IMPACT OF PASSIVE HOUSE ENVELOPE SYSTEMS ON EMBODIED CARBON

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OUTLINE

BACKGROUND:

- What is embodied carbon?
- Why do we care?
- How do we measure it?
- Where are codes going?

CASE STUDY:

- Sample wall assembly
  - Code v. Passive House Compliance

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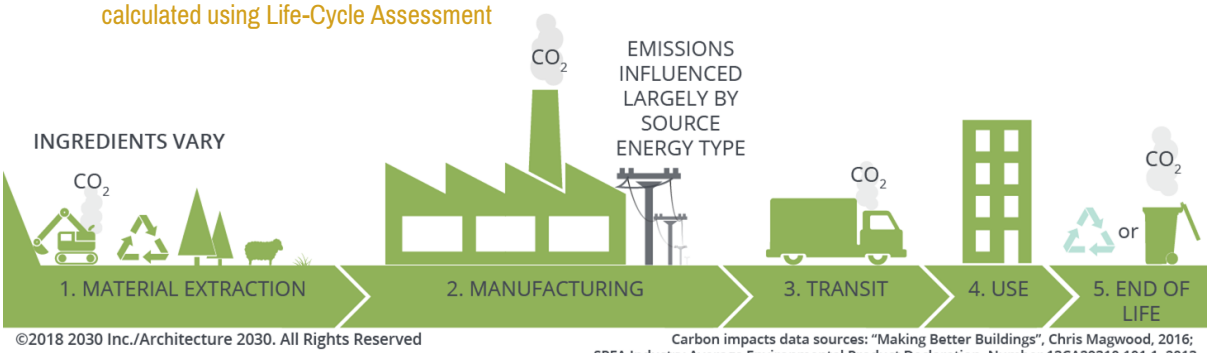
WHAT IS EMBODIED CARBON?

Total materials-related greenhouse gas emissions released during the life of a product or system, calculated using Life-Cycle Assessment



Carbon impacts data sources: "Making Better Buildings", Chris Magwood, 2016; SPFA Industry Average Environmental Product Declaration, Number 13CA29310.101.1, 2013

Embodied Carbon = Greenhouse Gas Emissions = Global Warming Potential

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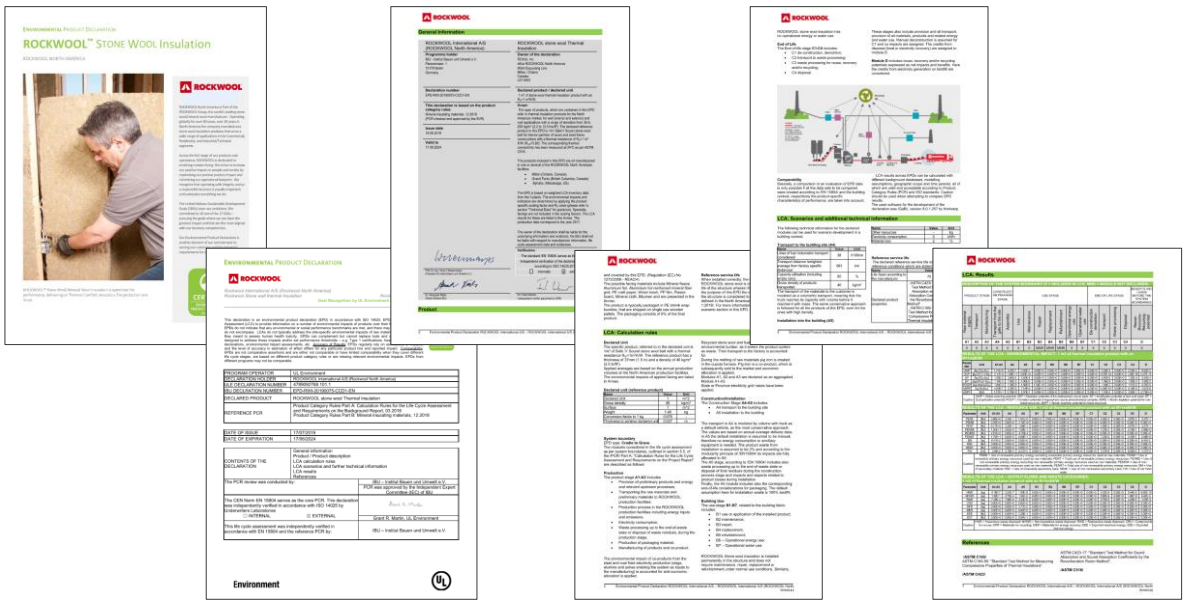
SAMPLE EPD – ROCKWOOL STONE WOOL INSULATION



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SAMPLE EPD – ROCKWOOL STONE WOOL INSULATION

System boundary
EPD type: **Cradle to Grave**.

Verification
The standard /EN 15804/ serves as the core PCR
Independent verification of the declaration and data according to /ISO 14025:2010/
☐ internally ☒ externally
Dr. Frank Werner (Independent verifier appointed by SVR)

/ISO 14025/
DIN EN /ISO 14025:2011-10/, Environmental labels and declarations — Type III environmental declarations — Principles and procedures

/EN 15804/
/EN 15804:2012-04+A1 2013/, Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products

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

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

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SAMPLE EPD – ROCKWOOL STONE WOOL INSULATION

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

Parameter	Unit	A1-A3	A4	A5	B1	B2	B6	B7	C1	C2	C3	C4	D
GWP	[kg CO_2-Eq.]	1.31E+0	4.25E-1	2.65E-1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	5.29E-3	0.00E+0	2.20E-2	-9.93E-2
ODP	[kg CFC11-Eq.]	2.11E-9	7.06E-17	3.50E-10	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	8.76E-19	0.00E+0	1.28E-16	2.27E-15
AP	[kg SO_2-Eq.]	1.03E-2	3.60E-4	2.62E-4	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	4.84E-6	0.00E+0	1.32E-4	-2.44E-4
EP	[kg $(PO_4)^{3-}$-Eq.]	1.14E-3	7.96E-5	4.96E-5	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.09E-6	0.00E+0	1.50E-5	-1.99E-5
POCP	[kg ethene-Eq.]	1.84E-3	1.38E-6	4.56E-5	1.54E-10	0.00E+0	0.00E+0	0.00E+0	0.00E+0	-1.40E-7	0.00E+0	1.01E-5	-3.35E-5
ADPE	[kg Sb-Eq.]	4.63E-7	3.29E-8	7.19E-9	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	4.09E-10	0.00E+0	8.10E-9	-1.61E-8
ADPF	[MJ]	1.57E+1	5.79E+0	5.97E-1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	7.19E-2	0.00E+0	3.08E-1	-2.70E+0

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WHY DO WE CARE ABOUT EMBODIED CARBON?

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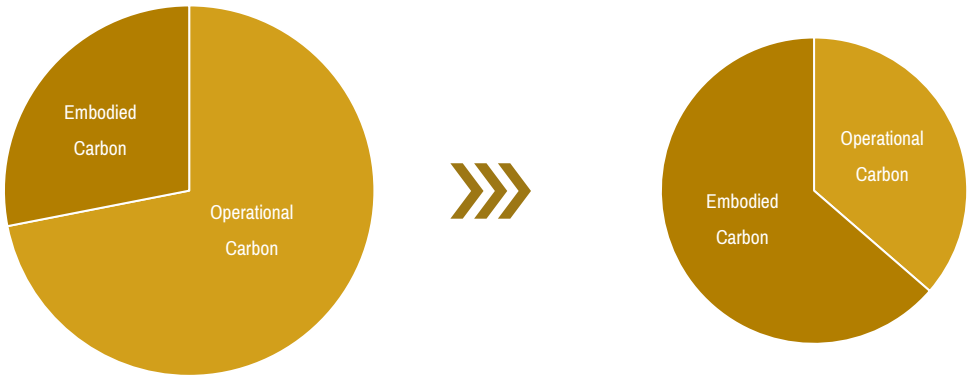
WHY DO WE CARE ABOUT EMBODIED CARBON?



NET ZERO → OPERATIONAL CARBON = ZERO
NET ZERO CARBON → EMBODIED CARBON = ZERO

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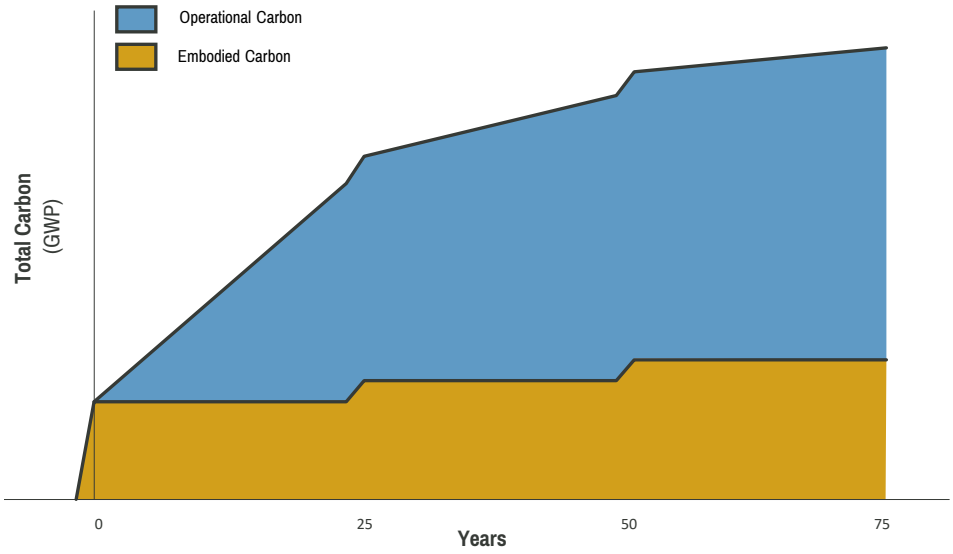
OPERATIONAL VERSUS EMBODIED CARBON



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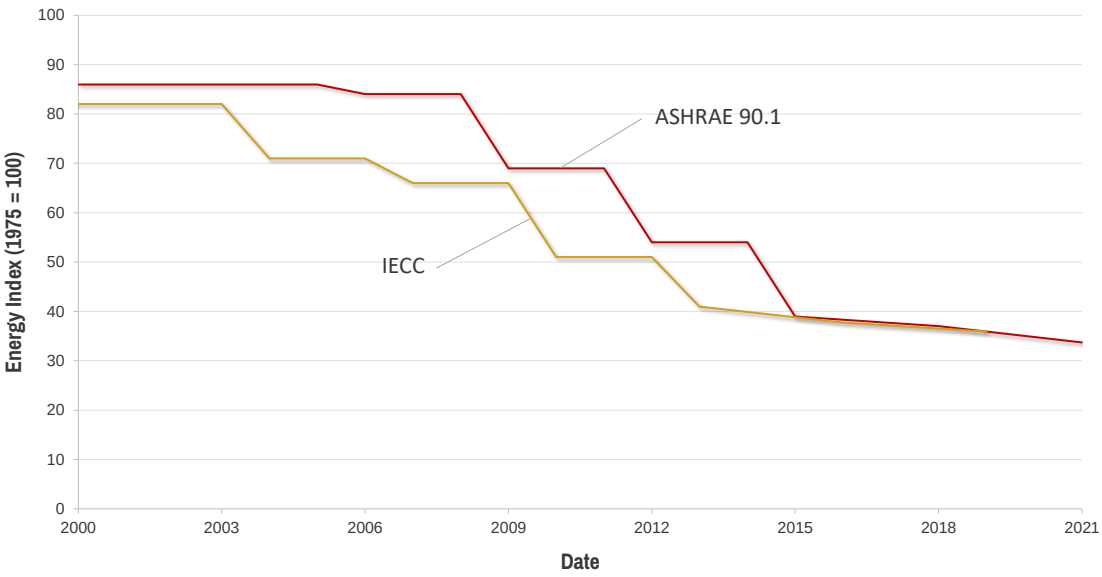
WHERE ARE CODES GOING?



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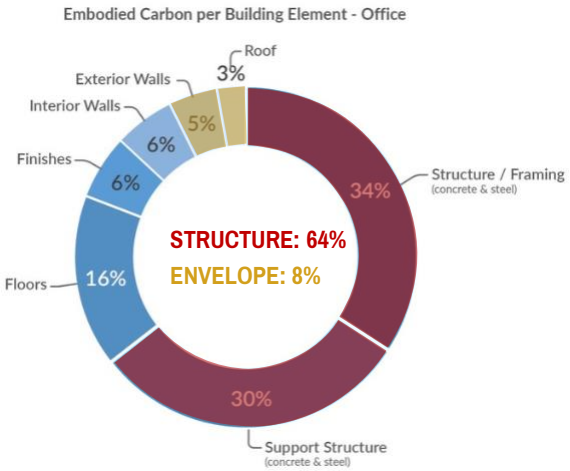
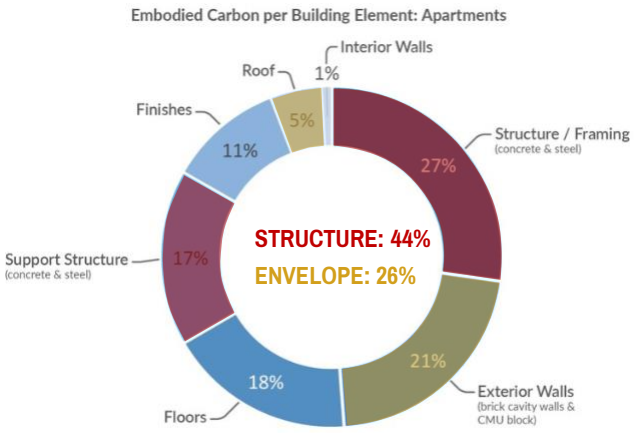
DISTRIBUTION OF EMBODIED CARBON IN BUILDINGS





Source: How to approach embodied carbon reduction within an architectural project, ArchDaily (https://www.archdaily.com)

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EMBODIED CARBON STUDY

- Typical mid-rise, mixed-use commercial building in Climate Zone 5
  - Multifamily residential occupancy
- 100 sf opaque wall module
- Code compliant construction versus PH ready construction

What's the embodied carbon difference?

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SOFTWARE TOOLS TO CALCULATE EMBODIED CARBON

tally
EC3
Athena Pavement LCA
circular ecology
One Click LCA
BEAM BUILDING EMISSIONS ACCOUNTING FOR MATERIALS
ClimateStudio
Kaleidoscope: Embodied Carbon Design Tool
sphera™

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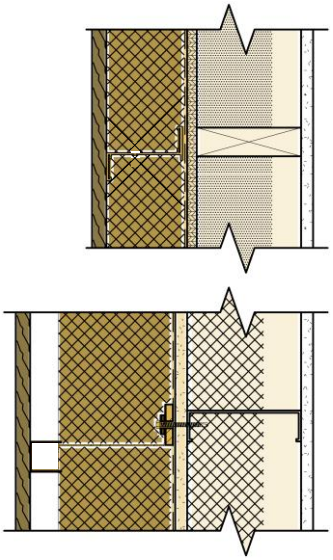
WALL ASSEMBLY DESCRIPTION – 100 SQ FT – ZONE 5

- Built 10’-0” x 10’-0” wall in Revit
  - Easy Comparison across types & design options
- Residential occupancy for large mid-rise apartment building
- Compared individual components based on type
- Limited Variables for composite comparison
  - Same cladding – Fiber Cement
  - Interior finish – Gypsum Wall Board, Type X, with Acrylic Latex Paint
  - 6” Framing
  - Site location excluded



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BIOGENIC CARBON INCLUSION VS EXCLUSION

- Biogenic carbon excluded from calculations
  - Biogenic carbon is the concept that certain materials will rust or rot and return into the natural carbon cycle.
- No guarantee of sustainable forestry products for all wood products
- Controversial as to how biogenic carbon is calculated
- Including vs excluding methane from biodegradable process & biological digestion

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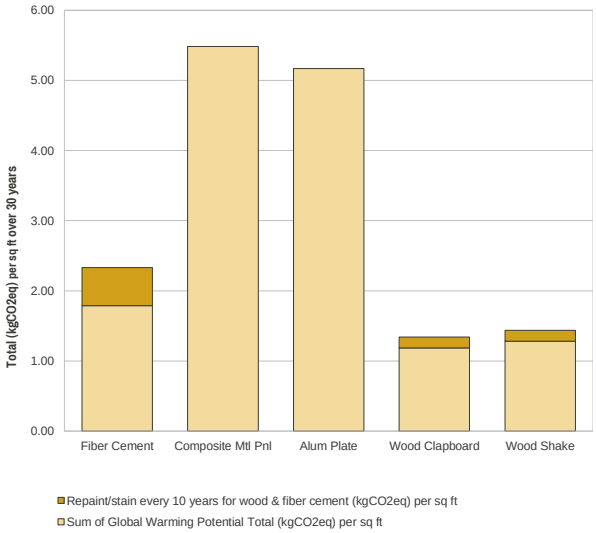
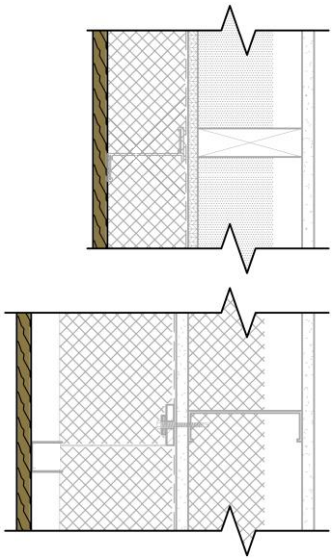
CLADDING COMPARISON – PER SQ FT





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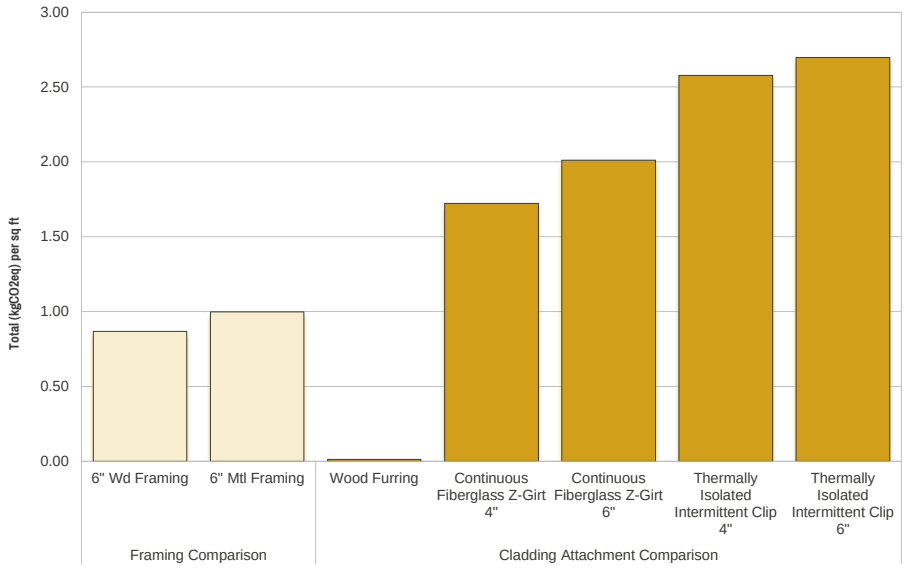
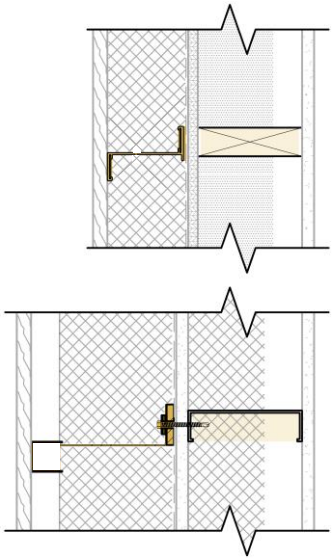
FRAMING & CLADDING ATTACHMENT COMPARISONS – PER SQ FT





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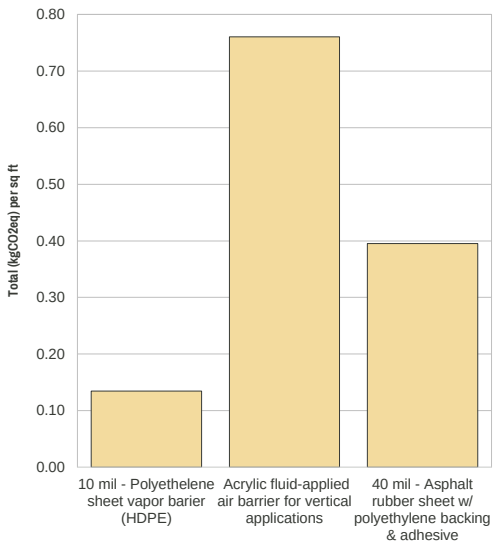
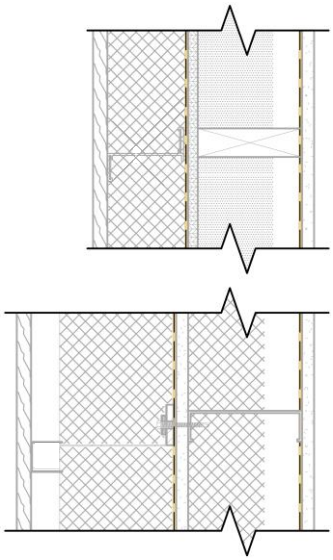
MEMBRANE COMPARISON – PER SQ FT





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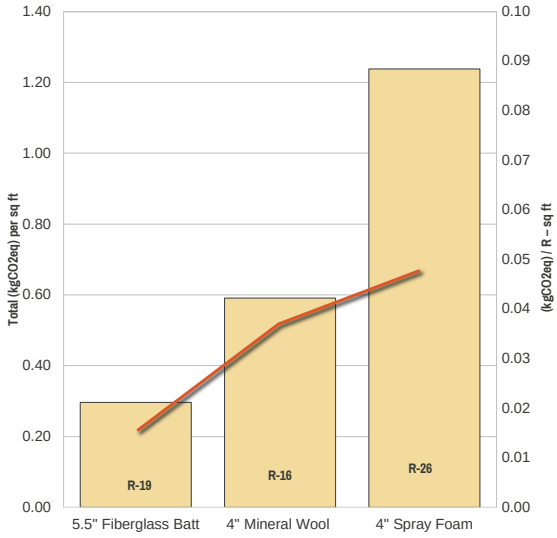
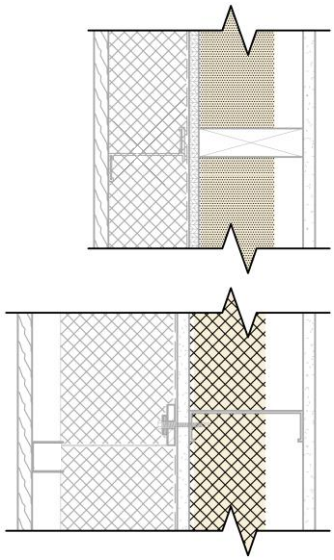
ONLY INSULATION COMPARISON – PER SQ FT





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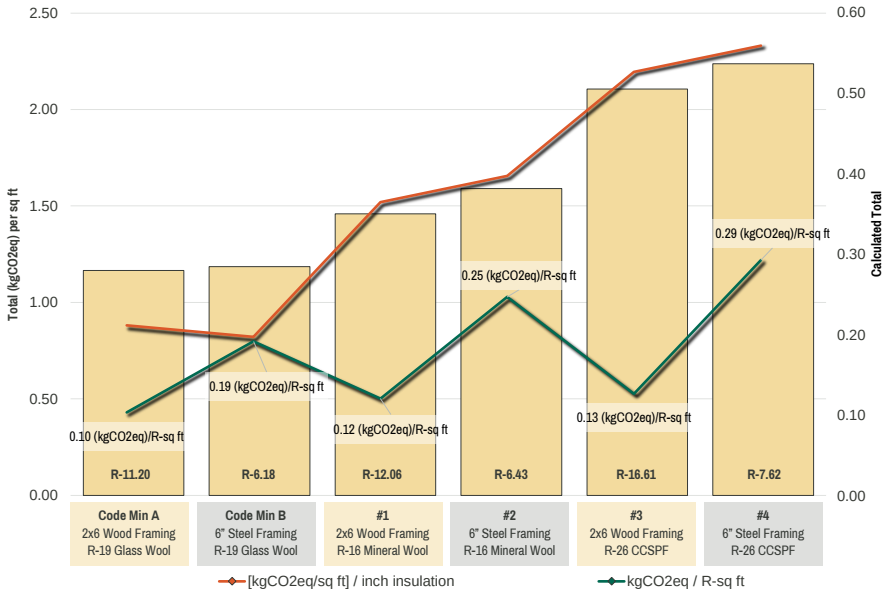
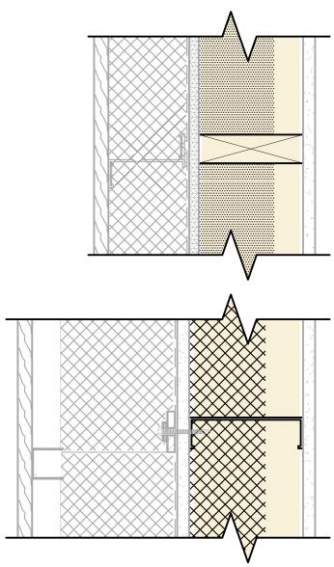
INSULATED WALL FRAMING – PER SQ FT – ZONE 5





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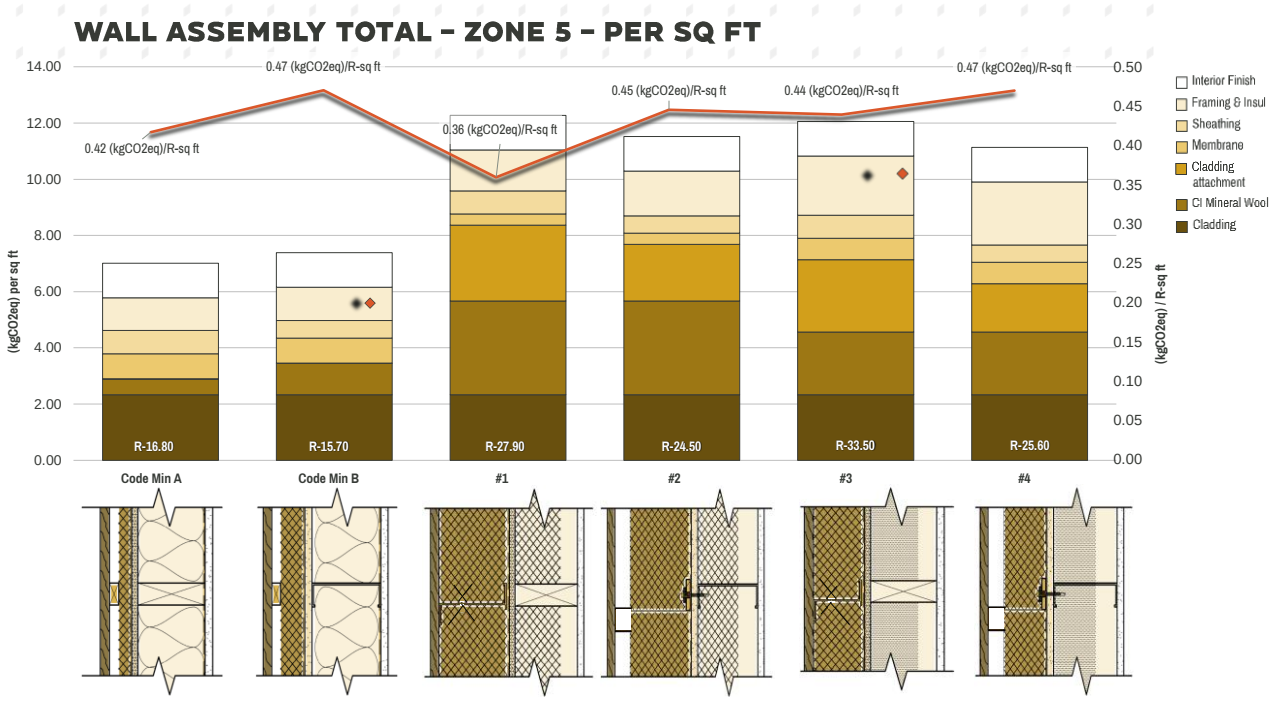

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PUTTING IT ALL TOGETHER…

- More Materials = More Carbon
- Better Envelope = Less Operational Carbon
- (kgCO2eq) / R ≥ Code Minimum
- Don't sweat the small stuff
  - Envelope is not as significant as structure

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FUTURE QUESTIONS

- Fenestration – opaque vs vision
- Roofs
- Foundations
- Structure + mechanical systems
- Hygrothermal performance
- Maintenance / replacement
- Different occupancies – residential vs office vs school vs hospital vs lab

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ACKNOWLEDGEMENTS

Kyung Yoon

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THANK YOU!
QUESTIONS?

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