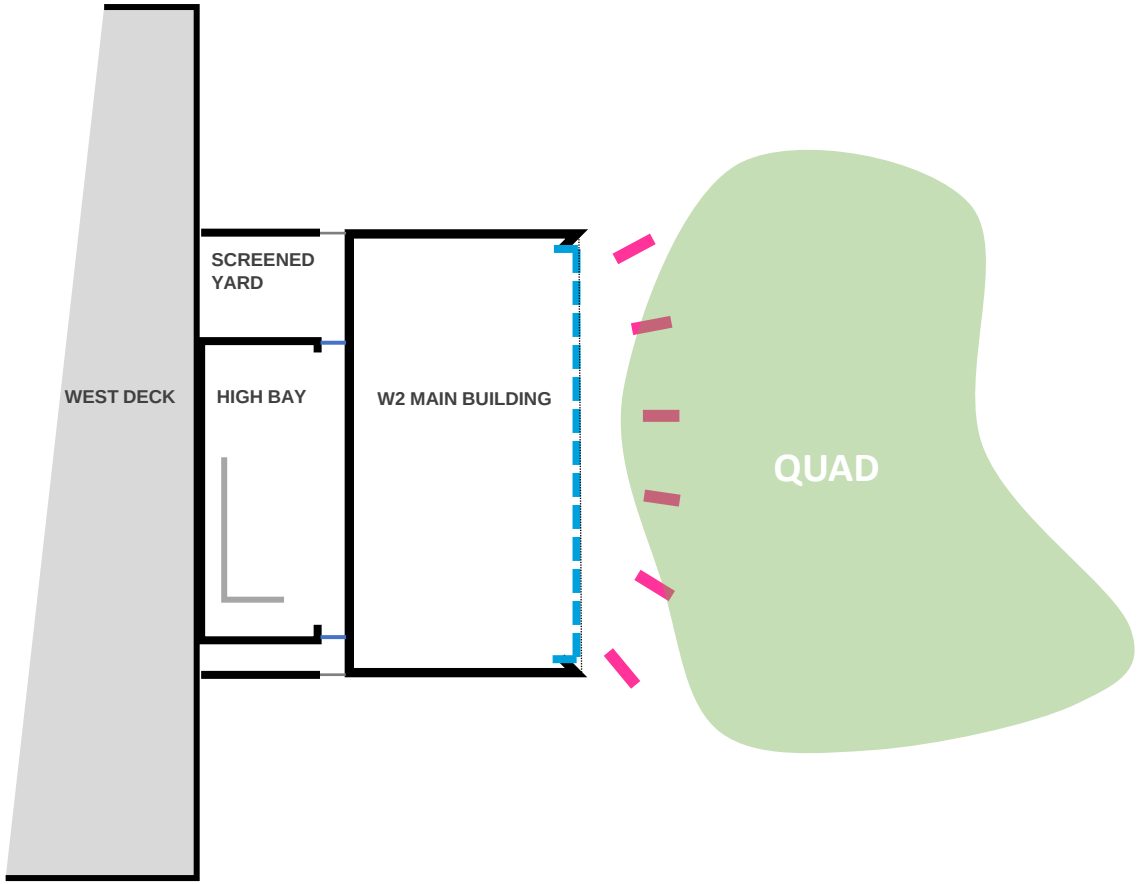
Embodied Carbon Assessment of Wood: From Early-Stage Analysis to WBLCA

Presented by Jennifer Hardy and Melanie Silver

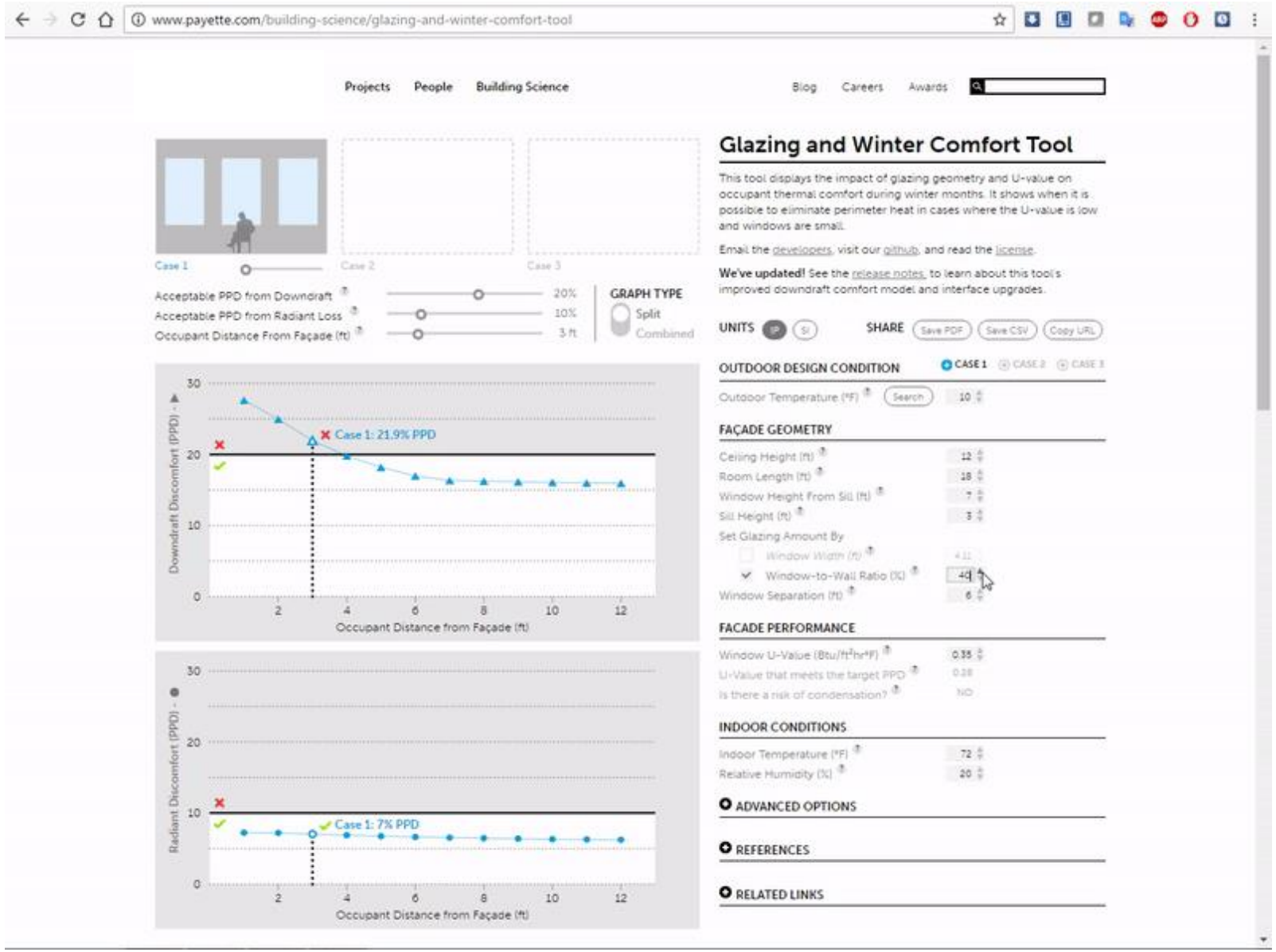
PAYETTE

Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.

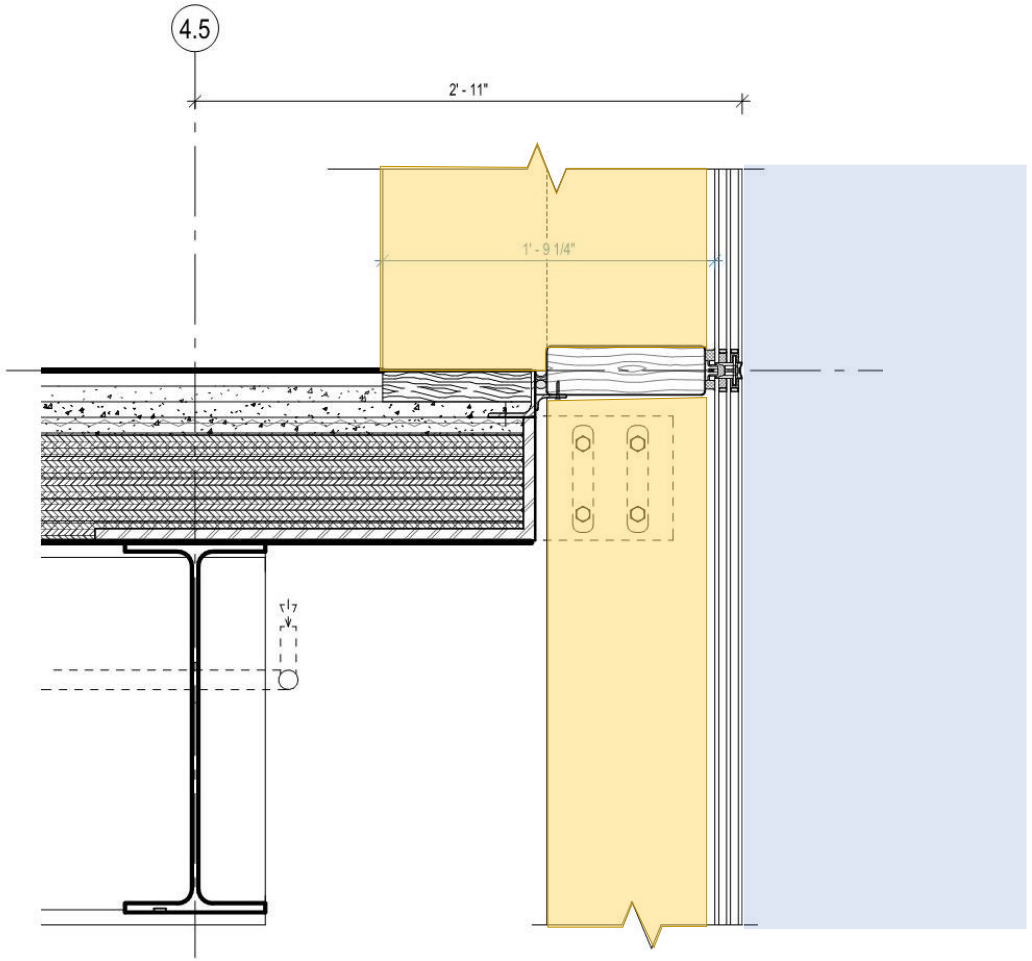
WINDOW TO THE QUAD



GLAZING AND WINTER COMFORT TOOL

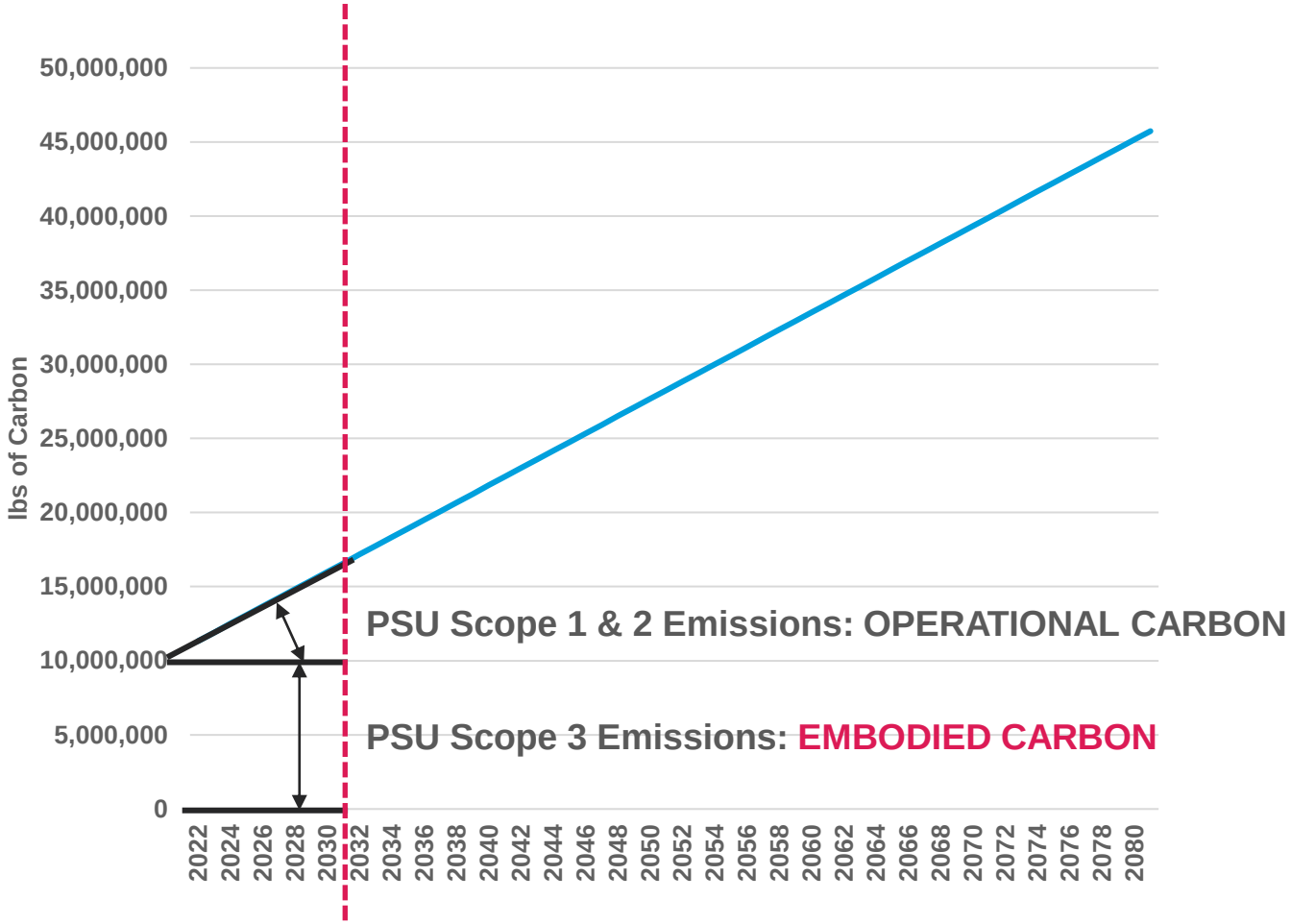


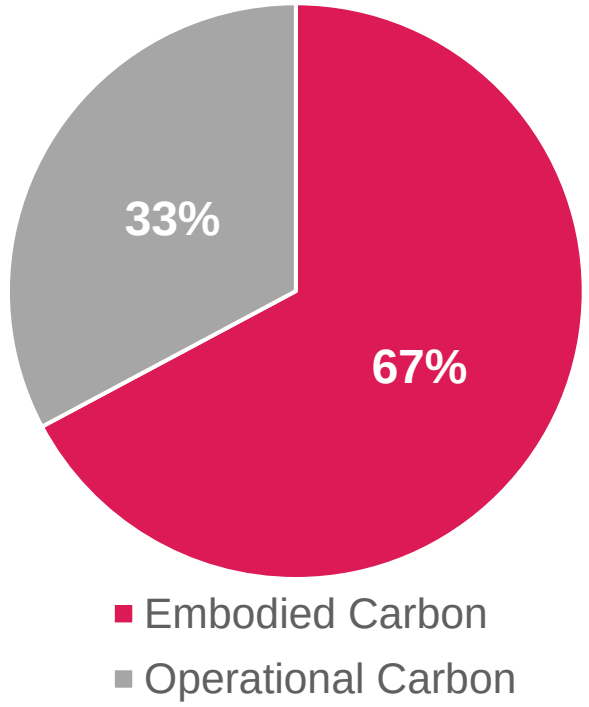
TIMBER CURTAIN WALL



CARBON EMISSIONS

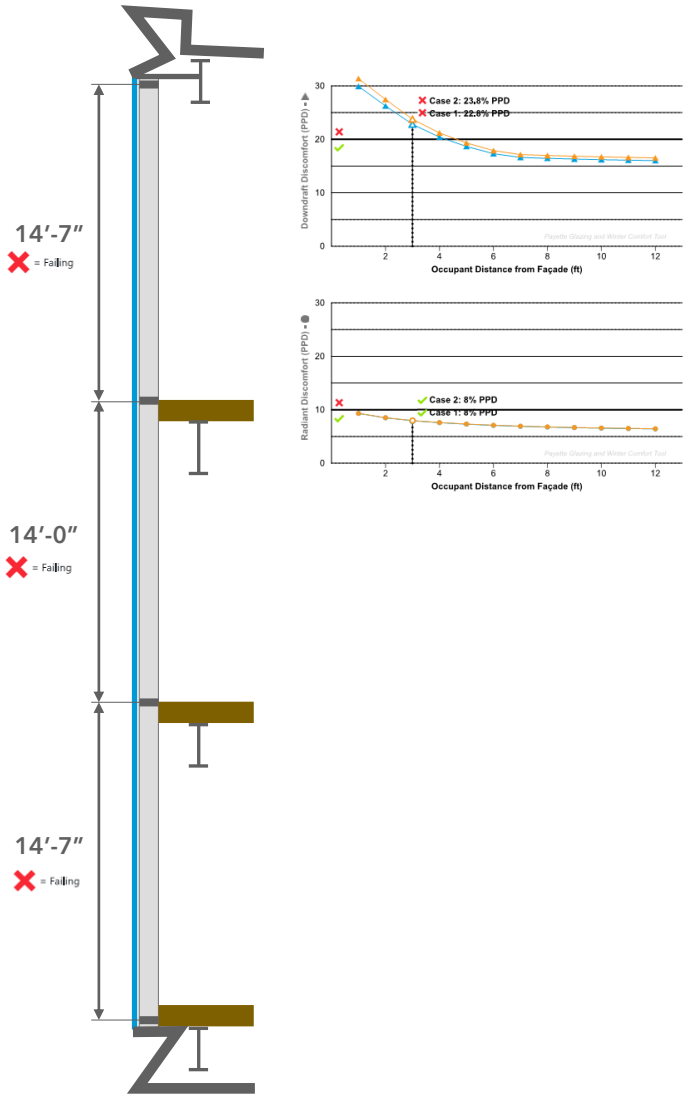
There is greater urgency to minimize carbon emissions between now & 2030 to stem the impacts of climate change - there is a time value to targeting embodied carbon



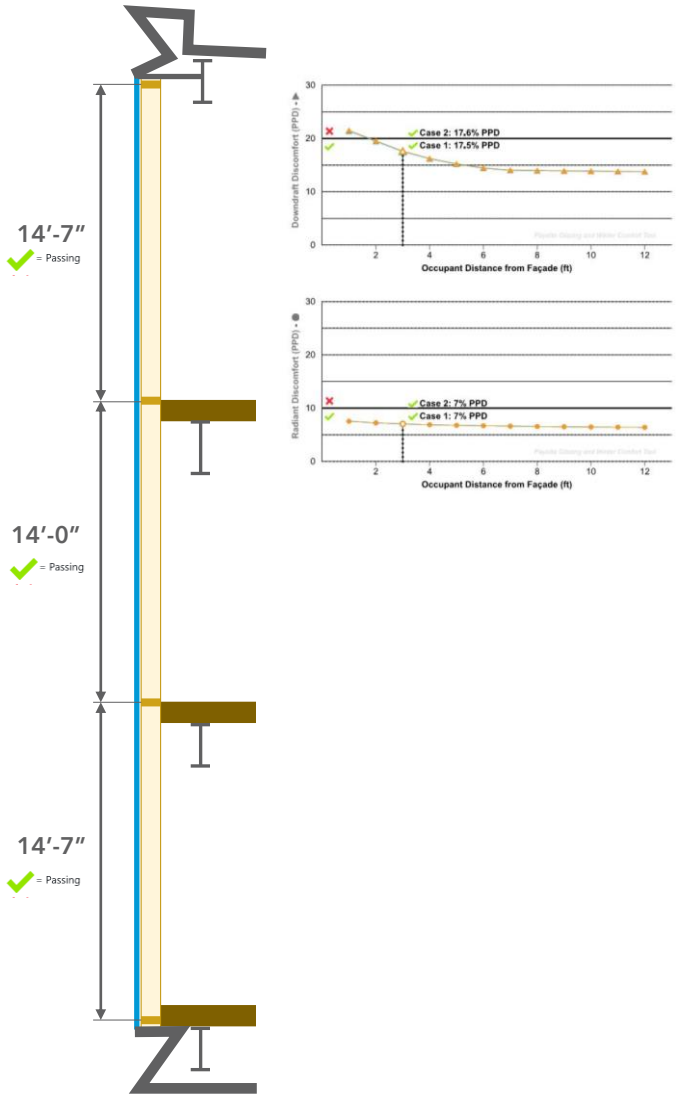


ENVELOPE AND THERMAL COMFORT

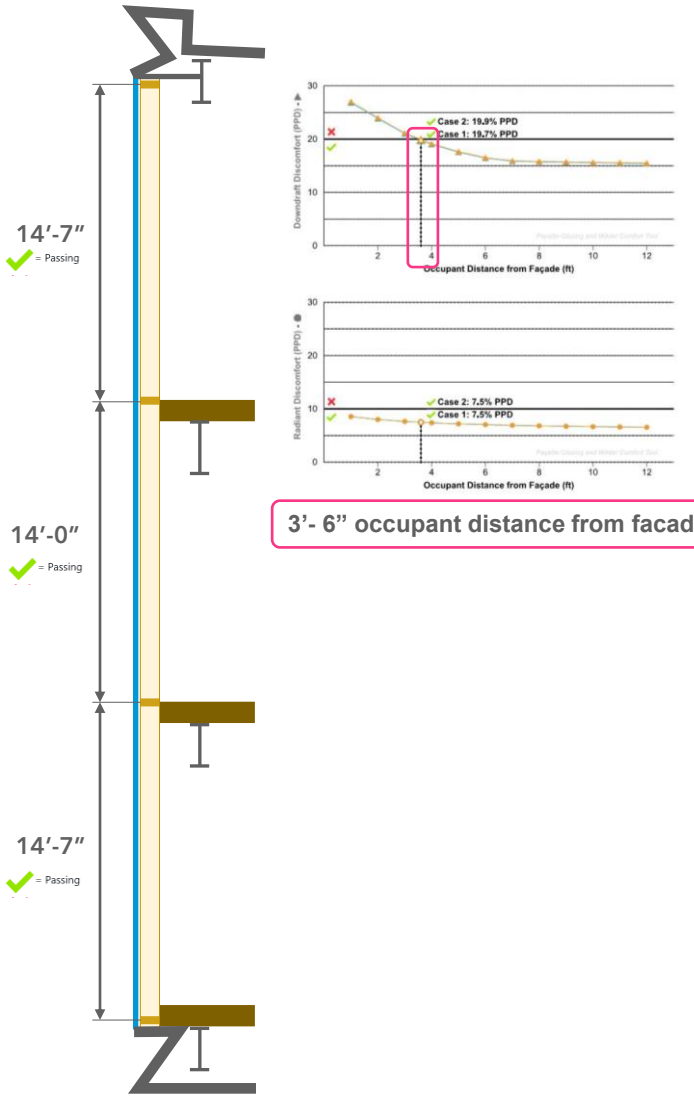
ALUMINUM + TRIPLE GLAZING
U = 0.25



TIMBER + TRIPLE GLAZING
U = 0.16

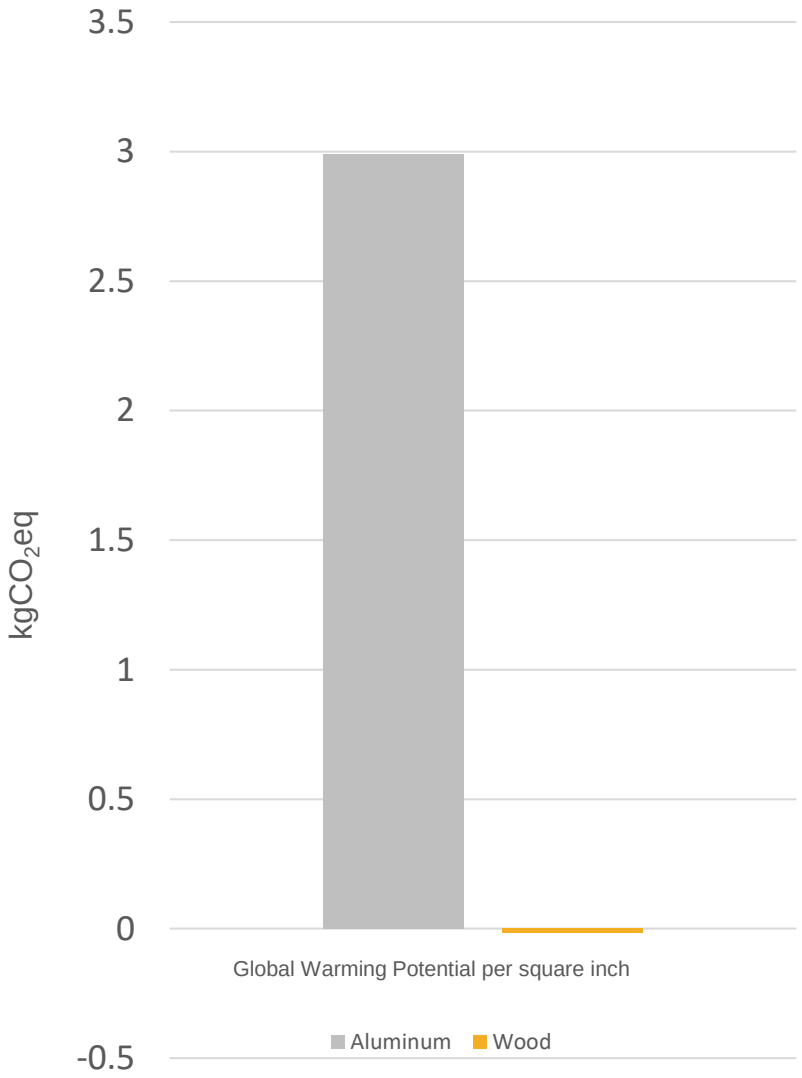


TIMBER + DOUBLE GLAZING
U = 0.22



3’- 6” occupant distance from facade

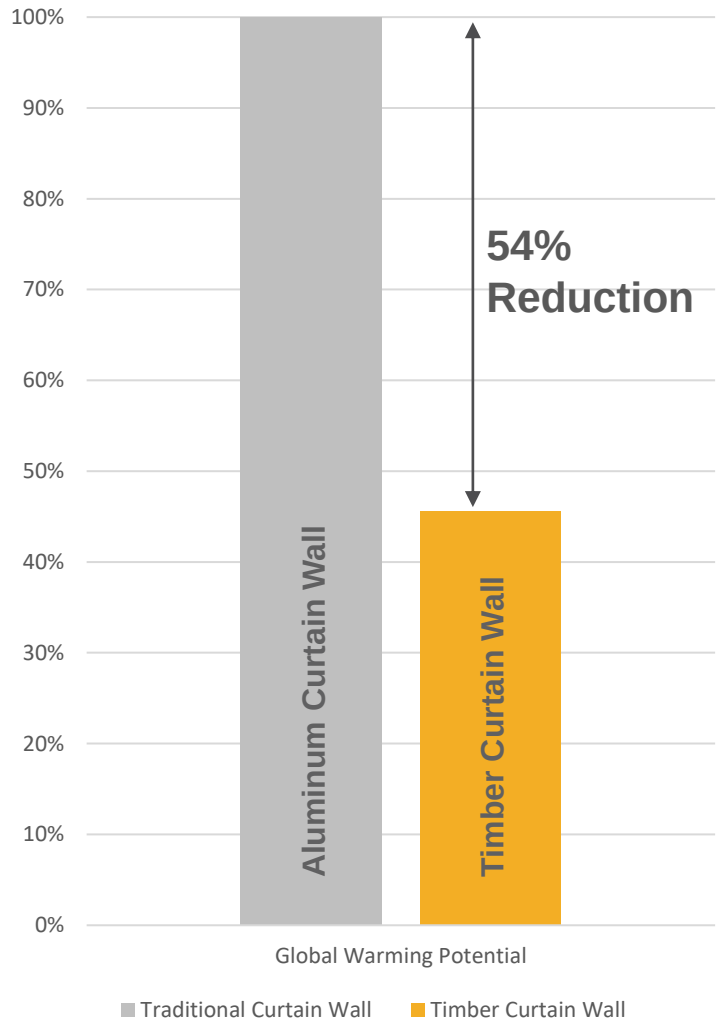
UNIT BASED EMBODIED CARBON SAVINGS

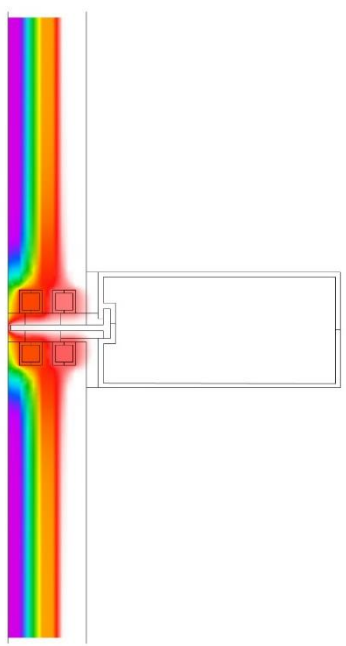


Aluminum

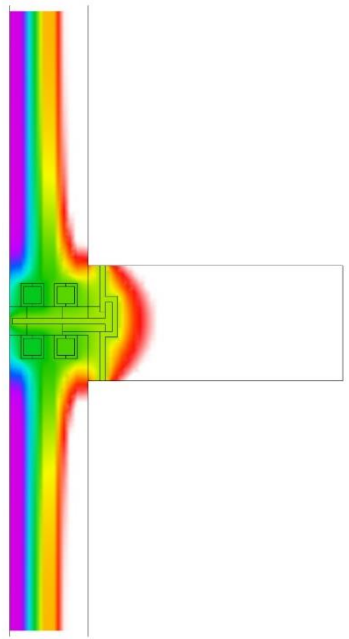
Timber

VOLUME BASED EMBODIED CARBON SAVINGS



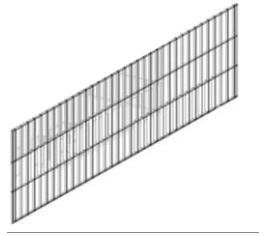


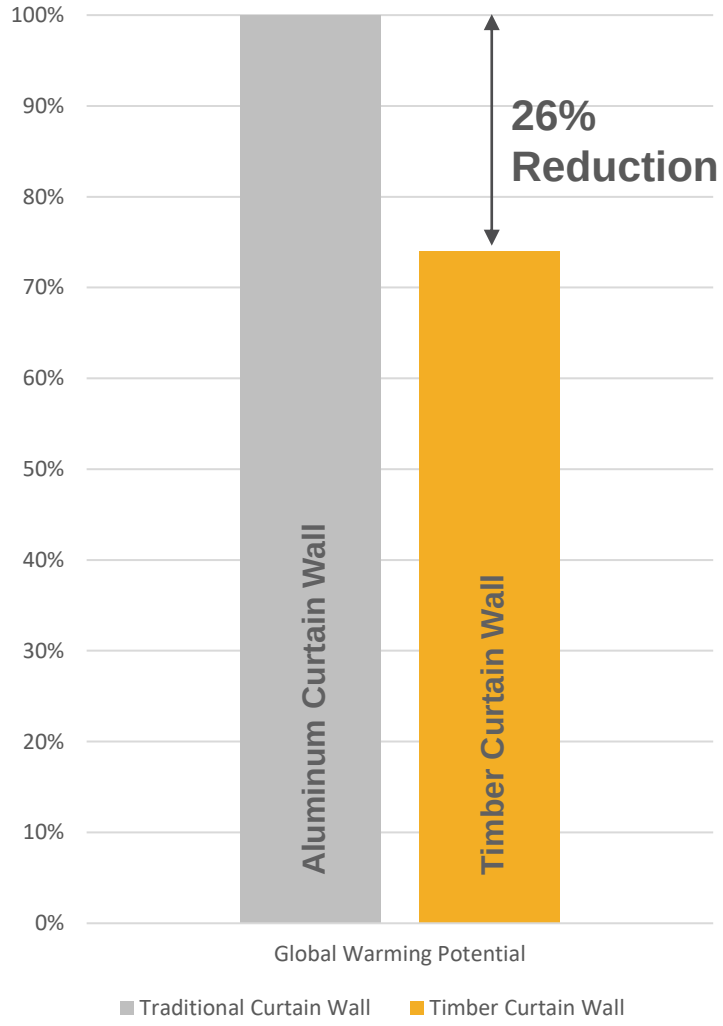
Aluminum Extrusion

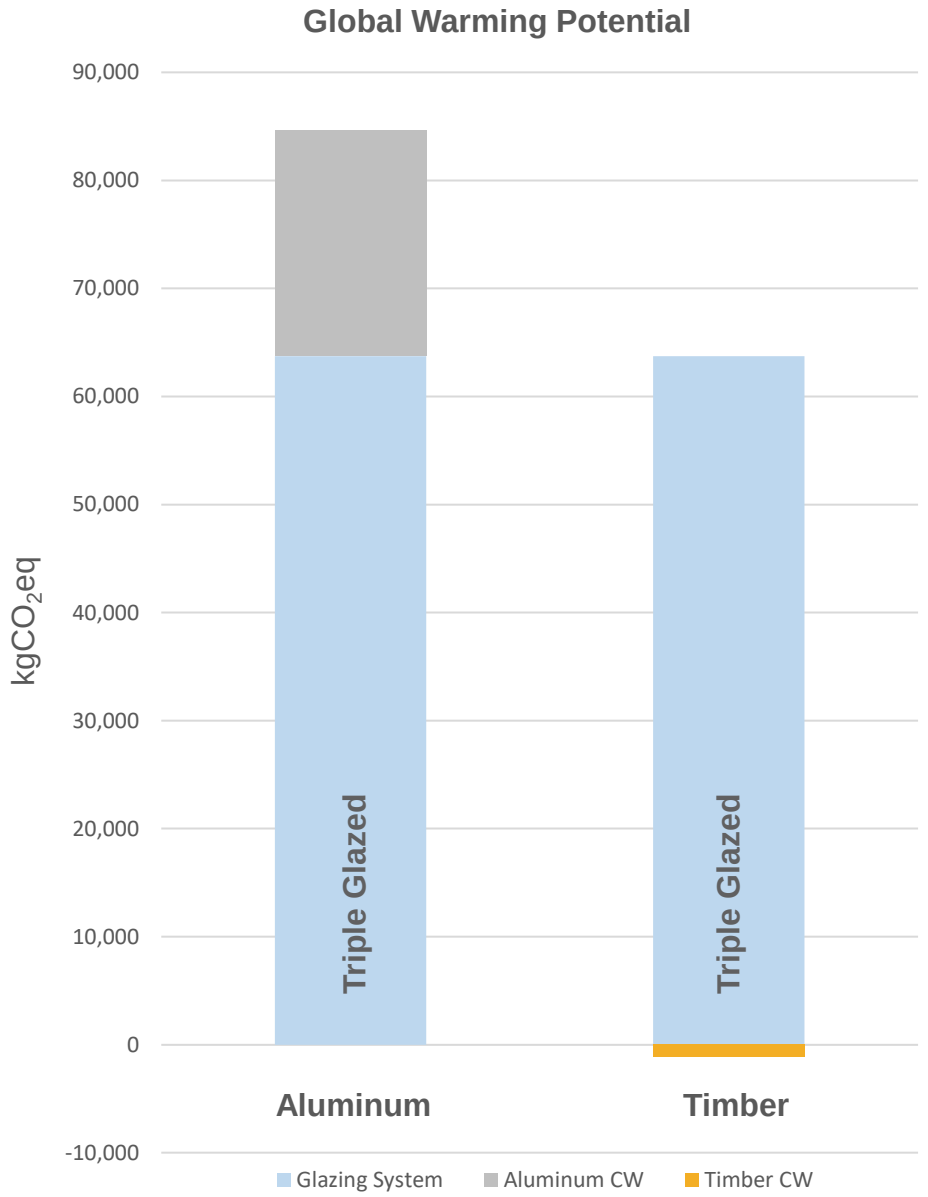


Glulam

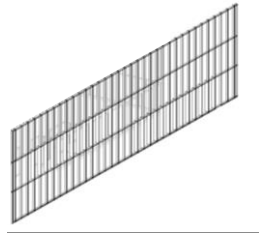
CURTAIN WALL BASED EMBODIED CARBON SAVINGS

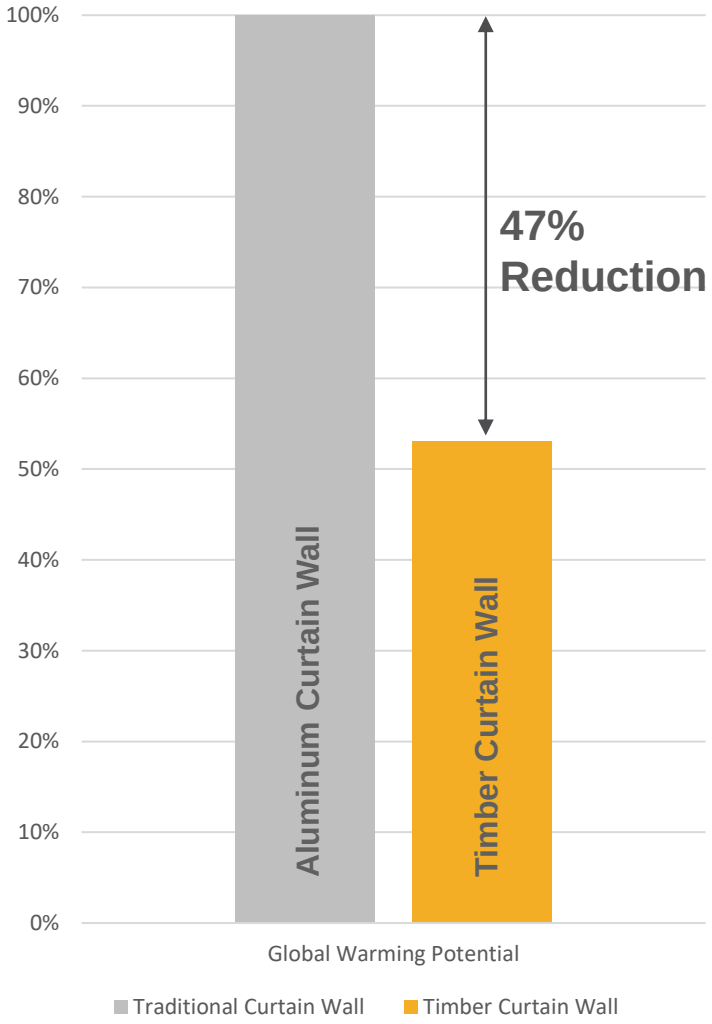


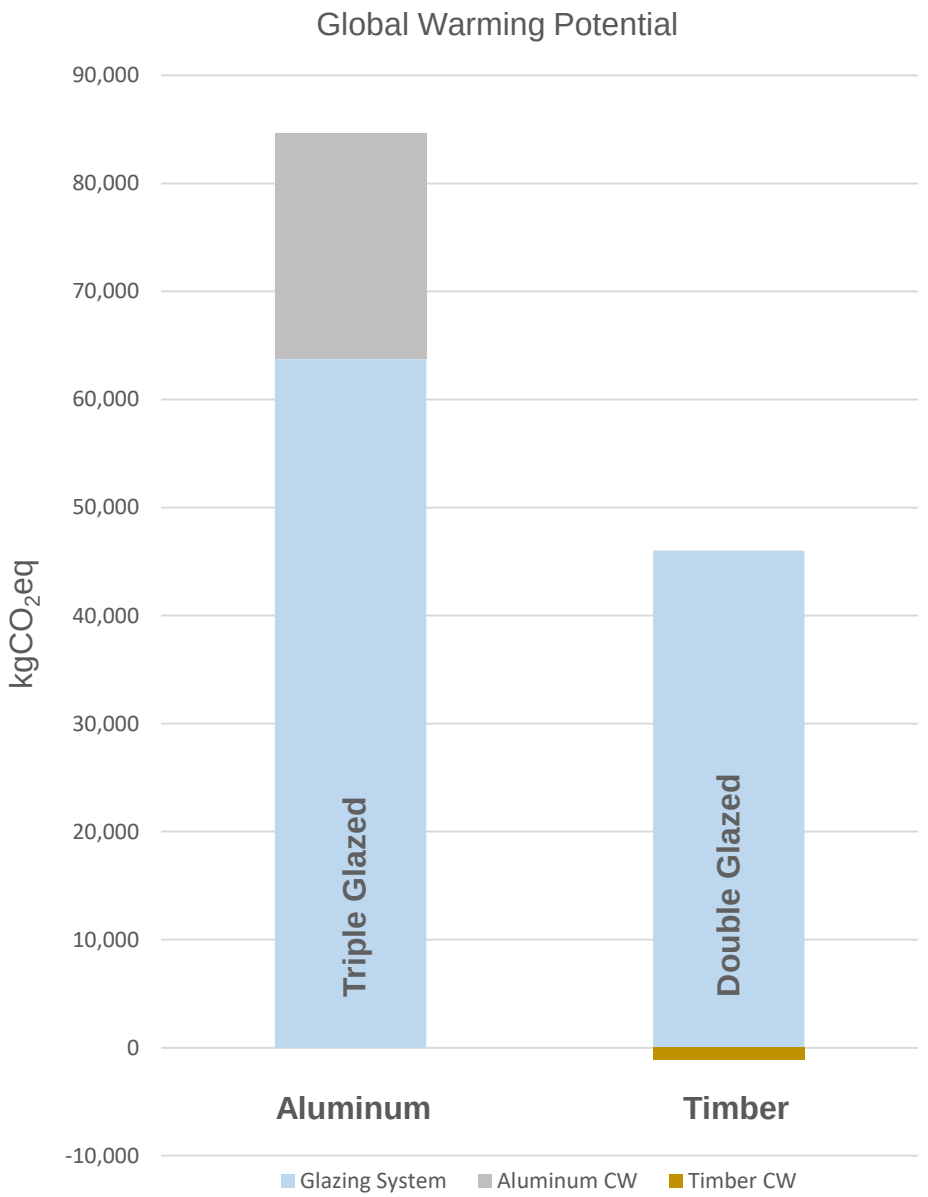




PERFORMANCE BASED EMBODIED CARBON SAVINGS

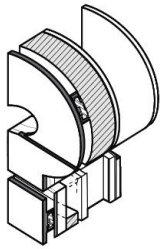






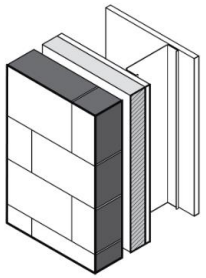
KALEIDOSCOPE

WELCOME
Want A Tour?



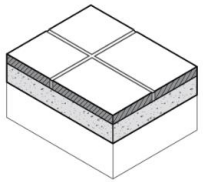
VIEW INTRO

ENVELOPES
Exterior Assemblies



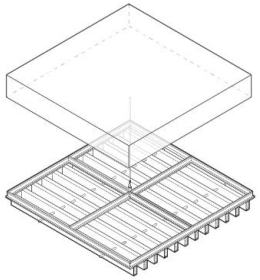
VIEW ENVELOPES

FLOORING
Flooring Assemblies



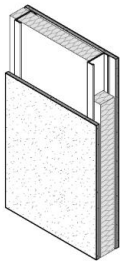
VIEW FLOORING

CEILINGS
Ceiling Assemblies



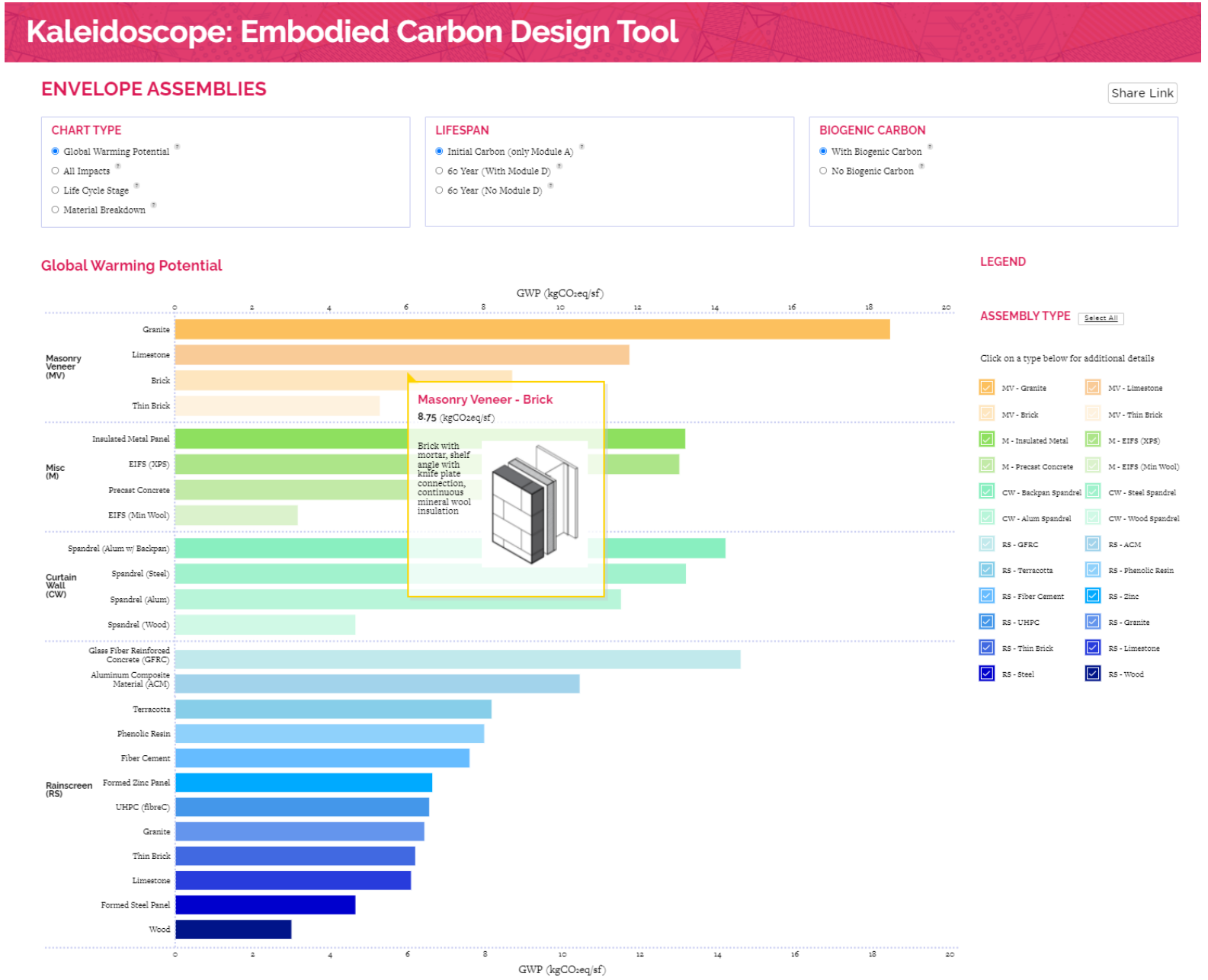
VIEW CEILINGS

PARTITIONS
Partitions Assemblies



VIEW PARTITIONS

KALEIDOSCOPE



KALEIDOSCOPE

Kaleidoscope: Embodied Carbon Design Tool

ENVELOPE ASSEMBLIES

Share Link

CHART TYPE

- (•) Global Warming Potential
- ( ) All Impacts
- ( ) Life Cycle Stage
- ( ) Material Breakdown

LIFESPAN

- (•) Initial Carbon (only Module A)
- ( ) 60 Year (With Module D)
- ( ) 60 Year (No Module D)

BIOGENIC CARBON

- (•) With Biogenic Carbon
- ( ) No Biogenic Carbon

Global Warming Potential

LEGEND

ASSEMBLY TYPE Select All

Click on a type below for additional details

ENVELOPE CALCULATOR

(•) Initial Carbon (only Module A) ( ) 60 Year (with Module D) ( ) 60 Year (no Module D)

Export CSV

Option 1

Type	Square Feet	GWP
CW - Wood Spandrel	8500	39950.00
	8,500 ft²	39,950.00 kgCO₂eq

Add row | Remove row

Export CSV

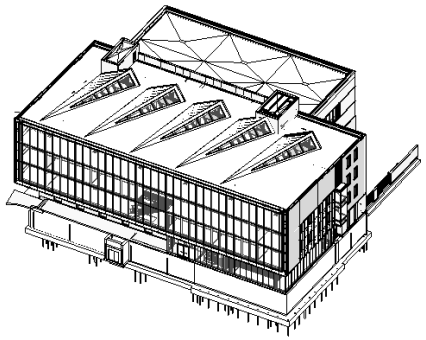
Option 2

Type	Square Feet	GWP
CW - Alum Spandrel	8500	98430.00
	8,500 ft²	98,430.00 kgCO₂eq

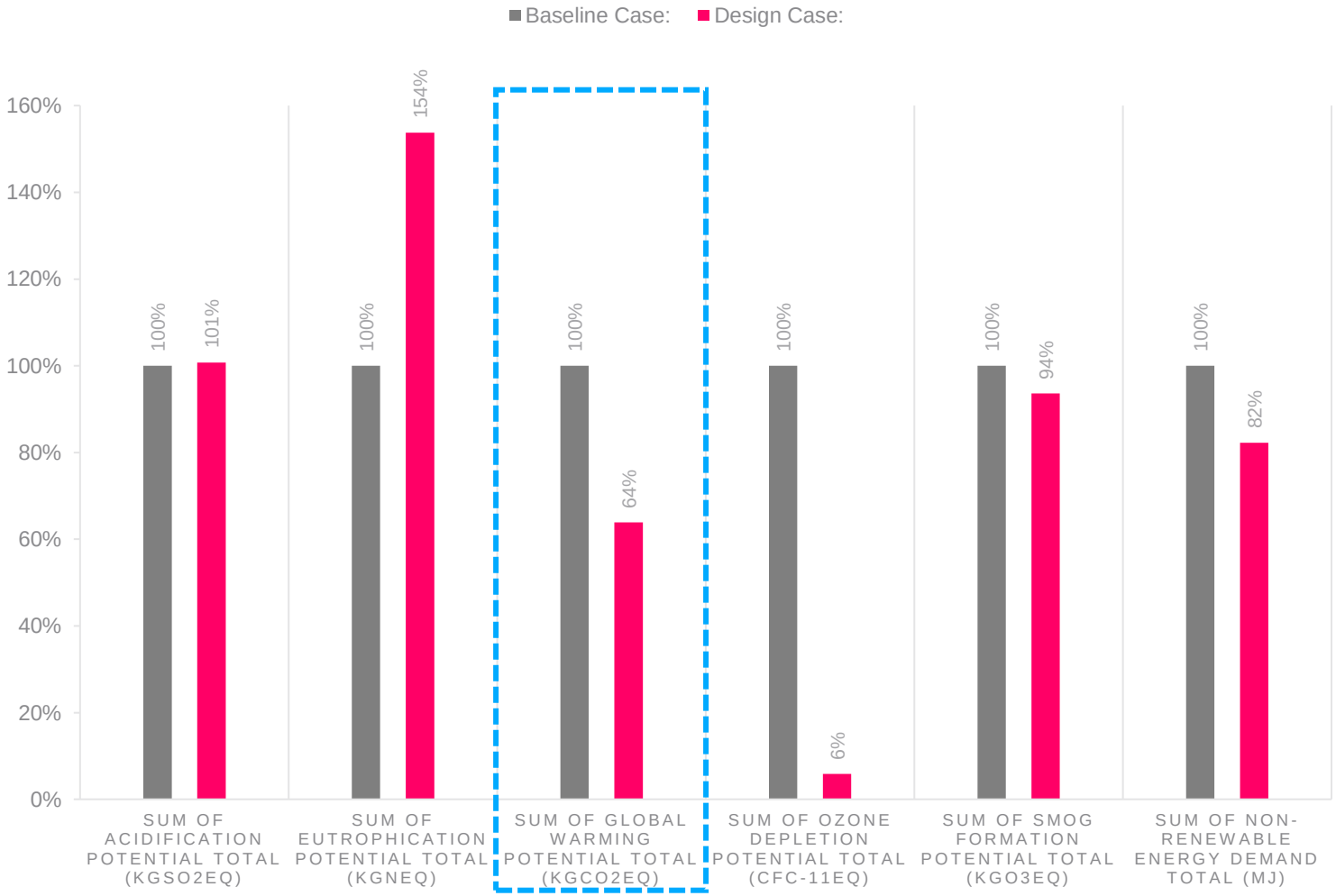
Add row | Remove row

Add Option | Delete Option

WHOLE BUILDING LCA



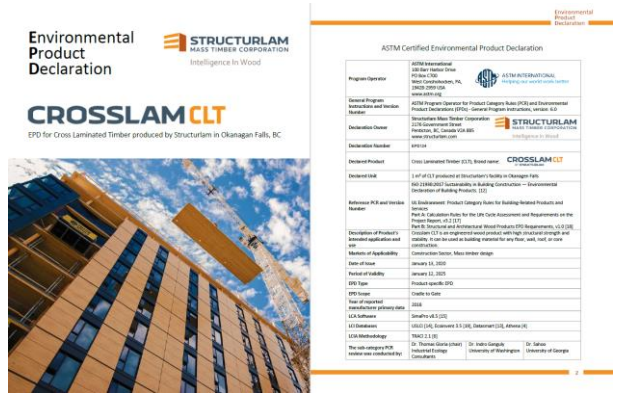
BASELINE VS DESIGN CASE



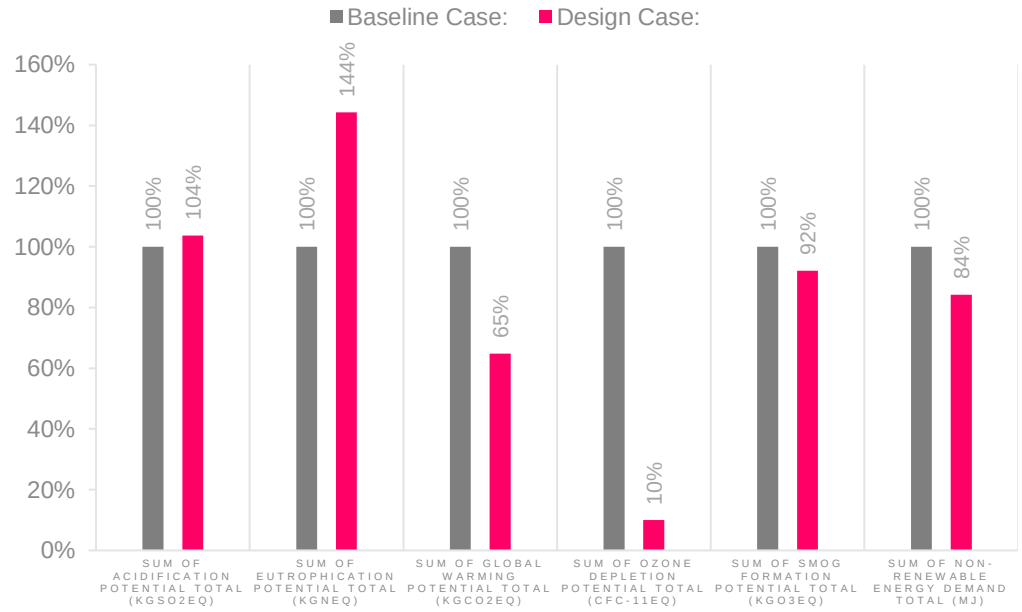
WHOLE BUILDING LCA - CHALLENGES

Glulam as CLT proxy

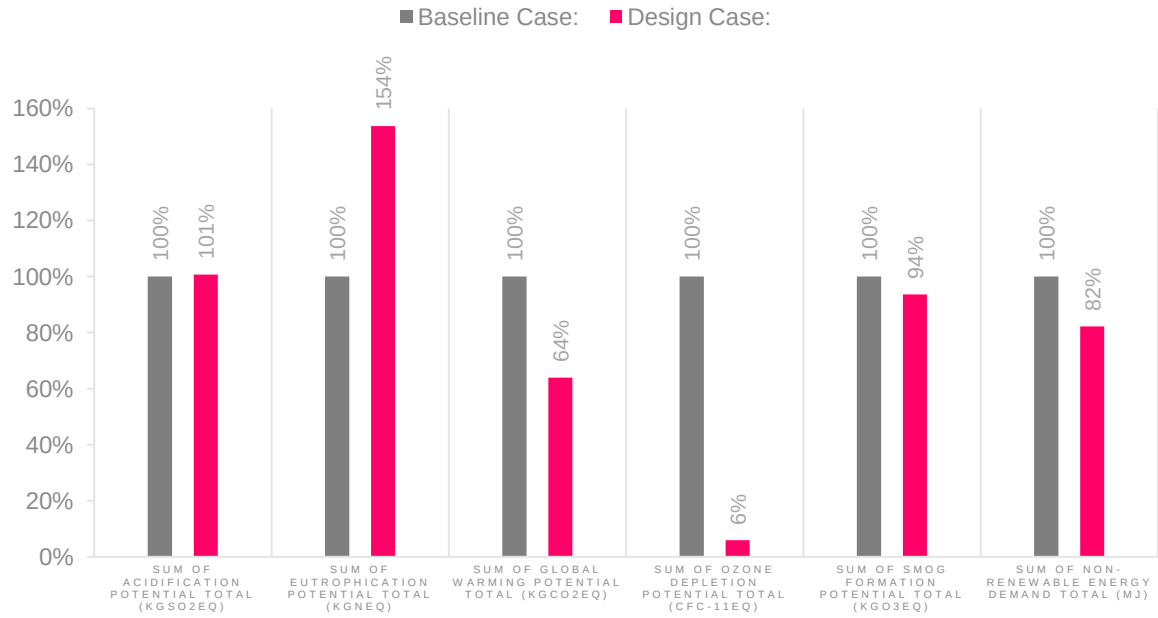
EPD specific data for CLT



BASELINE VS DESIGN CASE



BASELINE VS DESIGN CASE

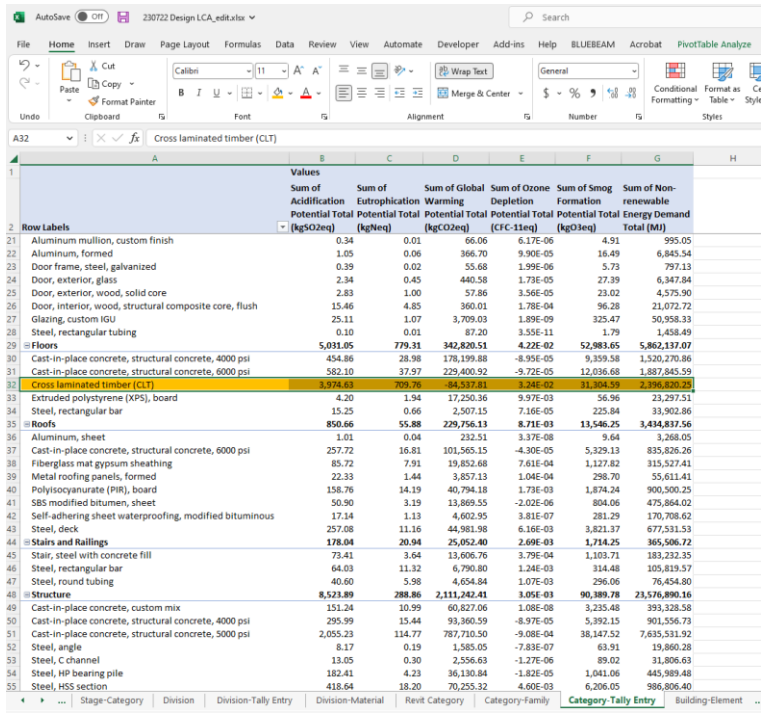


PROCESS

Tools tested (only Module A)

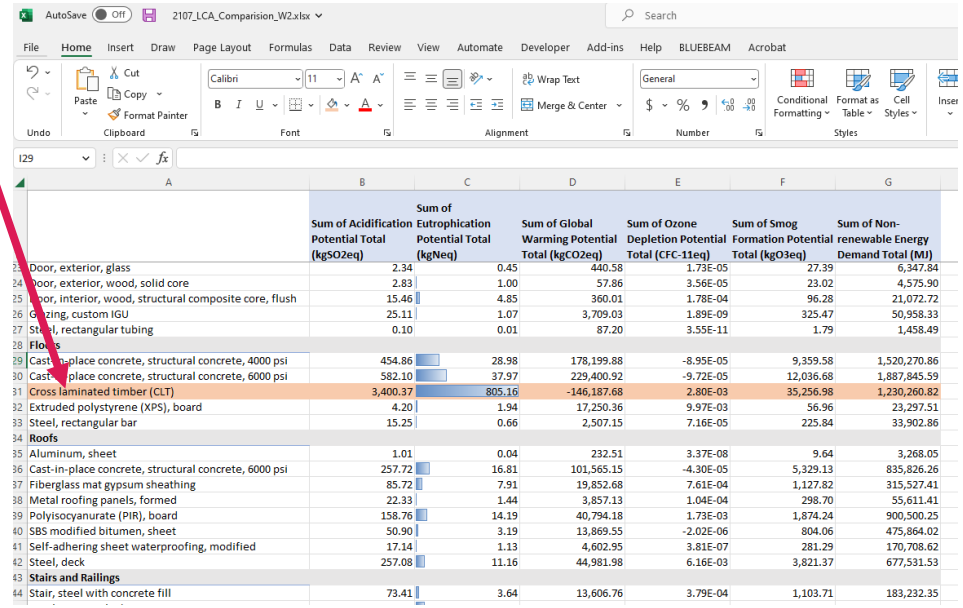
Updated CSV output with product specific EPD

Replaced with EPD data, calculated for same volume



Row Labels	Sum of Acidification Potential Total (kgSO2eq)	Sum of Eutrophication Potential Total (kgNeq)	Sum of Global Warming Potential Total (kgCO2eq)	Sum of Ozone Depletion Potential Total (CFC-11eq)	Sum of Smog Formation Potential Total (kgO3eq)	Sum of Non-renewable Energy Demand Total (MJ)
Aluminum mullion, custom finish	0.34	0.01	66.06	6.17E-06	4.91	995.05
Aluminum, formed	1.05	0.06	366.70	9.90E-05	16.49	6,845.54
Door frame, steel, galvanized	0.39	0.02	55.68	1.99E-06	5.73	797.13
Door, exterior, glass	2.34	0.45	440.58	1.73E-05	27.39	6,347.84
Door, exterior, wood, solid core	2.83	1.00	57.86	3.56E-05	23.02	4,575.90
Door, interior, wood, structural composite core, flush	15.46	4.85	360.01	1.78E-04	96.28	21,072.72
Glazing, custom IGU	25.11	1.07	3,709.03	1.89E-09	325.47	50,958.33
Steel, rectangular tubing	0.10	0.01	87.20	3.55E-11	1.79	1,458.49
Floors	**5,031.05**	**779.31**	**342,820.51**	**4.22E-02**	**52,983.65**	**5,862,137.07**
Cast-in-place concrete, structural concrete, 4000 psi	454.86	28.98	178,199.88	-8.95E-05	9,359.58	1,520,270.86
Cast-in-place concrete, structural concrete, 6000 psi	582.10	37.97	229,400.92	-9.72E-05	12,036.68	1,887,845.59
Cross laminated timber (CLT)	3,974.63	709.76	-84,537.81	3.24E-02	31,304.59	2,396,820.25
Extruded polystyrene (XPS), board	4.20	1.94	17,250.36	9.97E-03	56.96	23,297.51
Steel, rectangular bar	15.25	0.66	2,507.15	7.16E-05	225.84	33,902.86
Roofs	**850.66**	**55.88**	**229,756.13**	**8.71E-03**	**13,546.25**	**3,434,837.56**
Aluminum, sheet	1.01	0.04	232.51	3.37E-08	9.64	3,268.05
Cast-in-place concrete, structural concrete, 6000 psi	257.72	16.81	101,565.15	-4.30E-05	5,329.13	835,826.26
Fiberglass mat gypsum sheathing	85.72	7.91	19,852.68	7.61E-04	1,127.82	315,527.41
Metal roofing panels, formed	22.33	1.44	3,857.13	1.04E-04	298.70	55,611.41
Polyisocyanurate (PIR), board	158.76	14.19	40,794.18	1.73E-03	1,874.24	900,500.25
SBS modified bitumen, sheet	50.90	3.19	13,869.55	-2.02E-06	804.06	475,864.02
Self-adhering sheet waterproofing, modified bituminous	17.14	1.13	4,602.95	3.81E-07	281.29	170,708.62
Steel, deck	257.08	11.16	44,981.98	6.16E-03	3,821.37	677,531.53
Stairs and Railings	**178.04**	**20.94**	**25,052.40**	**2.69E-03**	**1,714.25**	**365,506.72**
Stair, steel with concrete fill	73.41	3.64	13,606.76	3.79E-04	1,103.71	183,232.35
Steel, rectangular bar	64.03	11.32	6,790.80	1.24E-03	314.48	105,819.57
Steel, round tubing	40.60	5.98	4,654.84	1.07E-03	296.06	76,454.80
Structure	**8,523.89**	**288.86**	**2,111,242.41**	**3.05E-03**	**90,389.78**	**23,576,890.16**
Cast-in-place concrete, custom mix	151.24	10.99	60,827.06	1.08E-08	3,235.48	393,328.58
Cast-in-place concrete, structural concrete, 4000 psi	295.99	15.44	93,360.59	-8.97E-05	5,392.15	901,556.73
Cast-in-place concrete, structural concrete, 5000 psi	2,055.23	114.77	787,710.50	-9.08E-04	38,147.52	7,635,531.92
Steel, angle	8.17	0.19	1,585.05	-7.83E-07	63.91	19,860.28
Steel, C channel	13.05	0.30	2,556.63	-1.27E-06	89.02	31,806.63
Steel, HP bearing pile	182.41	4.23	36,130.84	-1.82E-05	1,041.06	445,989.48
Steel, HSS section	418.64	18.20	70,255.32	4.60E-03	6,206.05	986,806.40

Step 1: Tally locked CSV



	Sum of Acidification Potential Total (kgSO2eq)	Sum of Eutrophication Potential Total (kgNeq)	Sum of Global Warming Potential Total (kgCO2eq)	Sum of Ozone Depletion Potential Total (CFC-11eq)	Sum of Smog Formation Potential Total (kgO3eq)	Sum of Non-renewable Energy Demand Total (MJ)
Door, exterior, glass	2.34	0.45	440.58	1.73E-05	27.39	6,347.84
Door, exterior, wood, solid core	2.83	1.00	57.86	3.56E-05	23.02	4,575.90
Door, interior, wood, structural composite core, flush	15.46	4.85	360.01	1.78E-04	96.28	21,072.72
Glazing, custom IGU	25.11	1.07	3,709.03	1.89E-09	325.47	50,958.33
Steel, rectangular tubing	0.10	0.01	87.20	3.55E-11	1.79	1,458.49
Floors						
Cast-in-place concrete, structural concrete, 4000 psi	454.86	28.98	178,199.88	-8.95E-05	9,359.58	1,520,270.86
Cast-in-place concrete, structural concrete, 6000 psi	582.10	37.97	229,400.92	-9.72E-05	12,036.68	1,887,845.59
Cross laminated timber (CLT)	3,400.37	805.16	-146,187.68	2.80E-03	35,256.98	1,230,260.82
Extruded polystyrene (XPS), board	4.20	1.94	17,250.36	9.97E-03	56.96	23,297.51
Steel, rectangular bar	15.25	0.66	2,507.15	7.16E-05	225.84	33,902.86
Roofs						
Aluminum, sheet	1.01	0.04	232.51	3.37E-08	9.64	3,268.05
Cast-in-place concrete, structural concrete, 6000 psi	257.72	16.81	101,565.15	-4.30E-05	5,329.13	835,826.26
Fiberglass mat gypsum sheathing	85.72	7.91	19,852.68	7.61E-04	1,127.82	315,527.41
Metal roofing panels, formed	22.33	1.44	3,857.13	1.04E-04	298.70	55,611.41
Polyisocyanurate (PIR), board	158.76	14.19	40,794.18	1.73E-03	1,874.24	900,500.25
SBS modified bitumen, sheet	50.90	3.19	13,869.55	-2.02E-06	804.06	475,864.02
Self-adhering sheet waterproofing, modified	17.14	1.13	4,602.95	3.81E-07	281.29	170,708.62
Steel, deck	257.08	11.16	44,981.98	6.16E-03	3,821.37	677,531.53
Stairs and Railings						
Stair, steel with concrete fill	73.41	3.64	13,606.76	3.79E-04	1,103.71	183,232.35

Step 2: Copied and changed in new excel document

PROCESS

From Tally (1 ft3)	A1-3	A4	C1-4	D	Total
GWP Inc Bio Carb (kg CO2e)	-19.98	0.35	16.1	1.28	-2.25
Acidification (kg SO2e)	0.05	0.00	0.06	-0.01	0.11
Eutrophication (kg N e)	3.01E-03	1.34E-04	1.61E-02	-3.86E-04	1.89E-02
Smog Formation (kg o3e)	0.68	0.05	0.21	-0.11	0.83
Ozone Depletion (kg CFC-11e)	8.60E-07	1.21E-14	1.29E-13	-1.86E-11	8.60E-07
Non-Renewable Energy Demand	87.41	5.03	8.27	-37.05	63.67

EPD Conversion + Tally Module C&D (1 ft3)	A1-3	A4	C1-4	D	Total
GWP Inc Bio Carb (kg CO2e)	-21.261	0	16.1	1.28	-3.88
Acidification (kg SO2e)	0.038	0	0.06	-0.01	0.090
Eutrophication (kg N e)	5.66E-03	0.00E+00	1.61E-02	-3.86E-04	2.14E-02
Smog Formation (kg o3e)	0.840	0	0.21	-0.11	0.936
Ozone Depletion (kg CFC-11e)	7.45E-08	0	1.29E-13	-1.86E-11	7.45E-08
Non-Renewable Energy Demand	61.434	0	8.27	-37.05	32.66

CLT (Cross laminated timber) **522,331.0 kg**

Used in the following Revit families:

4" FINISHED FLOOR CLT DECK ASSEMBLY 522,331.0 kg (60 yrs)

Used in the following Tally entries:

Cross laminated timber (CLT)

Description:

Engineered wood panel made of several layers of kiln-dried lumber stacked in alternating directions, bonded with structural adhesives, and pressed to form a solid rectangular panel.

Life Cycle Inventory:

Proxied by Glulam

Product Scope:

Cradle to gate

Transportation Distance:

By truck: 468 km

End-of-Life Scope:

14.5% Recovered
22% Incinerated with energy recovery
63.5% Landfilled (wood product waste)

Module D Scope:

Recovered wood products credited as avoided burden.

LCI Source:

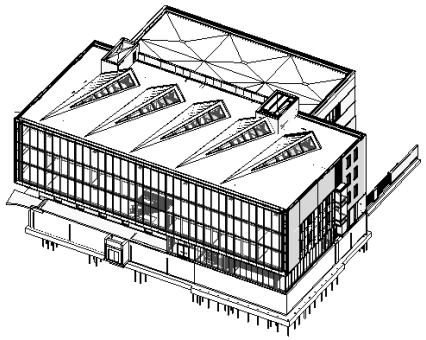
RNA: Glue laminated timbers CORRIM (2011)

Wood End-of-Life

Scope:

End of Life waste treatment methods and rates for wood are based on the 2014 Municipal Solid Waste and Construction Demolition Wood Waste Generation and Recovery in the United States report by Dovetail Partners, Inc. It is assumed that 63.5% of wood is sent to landfill, 22% to incineration, and 14.5% to recovery.

WHOLE BUILDING LCA

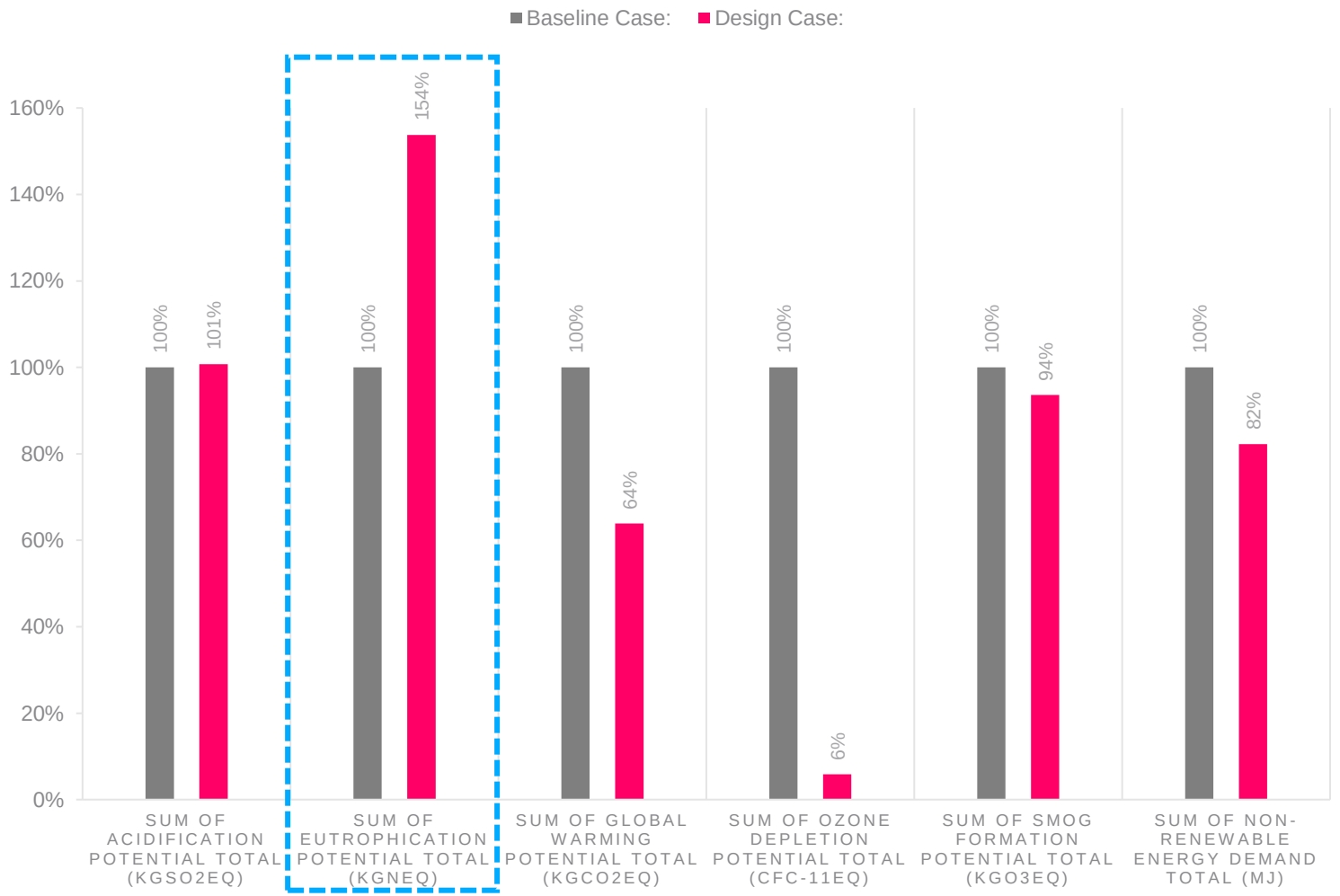


Environmental Product Declaration

STRUCTURLAM MASS TIMBER CORPORATION

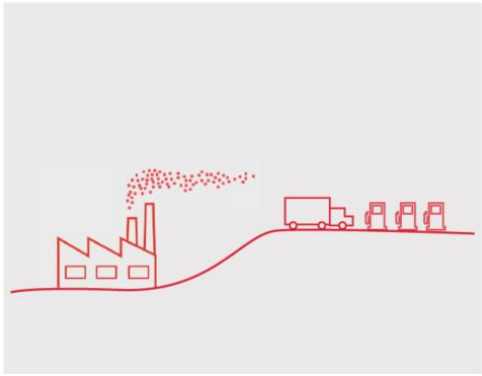
CROSSLAM CLT

BASELINE VS DESIGN CASE



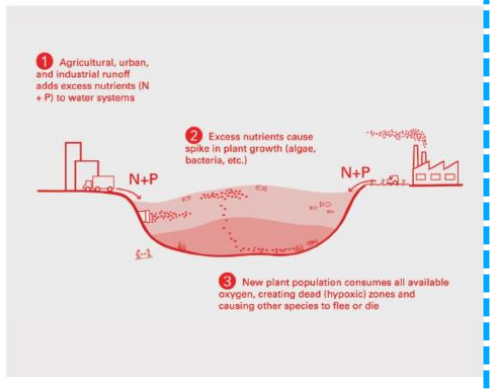
OTHER LIFE CYCLE IMPACTS

non-renewable energy [MJ]



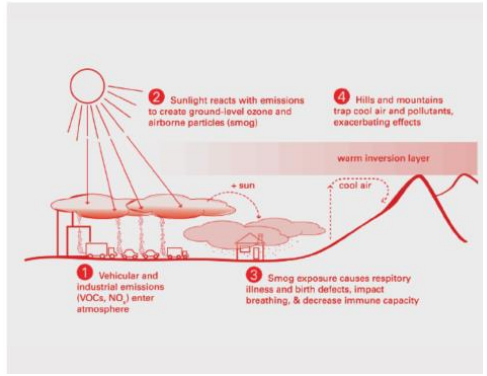
Source: iStock, & K. Simonen, Life Cycle Assessment, Routledge, 2014

eutrophication potential [kg N-eq]



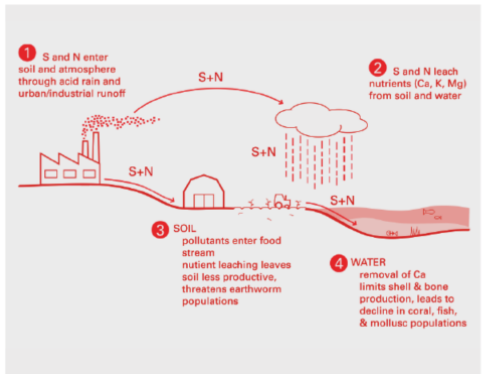
Source: Wikimedia, & K. Simonen, Life Cycle Assessment, Routledge, 2014

smog formation potential [kg O_3-eq]



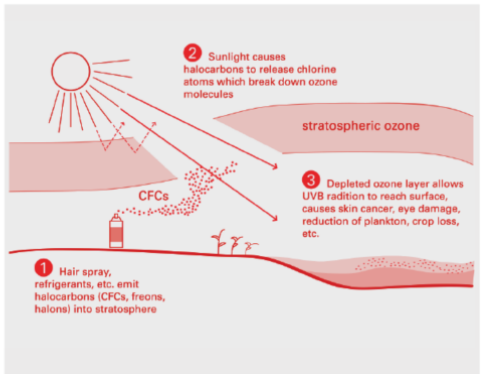
Source: Getty images, & K. Simonen, Life Cycle Assessment, Routledge, 2014

acidification potential [kg SO_2-eq]



Source: Wikipedia, & K. Simonen, Life Cycle Assessment, Routledge, 2014

ozone depletion potential [kg CFC 11-eq]



Source: recondoil.com, & K. Simonen, Life Cycle Assessment, Routledge, 2014

LEED V4.1 CREDITS

Materials & Resources: Building Life-Cycle Impact Reduction

Option 2: Whole Building Life-Cycle Assessment (1-4 points):

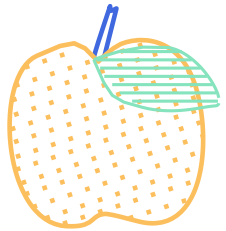
For new construction (buildings or portions of buildings), conduct a cradle-to-grave LCA of the project's structure and enclosure and follow one of the paths below to earn up to 4 points:

- *Path 1 (1 point):* Conduct LCA of structure and enclosure
- *Path 2 (2 points):* Conduct LCA of structure and enclosure that demonstrates a minimum of 5% reduction, compared with baseline building in at least 3 of the 6 impact categories, one of which must be GWP*
- *Path 3 (3 points):* Conduct LCA of structure and enclosure that demonstrates a minimum of 10% reduction, compared with baseline building in at least 3 of the 6 impact categories, one of which must be GWP*
- *Path 4 (4 points):* Meet requirements of Path 3 and incorporate reuse and/or salvage materials into the project's structure and enclosure for the proposed design. Demonstrate reductions compared to baseline building of at least 20% reduction for GWP, and at least 10% reduction in 2 additional impact categories*

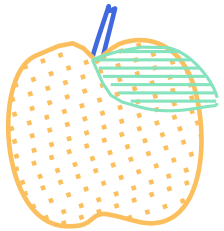
* no impact category assessed as part of the life-cycle assessment may increase by more than 5% compared with the baseline building

** impact categories: GWP in kg CO2e, depletion of stratospheric ozone layer in kg CFC-11e, acidification in kg SO2e, eutrophication in kg nitrogen eq, formation of tropospheric ozone in kg O3 eq (smog), depletion of nonrenewable energy resources in MJ

END-OF-LIFE - EUTROPHICATION



(to)



?

Metal

Metals End-of-Life

Scope:

Metal products are modeled using the avoided burden approach. The recycling rate at end of life is used to determine how much secondary metal can be recovered after having subtracted any scrap input into manufacturing (net scrap). Net scrap results in an environmental credit in Module D for the corresponding share of the primary burden that can be allocated to the subsequent product system using secondary material as an input. If the value in Module D reflects an environmental burden, then the original product (A1-A3) contains more secondary material than is recovered.

LCI Source:

Aluminum - RNA: Primary Aluminum Ingot AA/ts (2010)
Aluminum - RNA: Secondary Aluminum Ingot AA/ts (2010)
Brass - GLO: Zinc mix ts (2012)
Brass - GLO: Copper (99.99% cathode) ICA (2013)
Brass - EU-28: Brass (CuZn20) ts (2017)
Copper - DE: Recycling potential copper sheet ts (2016)
Steel - GLO: Value of scrap worldsteel (2014)
Zinc - GLO: Special high grade zinc IZA (2012)

End-of-Life Scope:
98% Recovered
2% Landfilled (inert material)

Wood

Wood End-of-Life

Scope:

End of Life waste treatment methods and rates for wood are based on the 2014 Municipal Solid Waste and Construction Demolition Wood Waste Generation and Recovery in the United States report by Dovetail Partners, Inc. It is assumed that 63.5% of wood is sent to landfill, 22% to incineration, and 14.5% to recovery.

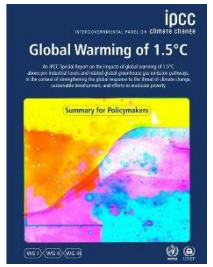
LCI Source:

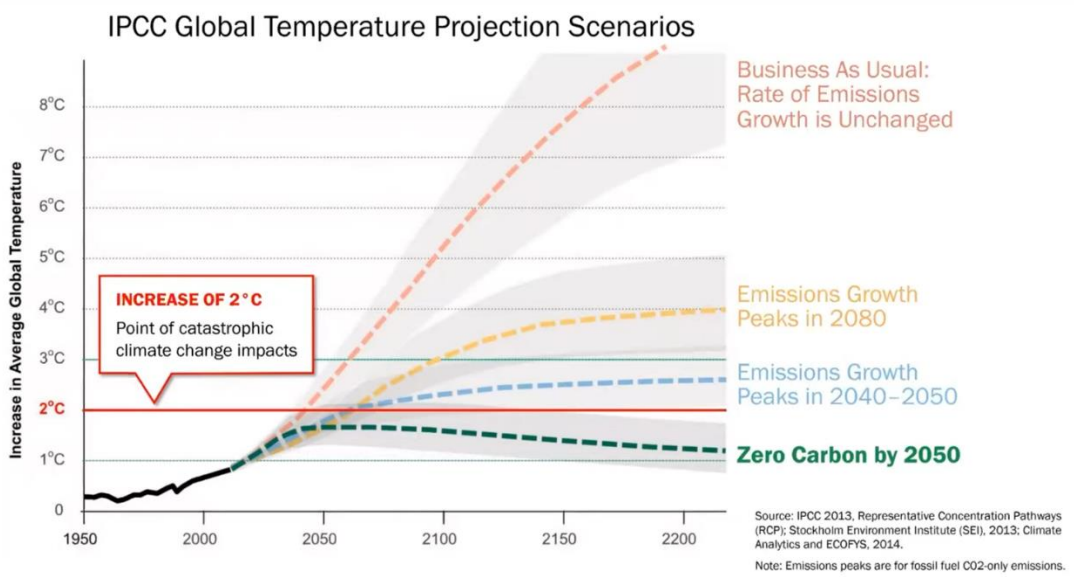
US: Untreated wood in waste incineration plant ts (2017)
US: Wood product (OSB, particle board) waste in waste incineration plant ts (2017)
US: Wood products (OSB, particle board) on landfill, post-consumer ts (2017)
US: Untreated wood on landfill, post-consumer ts (2017)
RNA: Softwood lumber CORRIM (2011)

End-of-Life Scope:
14.5% Recovered
22% Incinerated with energy recovery
63.5% Landfilled (wood product waste)

EUTROPHICATION - TOMORROW'S SOLUTION

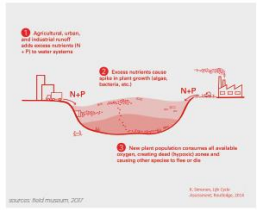
Today
Time value of carbon



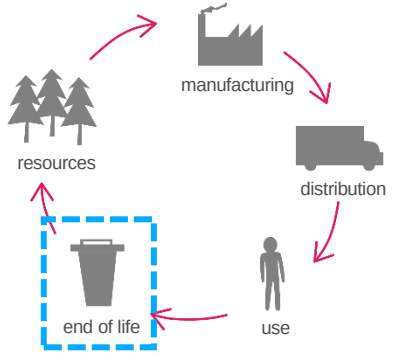


Tomorrow
Eutrophication

eutrophication potential [kg N-eq]



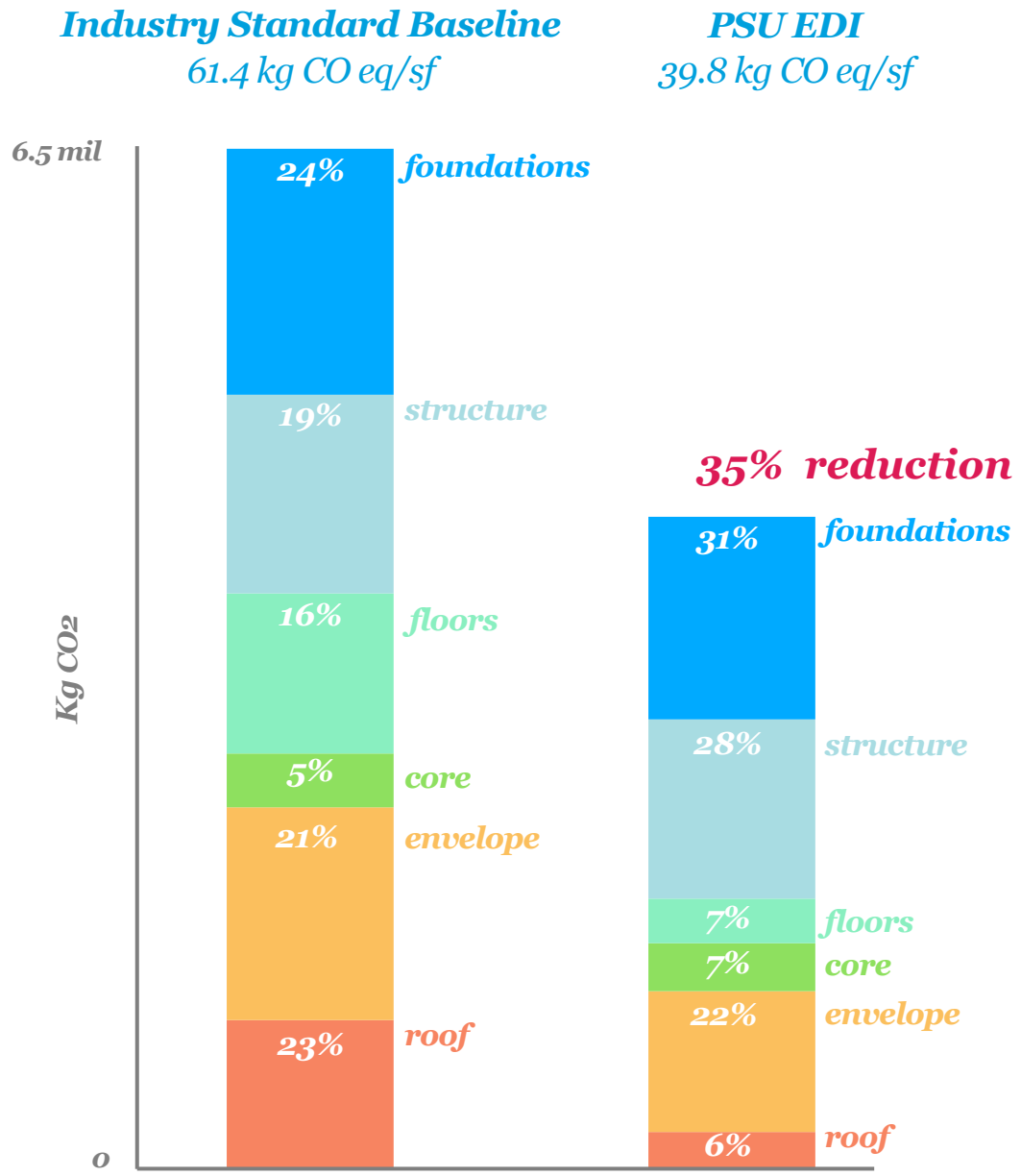
Source: Wikipedia



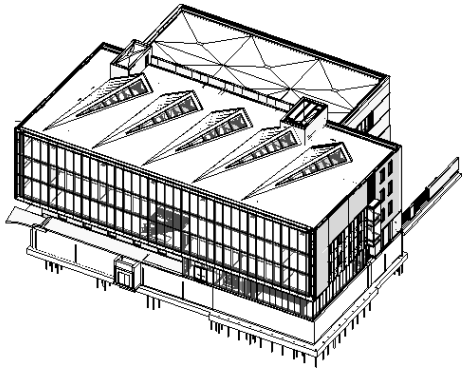
Call to action: Improve mass timber end of life in 60 years

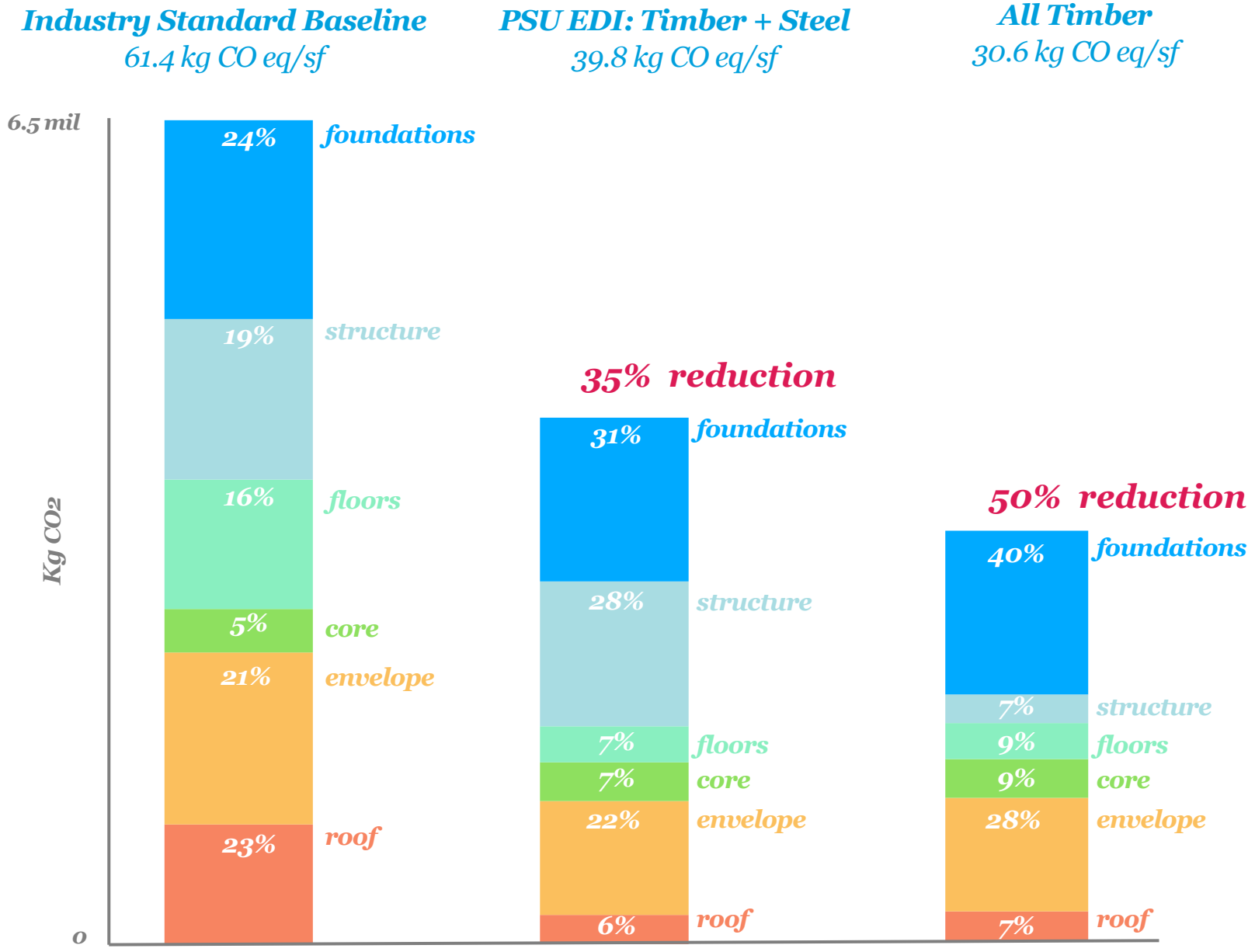
EMBODIED CARBON REDUCTION AREAS

- **Envelope Assembly**
  - Timber Curtainwall
- **Roof Assembly**
  - XPS to Polyiso
- **Floors**
  - CLT deck
- **Structural System**
  - Low Embodied Carbon Concrete mix
  - Steel beam quantity reduction



WHAT IF ALL TIMBER?





QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

Jennifer Hardy, AIA

Payette

jhardy@payette.com

Melanie Silver, AIA

Payette

msilver@payette.com