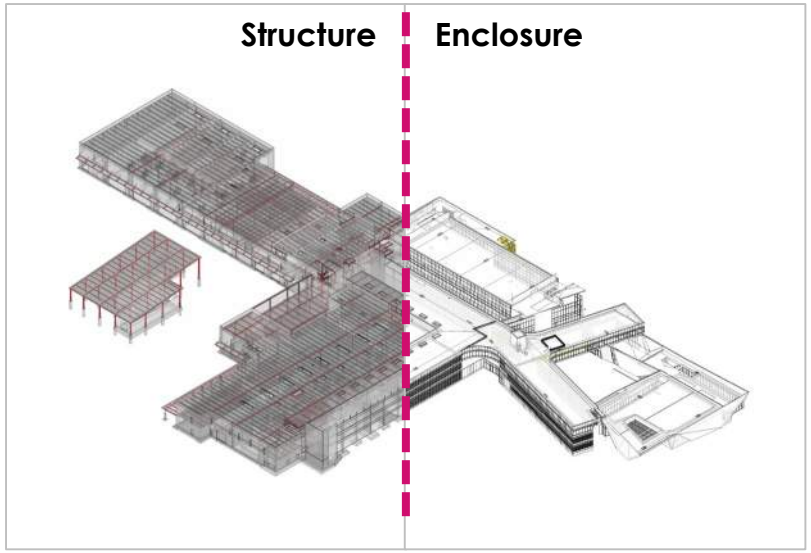




Concrete mix designs

Whole Building LCA





Concrete mix designs

Whole Building LCA

Concrete LCA Tool

User Inputs	
Results	

Select Region	NRMCA 6. Pacific Southwest Region

Proposed Mix Designs

Proposed - Total Volume of Concrete in the Building

	Weight (lbs)	Acidification Potential (kgSO2eq)	Eutrophication Potential (kgNeq)	Global Warming Potential (kgCO2eq)	Ozone Depletion Potential (CFC-11eq)	Smog Formation Potential (kgO3eq)	Non-renewable Energy Demand (MJ)	
Impact of All Concrete	4137	1	0	430	0.0000	25	4084	
Total CY of All Concrete in Buil	1	CY						

Proposed Mix - Floors - 4000 psi - 54010A (13.8% Cement & 15% SCM)

Application	Floors		
Mix Design #/Name	54010A		
Strength (psi)	4000 psi		
Total CY of Mix in Building	1	cubic yard	
SCM Ratio	15.0	%	<<< Less SCM than baseline!
Cement lbs to Total lbs Ratio	13.8	%	<<< Less cement than baseline.

	Mix Design Weight per 1 CY of Mix (lbs)	Acidification Potential (kgSO2eq)	Eutrophication Potential (kgNeq)	Global Warming Potential (kgCO2eq)	Ozone Depletion Potential (CFC-11eq)	Smog Formation Potential (kgO3eq)	Non-renewable Energy Demand (MJ)	kg/m3
Cement	551	0.58	0.05	259.48	0.0000	12.53	1680.71	326.90
Fly ash	97	0.02	0.00	10.22	0.0000	0.49	111.22	57.55
Slag		0.00	0.00	0.00	0.0000	0.00	0.00	0.00
Coarse Aggregate	1,715	0.11	0.01	20.45	0.0000	2.64	318.81	1017.47
Lightweight Aggregate		0.00	0.00	0.00	0.0000	0.00	0.00	0.00
Fine Aggregate (Sand)	1,332	0.13	0.01	40.71	0.0000	3.10	656.68	790.24
Water	292	0.01	0.00	2.79	0.0000	0.28	43.70	173.00
Steel Reinforcement	150	0.49	0.01	95.92	0.0000	5.81	1272.67	88.99
Air Content	3.00%							
Per 1 CY of MIX	4137	1.35	0.08	429.57	0.0000	24.85	4083.79	2454
Total Impact	4137	1	0	430	-3E-07	25	4084	2454

Baseline Mixes Designs

Baseline - Total Volume of Concrete in the Building

	Weight (lbs)	Acidification Potential (kgSO2eq)	Eutrophication Potential (kgNeq)	Global Warming Potential (kgCO2eq)	Ozone Depletion Potential (CFC-11eq)	Smog Formation Potential (kgO3eq)	Non-renewable Energy Demand (MJ)	
Impact of All Concrete	4013	1	0	487	0.0000	27	4434	
	1	CY						

Baseline Mix - Floors - 4000 psi - NRMCA 6. Pacific Southwest Region (17.4% Cement & 15% SCM)

Application	Floors	
Mix Design #/Name	NRMCA 6. Pacific Southwest Region	
Strength (psi)	4000 psi	
Total CY of Mix in Building	1	cubic yard
SCM Ratio	15.0	%
Cement lbs to Total lbs Ratio	17.4	%

	Mix Design Weight per 1 CY of Mix (lbs)	Acidification Potential (kgSO2eq)	Eutrophication Potential (kgNeq)	Global Warming Potential (kgCO2eq)	Ozone Depletion Potential (CFC-11eq)	Smog Formation Potential (kgO3eq)	Non-renewable Energy Demand (MJ)	kg/m3
Cement	674	0.71	0.06	317.40	0.0000	15.33	2055.90	399.87
Fly ash	119	0.03	0.00	12.54	0.0000	0.60	136.45	70.60
Slag	0	0.00	0.00	0.00	0.0000	0.00	0.00	0.00
Coarse Aggregate	1,394	0.09	0.01	16.62	0.0000	2.15	259.14	827.03
Lightweight Aggregate	0	0.00	0.00	0.00	0.0000	0.00	0.00	0.00
Fine Aggregate (Sand)	1,336	0.13	0.01	40.83	0.0000	3.11	658.65	792.62
Water	340	0.02	0.00	3.25	0.0000	0.32	50.95	201.71
Steel Reinforcement	150	0.49	0.01	95.92	0.0000	5.81	1272.67	88.99
Air Content	6.00%							
Per 1 CY of MIX	4013	1.46	0.09	486.56	0.0000	27.32	4433.76	2381
Total Impact	4013	1	0	487	-3E-07	27	4434	2381

Comparison

Environmental Impact Comparison - Total Volume of Concrete in the Building

	Weight (lbs)	Acidification Potential (kgSO2eq)	Eutrophication Potential (kgNeq)	Global Warming Potential (kgCO2eq)	Ozone Depletion Potential (CFC-11eq)	Smog Formation Potential (kgO3eq)	Non-renewable Energy Demand (MJ)	
Impact % vs Baseline		-8.0%	-11.1%	-11.7%	0.003%	-9.0%	-7.9%	
Better or Worse?								

Proposed vs Baseline - Floors - 4000 psi - Impact Comparison

	Mix Design Weight per 1 CY of Mix (lbs)	Acidification Potential (kgSO2eq)	Eutrophication Potential (kgNeq)	Global Warming Potential (kgCO2eq)	Ozone Depletion Potential (CFC-11eq)	Smog Formation Potential (kgO3eq)	Non-renewable Energy Demand (MJ)	kg/m3
Cement	22%	22%	22%	22%	22%	22%	22%	22%
Fly ash	23%	23%	23%	23%	23%	23%	23%	23%
Slag	0%	0%	0%	0%	0%	0%	0%	0%
Coarse Aggregate	-19%	-19%	-19%	-19%	-19%	-19%	-19%	-19%
Lightweight Aggregate	0%	0%	0%	0%	0%	0%	0%	0%
Fine Aggregate (Sand)	0%	0%	0%	0%	0%	0%	0%	0%
Water	17%	17%	17%	17%	17%	17%	17%	17%
Steel Reinforcement	0%	0%	0%	0%	0%	0%	0%	0%
Impact % Difference		-8.0%	-11.1%	-11.7%	0.003%	-9.0%	-7.9%	
Better or Worse?								

Proposed Mix **Regional Practices** **Better or Worse?**

Concrete LCA Tool

- Doesn't need Revit model or any geometry
- Doesn't require LCA expertise
- Applicable SD-CA
- Live LCA of concrete mix designs
- Can be used real time in meetings with project partners
- Focuses on Portland cement content vs. SCM
- Data can be updated in the future

We are making it available to others for free lca-tool@zgf.com

California Air Resources Board - Concrete

Portland cement

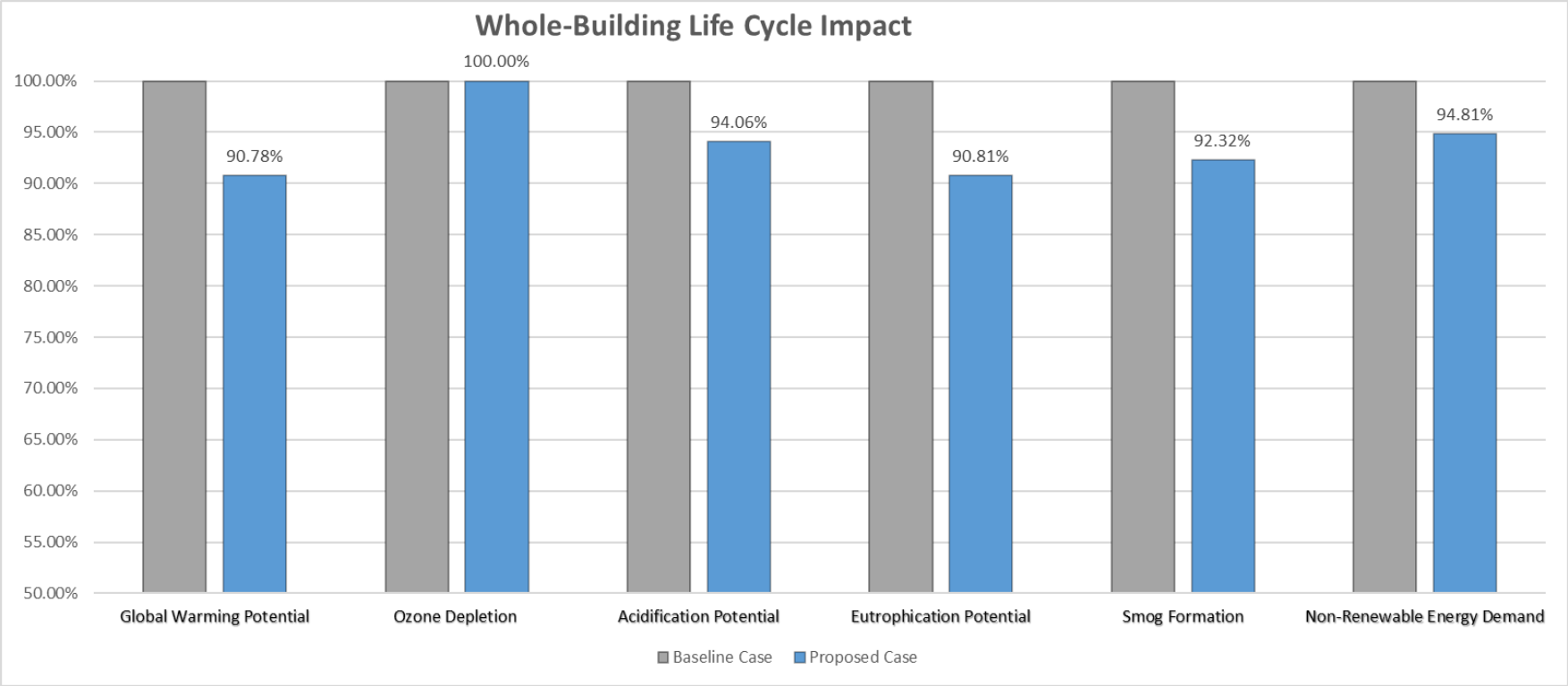
20,764,320 lbs in baseline

To

16,310,855 lbs in proposed

21.4% reduction in cement content

California Air Resources Board - WBLCA



2 points under LEED v4.1

DGS Clifford L. Allenby Building
Zero Net Energy Office Building
400,000 sf

DGS Clifford L. Allenby Building - Concrete

Portland cement

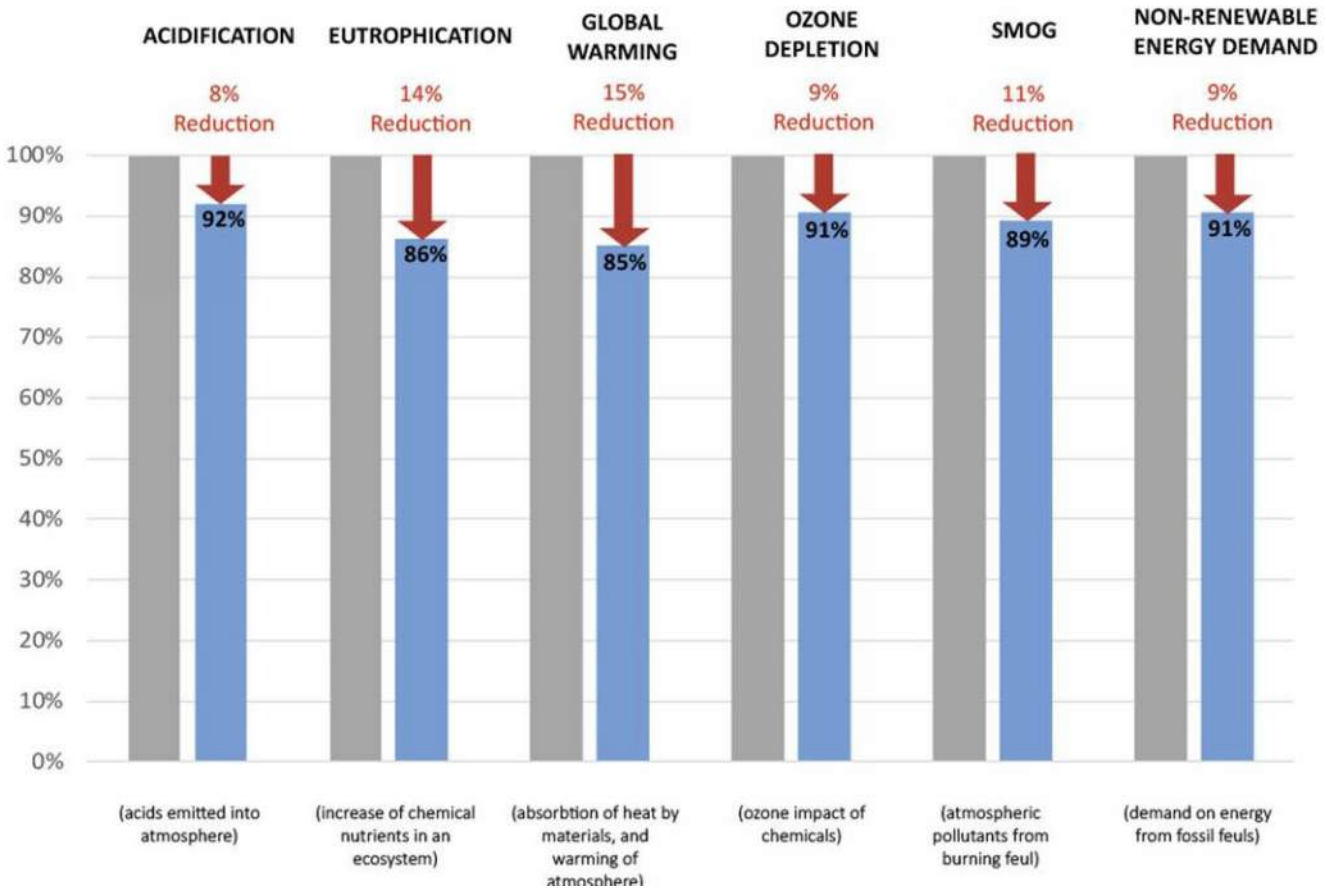
15,932,315 lbs in baseline

To

11,875,038 lbs in proposed

25.5% reduction in cement content

DGS Clifford L. Allenby Building - WBLCA



3 points under LEED v4.1

To get a free copy of the **ZGF Concrete LCA** tool email

lca-tool@zgf.com

Baha Sadreddin

High-Performance Design Specialist

ZGF Architects

ZGF

ZIMMER GUNSUL FRASCA ARCHITECTS LLP

ambient energy
impact • collaborate • innovate

Commissioning | Sustainability | Building Performance

ECN Webinar 5
Creating a WBLCA Baseline

Victoria Herrero-Garcia

Sustainability Consultant,

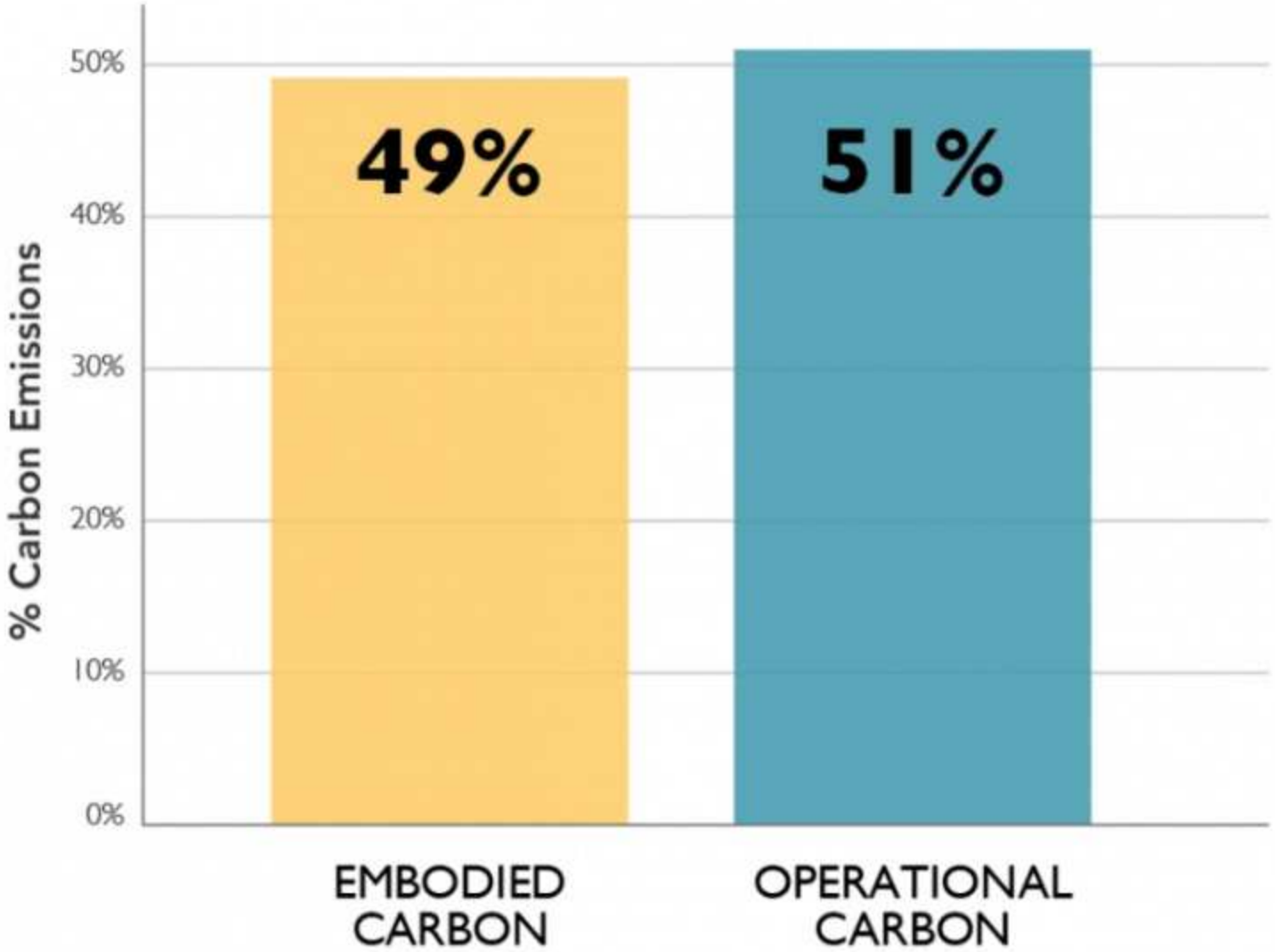
Daylight & WBLCA Analyst

Building Stock Market Predictions

By year 2060, the world is projected to add 2.5 trillion ft^2 of buildings

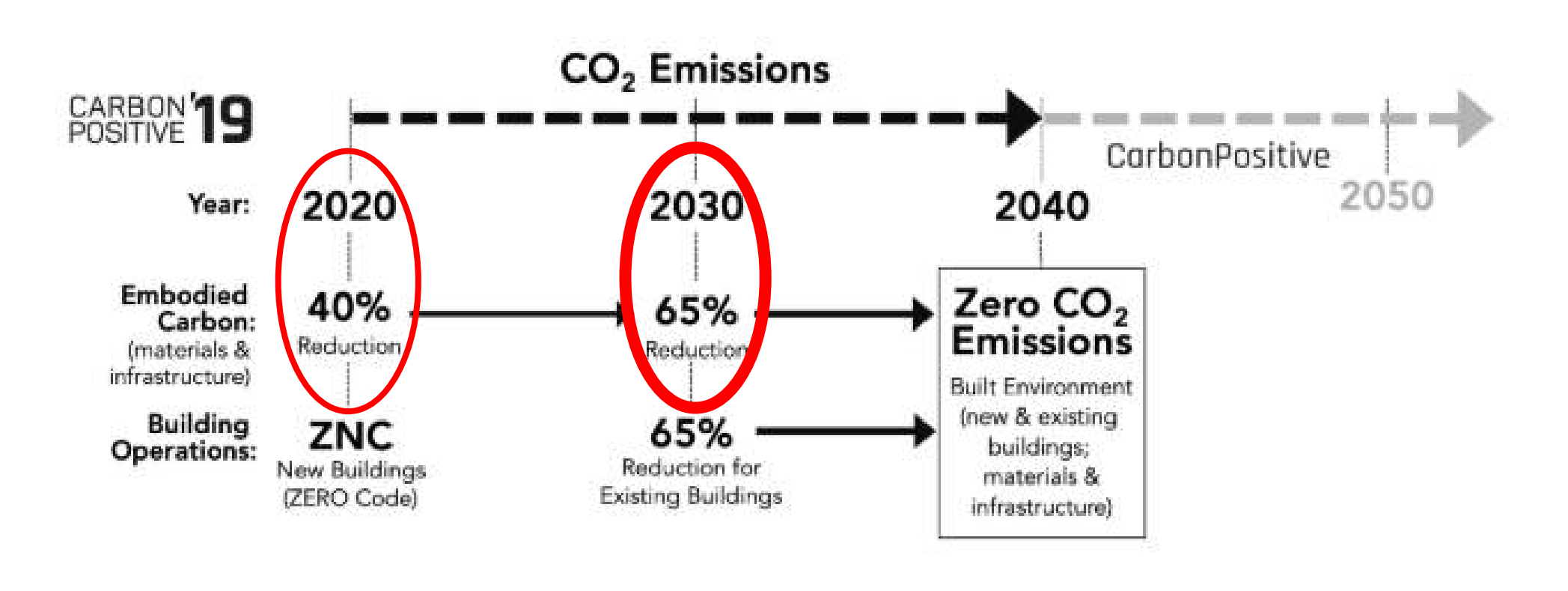
Total Carbon Emissions of Global New Construction from 2020-2050

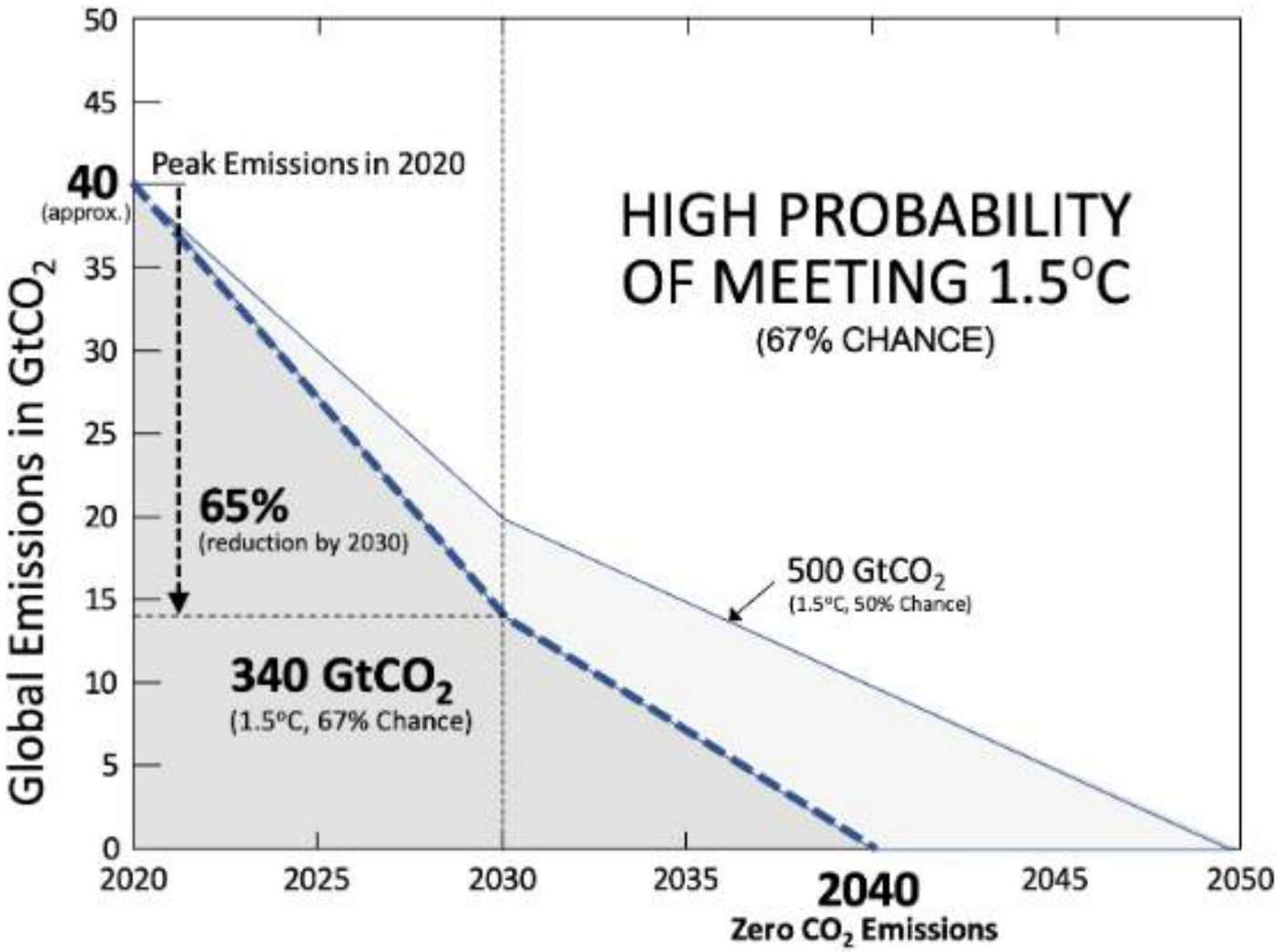
Business as Usual Projection



© 2018 2030, Inc. / Architecture 2030. All Rights Reserved. Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017

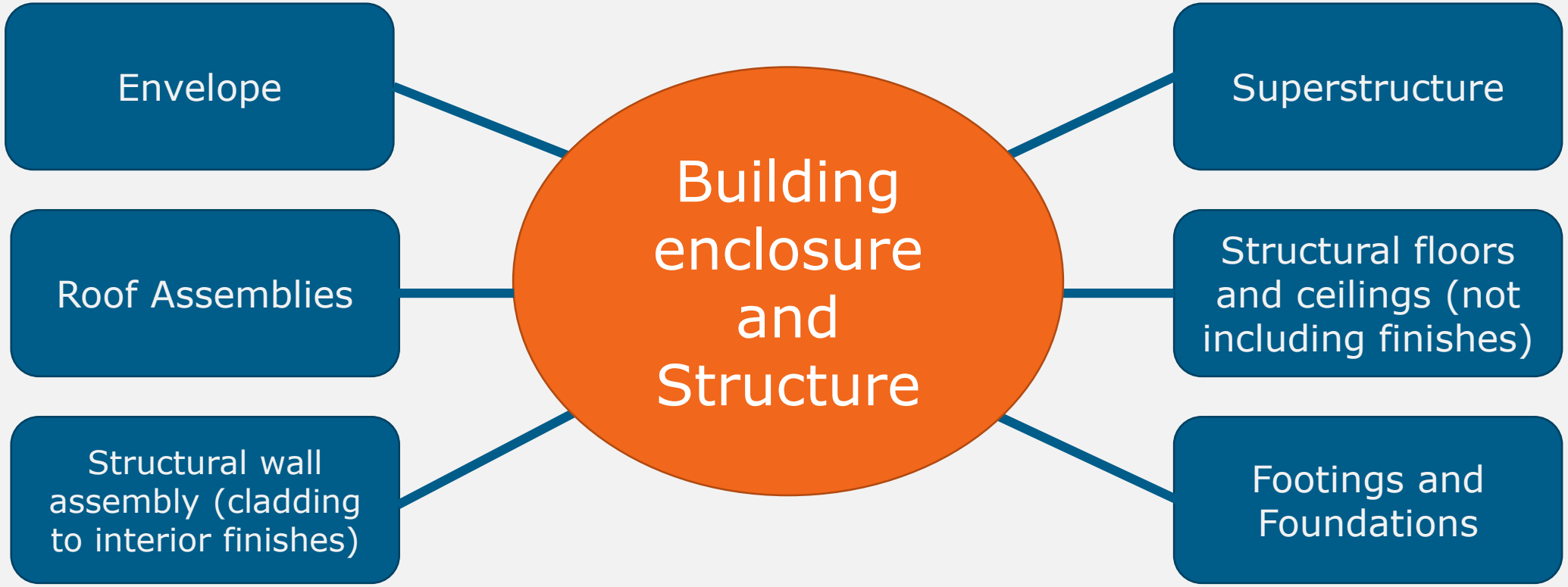
Architecture 2030
"Zero CO2 Emissions by 2040"




Global Emissions in $GtCO_2$
50
45
40
(approx.)
35
30
25
20
15
10
5
0
Peak Emissions in 2020
HIGH PROBABILITY
OF MEETING 1.5°C
(67% CHANCE)
65%
(reduction by 2030)
500 $GtCO_2$
(1.5°C, 50% Chance)
340 $GtCO_2$
(1.5°C, 67% Chance)
2020
2025
2030
2035
2040
2045
2050
Zero CO_2 Emissions

Creating a Baseline

Elements to include in LEED WBLCA



Optional Elements:

- Interior non-structural wall
- Interior finishes

Baseline vs Proposed – LEED requires to be comparable in….

1. Size

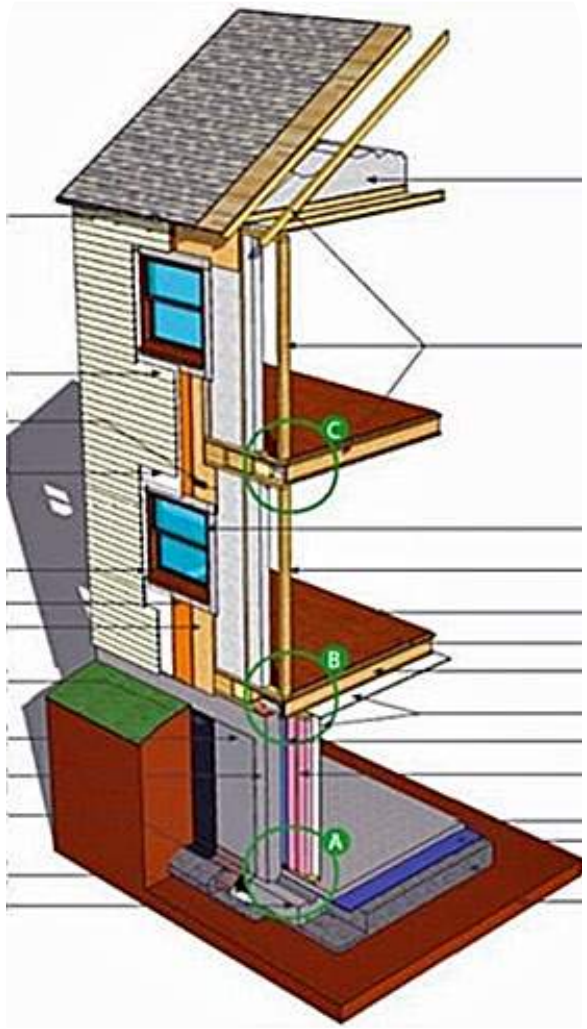
2. Programmatic Function

3. Orientation

4. Energy Performance per EA Prerequisite Minimum Energy Performance:

ASHRAE Standard 90.1 Appendix G Table 3.1

Building Enclosure



Early Design

- Use ASHRAE Standard 90.1 Appendix G Table 3.1 for your climate zone
- Research typical Assembly types for your climate zone based on building type
- Insulation type and thickness
- Coordinate with Energy Modeler

ASHRAE 90.1 - 2010 Prescriptive Enclosure Requirements

Opaque Assemblies. *Opaque* assemblies used for new buildings or *additions* shall conform with the following common, lightweight assembly types and shall match the appropriate assembly maximum *U-factors* in Tables 5.5-1 through 5.5-8:

- *Roofs*—Insulation entirely above deck
- *Above-grade walls*—Steel-framed
- Floors—Steel-joist
- *Opaque door* types shall match the *proposed design* and conform to the *U-factor* requirements from the same tables.
- *Slab-on-grade floors* shall match the *F-factor* for unheated slabs from the same tables.

TABLE 5.5-5 Building Envelope Requirements for Climate Zone 5 (A, B, C)*

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.119	R-7.6 c.i.
Metal Building[a]	U-0.055	R-13.0 + R-13.0	U-0.055	R-13.0 + R-13.0	U-0.083	R-13.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above-Grade						
Mass	U-0.090	R-11.4 c.i.	U-0.080	R-13.3 c.i.	U-0.151[b]	R-5.7 c.i.[b]
Metal Building	U-0.069	R-13.0 + R-5.6 c.i.	U-0.069	R-13.0 + R-5.6 c.i.	U-0.113	R-13.0
Steel-Framed	U-0.064	R-13.0 + R-7.5 c.i.	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
Wood-Framed and Other	U-0.064	R-13.0 + R-3.8 c.i.	U-0.051	R-13.0 + R-7.5 c.i.	U-0.089	R-13.0
Walls, Below-Grade						
Below-Grade Wall	C-0.119	R-7.5 c.i.	C-0.119	R-7.5 c.i.	C-1.140	NR
Floors						
Mass	U-0.074	R-10.4 c.i.	U-0.064	R-12.5 c.i.	U-0.137	R-4.2 c.i.
Steel-Joist	U-0.038	R-30.0	U-0.038	R-30.0	U-0.052	R-19.0
Wood-Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.051	R-19.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.540	R-10 for 24 in.	F-0.730	NR
Heated	F-0.860	R-15 for 24 in.	F-0.860	R-15 for 24 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.500		U-0.700	
Nonswinging	U-0.500		U-0.500		U-1.450	

See ASHRAE 90.1 for:

- Vertical Fenestration
- Skylights and Glazed Smoke Vents
- Roof Solar Reflectance and Thermal Emittance

* ASHRAE 90.1-2010 (Colorado Zone 5B)

Coordination with Energy Modeler

Energy Model Input	Standard Reference	Proposed Design
Roof	R-30 ci (U-0.032)	Roof const + R-40 ci (U-0.025)
Exterior Wall Type 1	8” CMU + R-11.4 ci (U-0.088)	3-5/8" brick + 1" airspace + 3-3/8" spray foam + 7-5/8" CMU + airspace + 3-5/8" brick interior (U-0.041)
Exterior Wall Type 1	8” CMU + R-11.4 ci (U-0.088)	3-5/8" brick + 1" airspace + 3-3/8" spray foam + 7-5/8" CMU (U-0.044)
Bellow Grade Walls	R-7.5 ci	R-15 ci
Slab on Grade	R-10 for 24”	R-15 for 36”

Final WBLCA – Construction Documents Baseline and proposed – Equal U-factor

Energy Model Input	Standard Reference	Proposed Design
Roof	R-30 ci (U-0.032)	Roof const + R-40 ci (U-0.025)
Exterior Wall Type 1	8” CMU + R-11.4 ci (U-0.088)	3-5/8" brick + 1" airspace + 3-3/8" spray foam + 7-5/8" CMU + airspace + 3-5/8" brick interior (U-0.041)
Exterior Wall Type 1	8” CMU + R-11.4 ci (U-0.088)	3-5/8" brick + 1" airspace + 3-3/8" spray foam + 7-5/8" CMU (U-0.044)
Bellow Grade Walls	R-7.5 ci	R-15 ci
Slab on Grade	R-10 for 24”	R-15 for 36”

If proposed design U-factor is better or worst than ASHRAE’s prescriptive enclosure requirements, the recommended U-factor for baseline should be the same U-factor as proposed design

Structure

Whole Building
Life Cycle Assessment

REFERENCE BUILDING STRUCTURE AND STRATEGIES

WBLCA Guide Special Project
Working Group

Edited by Frances Yang, S.E.

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Structure Baseline:

- What structural elements have been avoided?
- What is the typical reinforcement or spacing?
- Has the slab been reduced or modified?
- Has the roof framing changed from metal to wood?

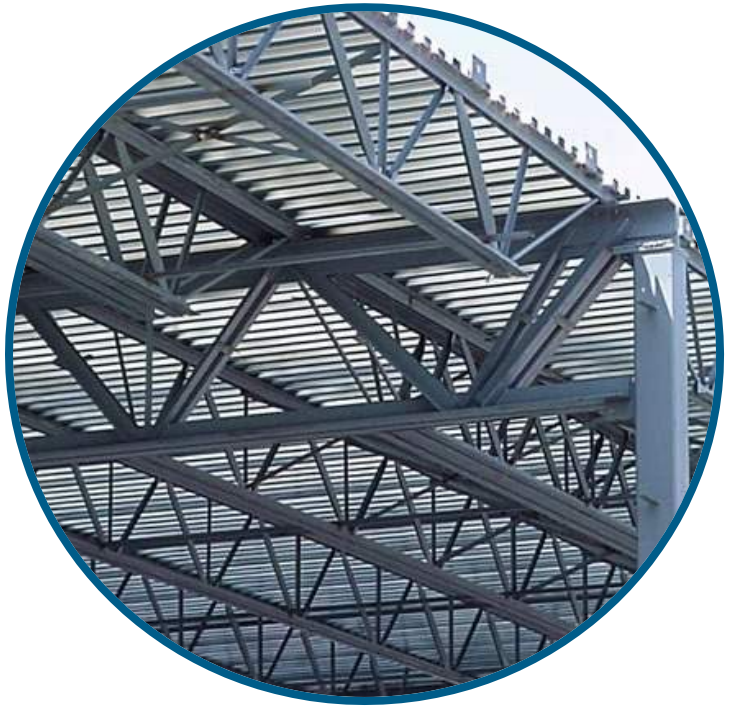
Steel Rebar

80% recycled content

Hot-rolled Structural Sections

80% recycled content

Steel decks, steel joist, cold formed steel framing for walls, insulated metal panels, steel roofing



25% recycled content

Values from American Iron and Steel Institute (AISI) for North America Steel

Concrete Baseline:

- Contact local concrete producers
- Supplementary Cementitious Materials (SCMs) might not always be available in your area
  - Fly Ash
  - Slag
  - Silica Fume
- i.e. In Denver area, baseline concrete has 0-3% fly ash

Final Thoughts

Final Thoughts

- WBLCA is not Energy Modeling
- Start the talk early in design
- To meet 2020 goal = 40% reductions
- To meet 2030 goal = 65% reductions
- ECN is a place to share your Knowledge and ask questions

Thank you

Victoria Herrero-Garcia

Sustainability Consultant, Daylight and WBLCA Analyst

vherrero@ambient-e.com

ambient energy

impact • collaborate • innovate

Q&A

Thank you!

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