



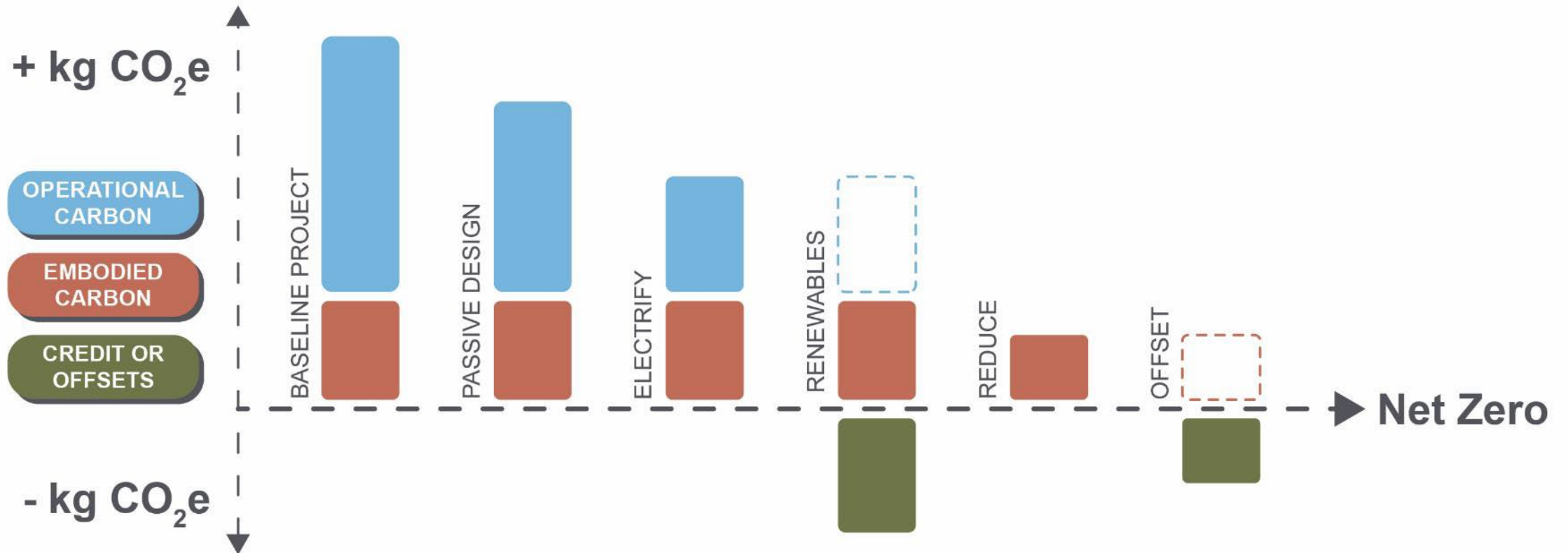
THE BUILT ENVIRONMENT AND EMBODIED CARBON

How Local and State Governments can
Meet the Challenge

February 15, 2024



Pathway to Decarbonization



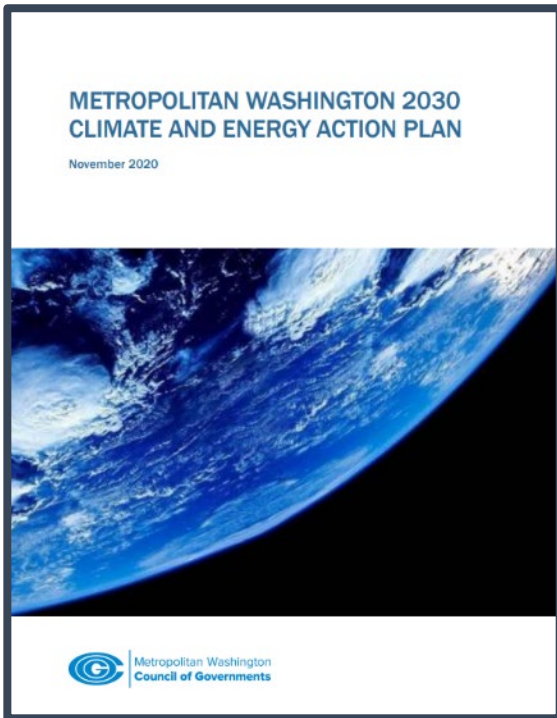
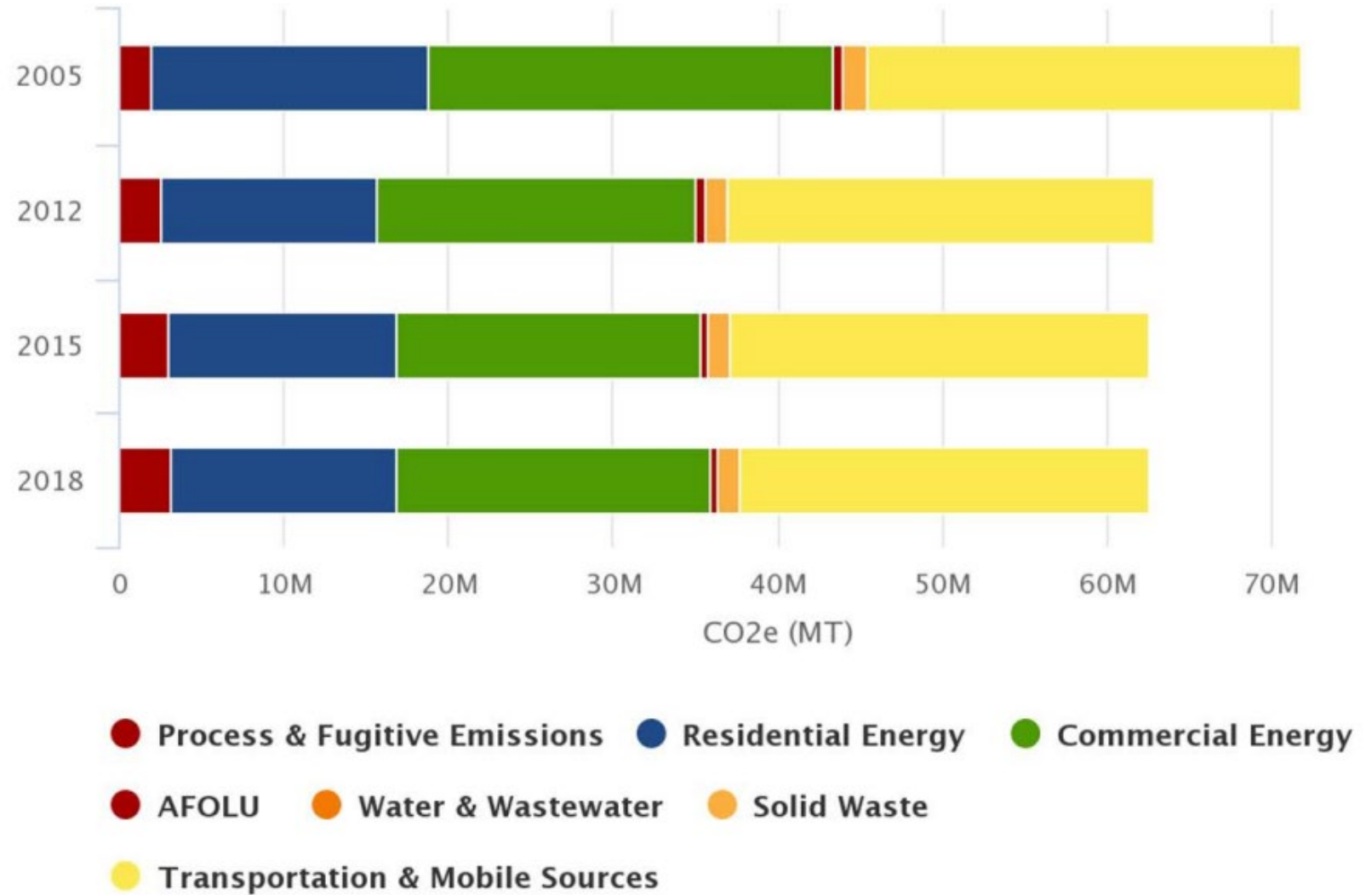
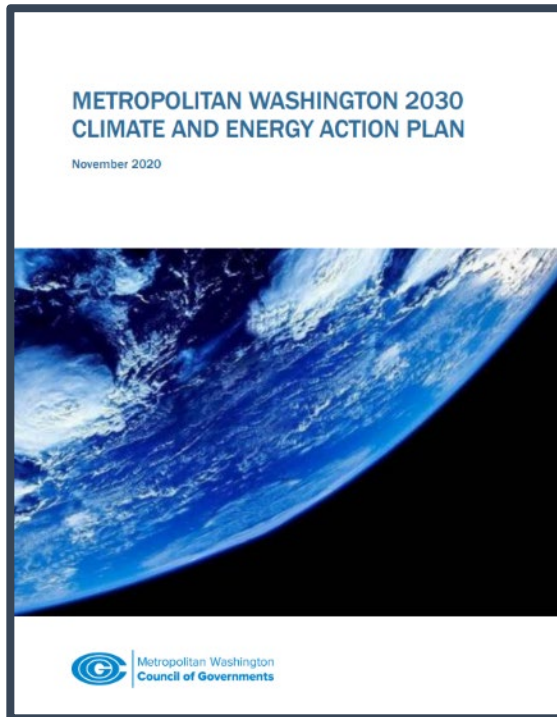


Figure ES-2: Metropolitan Washington GHG Emissions by Activity



Source: ICLEI's ClearPath, an online greenhouse gas inventory tool.

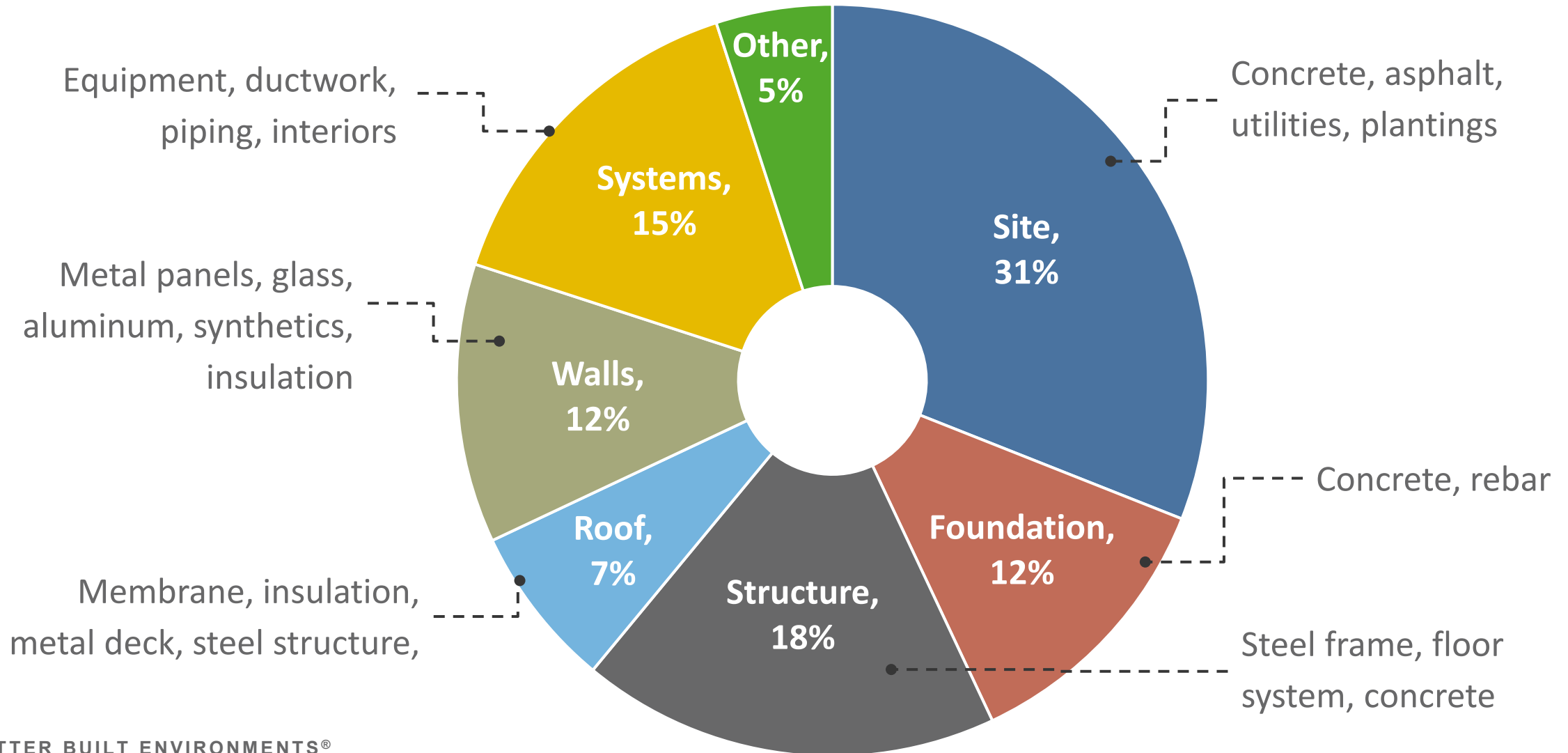


Appendix Table 2: Methodology Summary Table

Emissions Type	Emissions Activity or Source	GHG Types (CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆)	Methodology (From US Communities Protocol, v 1.1)	Data Quality Confidence Levels (High, Medium, Low)
BUILT ENVIRONMENT				
Residential Energy	Emissions from Grid Electricity *	CO ₂ , CH ₄ , N ₂ O	Appendix C, BE.2.1	High
	Emissions from Stationary Fuel (Natural Gas) *		Appendix C, BE.1.1	High
	Emissions from Stationary Fuel (Fuel Oil, LPG) *		Appendix C, BE.1.2	Medium
Commercial and Industrial Energy	Emissions from Grid Electricity *	CO ₂ , CH ₄ , N ₂ O	Appendix C, BE.2.1	High
	Emissions from Stationary Fuel (Natural Gas) *		Appendix C, BE.1.1	High
	Emissions from Stationary Fuel (Fuel Oil, LPG) *		Appendix C, BE.1.3	Medium
	Industrial Point Source Emissions from Stationary Fuel Combustion	Any GHG	IE in commercial and industrial stationary fuel and solid waste	N/A
	Consumption of District Energy	CO ₂ , CH ₄ , N ₂ O	IE in commercial and industrial grid electricity and stationary fuel	N/A



Example of Embodied Carbon in a Building





Measuring Embodied Carbon

Measures Environmental
Impact Categories
including GWP

**Life Cycle
Assessment**

LCA is a **method**

**Environmental
Product
Declaration**

EPDs are a **product report**

**Whole Building
LCA**

WBLCAs are a **project level LCA**

*Note: **Life Cycle Cost Analysis is a different assessment! LCCA** considers the total cost of an asset over its life cycle, including initial capital costs.*



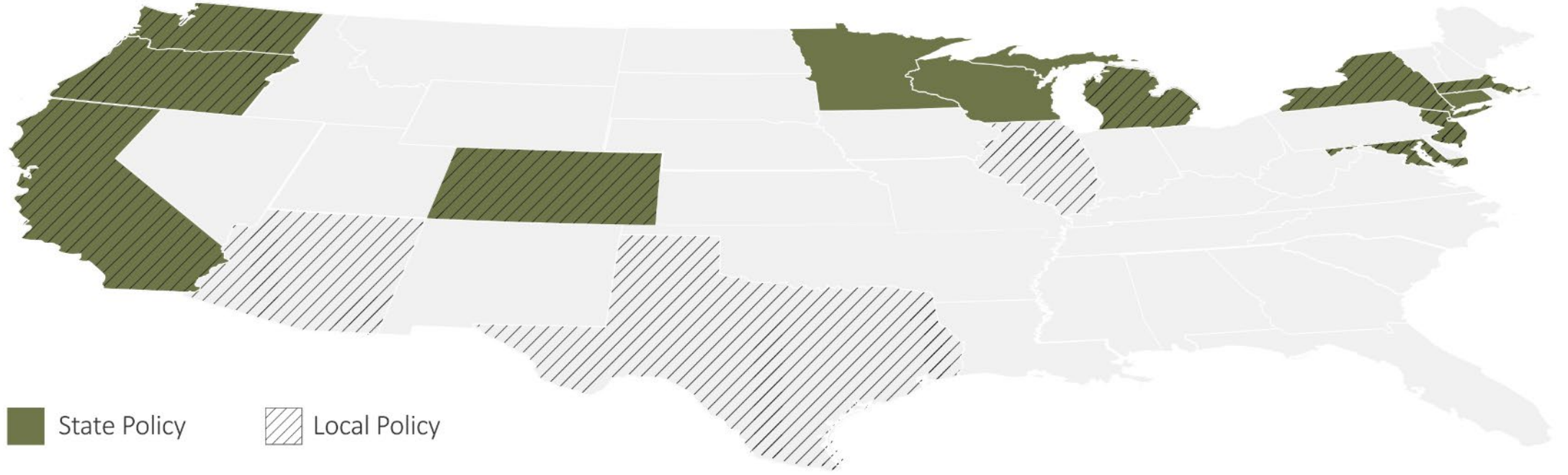
WBLCA Basic Process



- **Global warming potential** (greenhouse gases)
- Depletion of the stratospheric ozone layer
- Acidification of land and water sources
- Eutrophication
- Formation of tropospheric ozone
- Depletion of nonrenewable energy resources



Map of U.S. Jurisdictions with Embodied Carbon Policies



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Policy Example: Federal Buy Clean Initiative



Asphalt
Concrete
Glass
Steel

GSA IRA LEC Material Requirements

	GSA IRA Limits for Low Embodied Carbon Concrete (EPD-Reported GWPs, in kilograms of carbon dioxide equivalent per cubic meter - kgCO ₂ e/ m ³)		
Specified concrete strength class (compressive strength [f'c] in pounds per square inch [PSI])	Top 20% Limit	Top 40% Limit	Better Than Average Limit
≤2499	228	261	277
3000	257	291	318
4000	284	326	352
5000	305	357	382
6000	319	374	407
≥7200	321	362	402

Add 30% to these numbers for GWP limits where high early strength¹ concrete mixes are required for technical reasons.

Compliance Documentation

- A product-specific Type III (third-party verified) Environmental Product Declaration (EPD) that:
 - (i) is based on the PCR used to develop these limits: NSF International's [Product Category Rule for Concrete](#) (8/2021, version 2.1); and
 - (ii) conforms with ISO 14025 and ISO 21930.



Building Code Example



- 1) Adaptive reuse
- 2) WBLCA (10% reduction)
- 3) Materials thresholds

SECTION 5.409 LIFE CYCLE ASSESSMENT

5.409.1 Scope.

[BSC-CG] Effective July 1, 2024, projects consisting of newly constructed building(s) with a combined floor area of 100,000 square feet or greater shall comply with either Section 5.409.2 or Section 5.409.3. Alteration(s) to existing building(s) where the combined altered floor area is 100,000 square feet or greater shall comply with either Section 5.105.2, 5.409.2, or 5.409.3. Addition(s) to existing building(s) where the total floor area combined with the existing building(s) is 100,000 square feet or greater shall comply with either Section 5.105.2, Section 5.409.2, or Section 5.409.3. Effective January 1, 2026, the combined floor area shall be 50,000 square feet or greater.

[DSA-SS] Projects consisting of newly constructed building(s) with a combined floor area of 50,000 square feet or greater shall comply with either Section 5.409.2 or Section 5.409.3. Alteration(s) to existing building(s) where the combined altered floor area is 50,000 square feet or greater shall comply with either Section 5.105.2, 5.409.2, or 5.409.3. Addition(s) to existing building(s) where the total floor area combined with the existing building(s) is 50,000 square feet or greater shall comply with either Section 5.105.2, Section 5.409.2, or Section 5.409.3.

5.409.2 Whole building life cycle assessment. Projects shall conduct a cradle-to-grave whole building life cycle assessment performed in accordance with ISO 14040 and ISO 14044, excluding operating energy, and demonstrating a minimum 10-percent reduction in global warming potential (GWP) as compared to a reference baseline building of similar size, function, complexity, type of construction, material specification, and location that meets the requirements of the *California Energy Code* currently in effect. Software used to conduct the whole building life cycle assessment, including reference baseline building, shall have a data set compliant with ISO 14044, and ISO 21930 or EN 15804, and the software shall conform to ISO 21931 and/or EN 15978. The software tools and data sets shall be the same for evaluation of both the baseline building and the proposed building

required by the enforcing entity to demonstrate compliance with the requirements.

5.409.2.1 Building components. Building enclosure components included in the assessment shall be limited to glazing assemblies, insulation, and exterior finishes. Primary and secondary structural members included in the assessment shall be limited to footings and foundations, and structural columns, beams, walls, roofs, and floors.

5.409.2.2 Reference study period. The reference study period of the proposed building shall be equal to the reference baseline building and shall be 60 years.

5.409.2.3 Verification of compliance. A summary of the GWP analysis produced by the software and Worksheet WS-4 signed by the design professional of record shall be provided in the construction documents as documentation of compliance. A copy of the whole building life cycle assessment which includes the GWP analysis produced by the software, in addition to maintenance and training information, shall be included in the operation and maintenance manual and shall be provided to the owner at the close of construction. The enforcing agency may require inspection and inspection reports in accordance with Sections 702.2 and 703.1 during and at completion of construction to demonstrate substantial conformance. Inspection shall be performed by the design professional of record or third party acceptable to the enforcing agency.

5.409.3 Product GWP compliance—prescriptive path. Each product that is permanently installed and listed in Table 5.409.3 shall have a Type III environmental product declaration (EPD), either product-specific or factory-specific.

5.409.3.1 Products shall not exceed the maximum GWP value specified in Table 5.409.3.

Exception: Concrete may be considered one product category to meet compliance with this section. A weighted average of the maximum GWP for all concrete mixes installed in the project shall be less than the



What Strategy has the Greatest Impact?

Reducing Building Carbon Intensity

↓ kgCO_{2e}/ft²

If building carbon intensity limits require X% reductions for X building types, how much carbon would be saved by 2050?

Reducing Concrete Carbon Intensity

↓ kgCO_{2e}/yd³ concrete

If concrete carbon intensity limits require X% reductions for X building types, how much carbon would be saved by 2050?

Increasing Adaptive Reuse

↓ ft² of new construction

If X% of growth for X building types is achieved through adaptive reuse (rather than new construction), how much carbon would be saved by 2050?

Evaluating Housing Unit Size

↓ ft² of new construction

What is the carbon impact of housing type and unit size on the carbon footprint of growth required to meet 2050 housing needs?

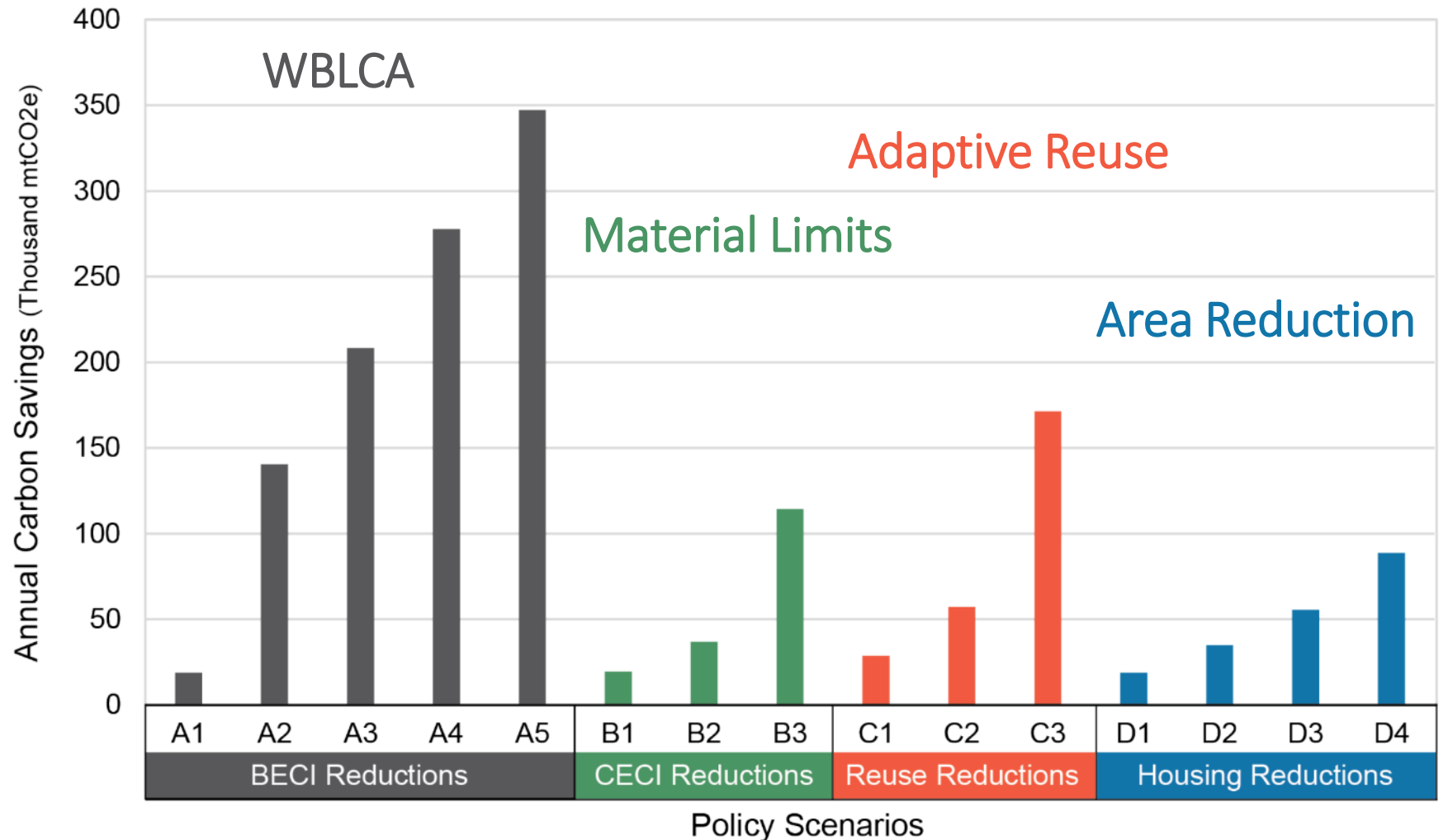


Benke, B., Lewis, M., Carlisle, S., Huang, M., and Simonen, K. (2022). Developing an Embodied Carbon Policy Reduction Calculator. Carbon Leadership Forum, University of Washington. Seattle, WA. <http://hdl.handle.net/1773/48566>



Policy Impact Study: City of New York

The holistic approach may have greatest impact, but is also most complex to calculate and administer





[Back to Policy Toolkit](#)

2 – What is a Buy Clean Policy?

This resource provides insight into why embodied carbon is an urgent problem, how Buy Clean poses a solution, and an overview of the key policy elements.

Buy Clean is a procurement policy approach that aims to fill a current gap in climate policy by incorporating low-carbon construction purchasing requirements that address the greenhouse gas emissions from construction materials into government purchasing.



Policy Toolkit

1 – Embodied Carbon 101

This resource aims to provide a high-level overview of embodied carbon...

2 – What is a Buy Clean Policy?

This resource provides insight into why embodied carbon is an urgent...

3 – Guidance on Embodied Carbon Disclosure

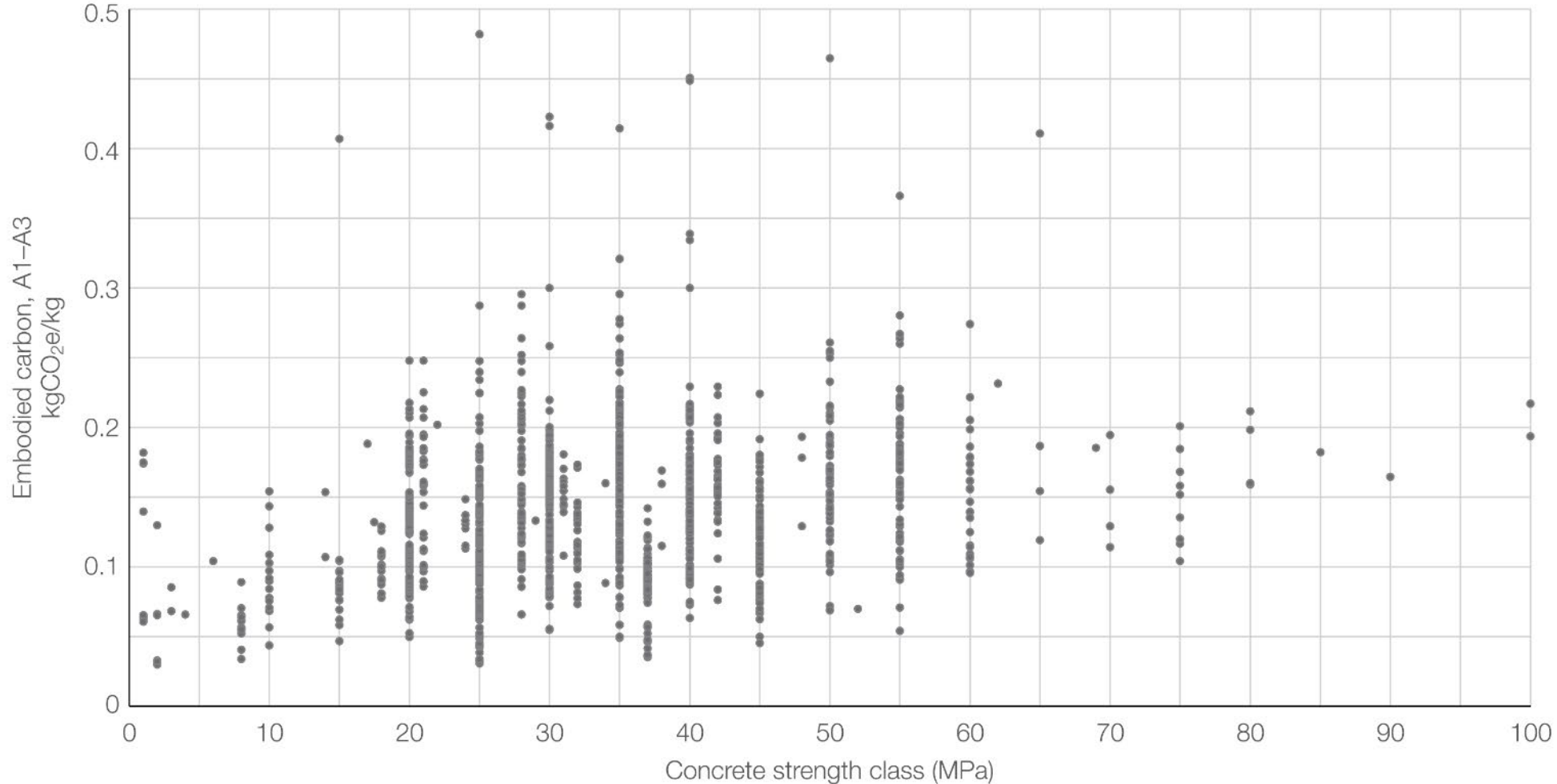
This resource aims to guide policymakers and procurement professionals...

4 – Steps to Develop a Buy Clean Policy

This resource provides an overview of the five basic components of Buy...



Variation in Embodied Carbon for Concrete Mixes



Gibbon, O. P., Orr, J. J., Archer-Jones, C., Arnold, W., & Green, D. (2022). How to calculate embodied carbon. The Institution of Structural Engineers.



Concrete

CODE: San Francisco Limits

	Cement limits for use with any compliance method 19.07.050.2 through 19.07.050.5	Embodied Carbon limits for use with any compliance method 19.07.050.2 through 19.07.050.5
Minimum specified compressive strength f _c , psi (1)	Maximum ordinary Portland cement content, lbs/yd ³ (2)	Maximum embodied carbon kg CO ₂ e/m ³ , per EPD
up to 2500	362	260
3000	410	289
4000	456	313
5000	503	338
6000	531	356
7000	594	394
7001 and higher	657	433
up to 3000 light weight	512	578
4000 light weight	571	626
5000 light weight	629	675
Notes		
(1) For concrete strengths between the stated values, use linear interpolation to determine cement and/or embodied carbon limits.		
(2) Portland cement of any type per ASTM C150.		

POLICY: City of Portland, OR

Table 1: Concrete Embodied Carbon Thresholds (per yd³)

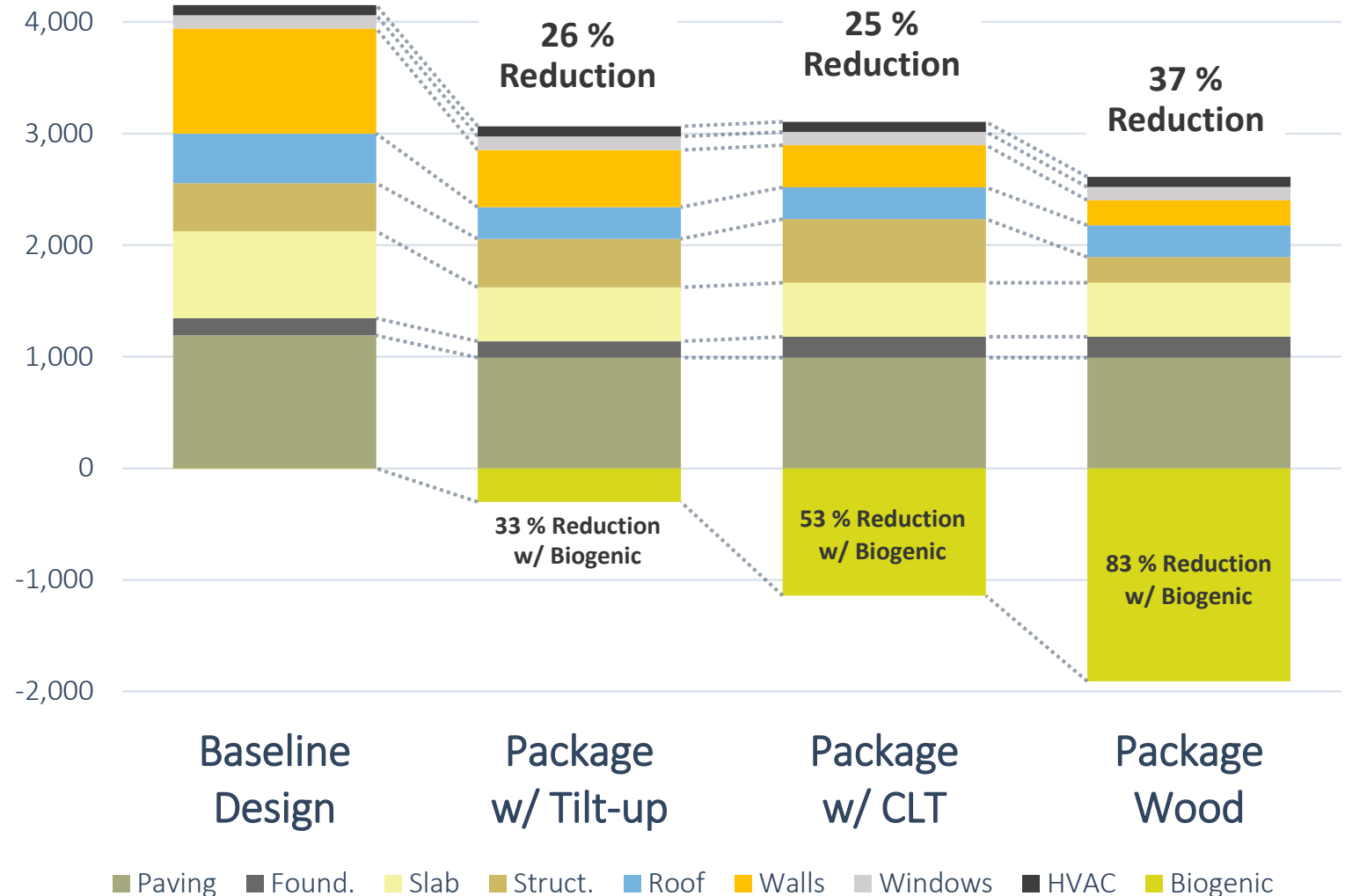
	Maximum GWP (kg CO₂e)/yd³	
Concrete Strength (psi) ⁽¹⁾	Portland Cement Concrete (PCC) including: Commercial Grade Concrete (CGC), Concrete Pavement, High- Performance Concrete (HPC)/Structural Concrete	Lightweight Concrete
2500	180	
3000	200	396
4000	242	440
5000	295	483
6000	312	
8000	373	



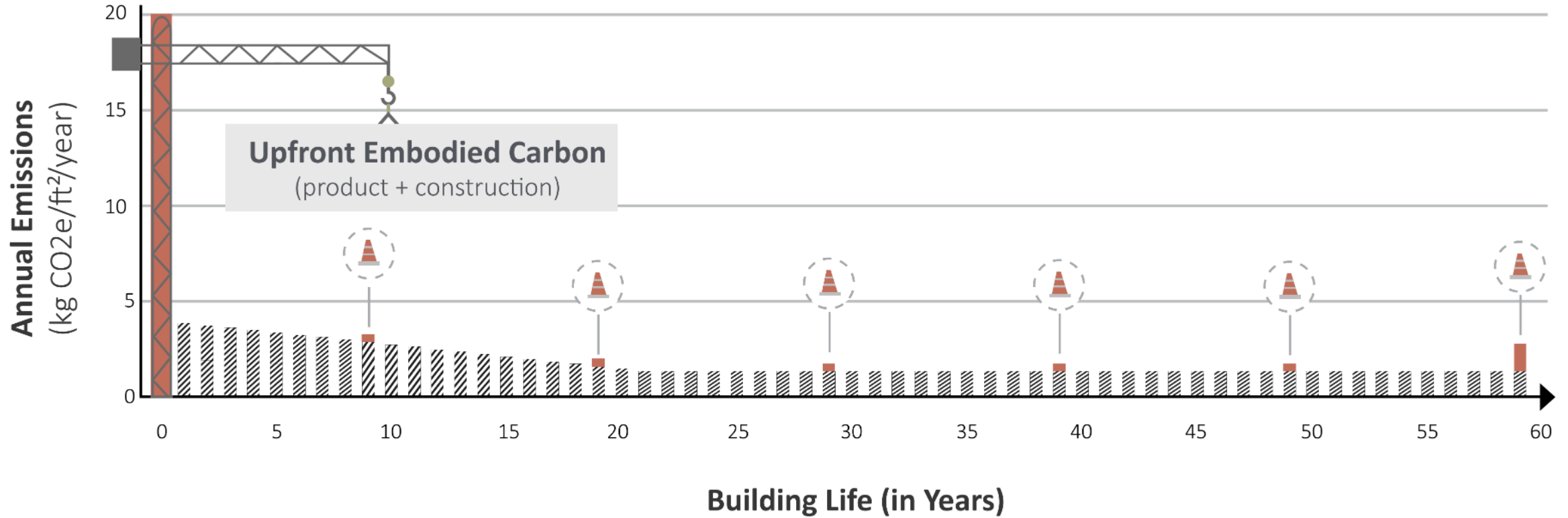
Mass Timber Example

Structure, enclosure, and paving are often a focus of optimization

Wood may not be as intuitively good as current trends suggest



Emissions from a Typical Building



KEY ■ Embodied ■ Operational ■ Maintenance/Material Replacement



Embodied Carbon in Rating Systems



**LIVING
BUILDING
CHALLENGESM**



BREEAM[®]





Life Cycle Assessment: Tools & Datasets



Athena Impact Estimator



Embodied Carbon in Construction Calculator



Embodied Carbon in Buildings: Standards



EN 15978:
Assessment of
environmental
performance of
buildings



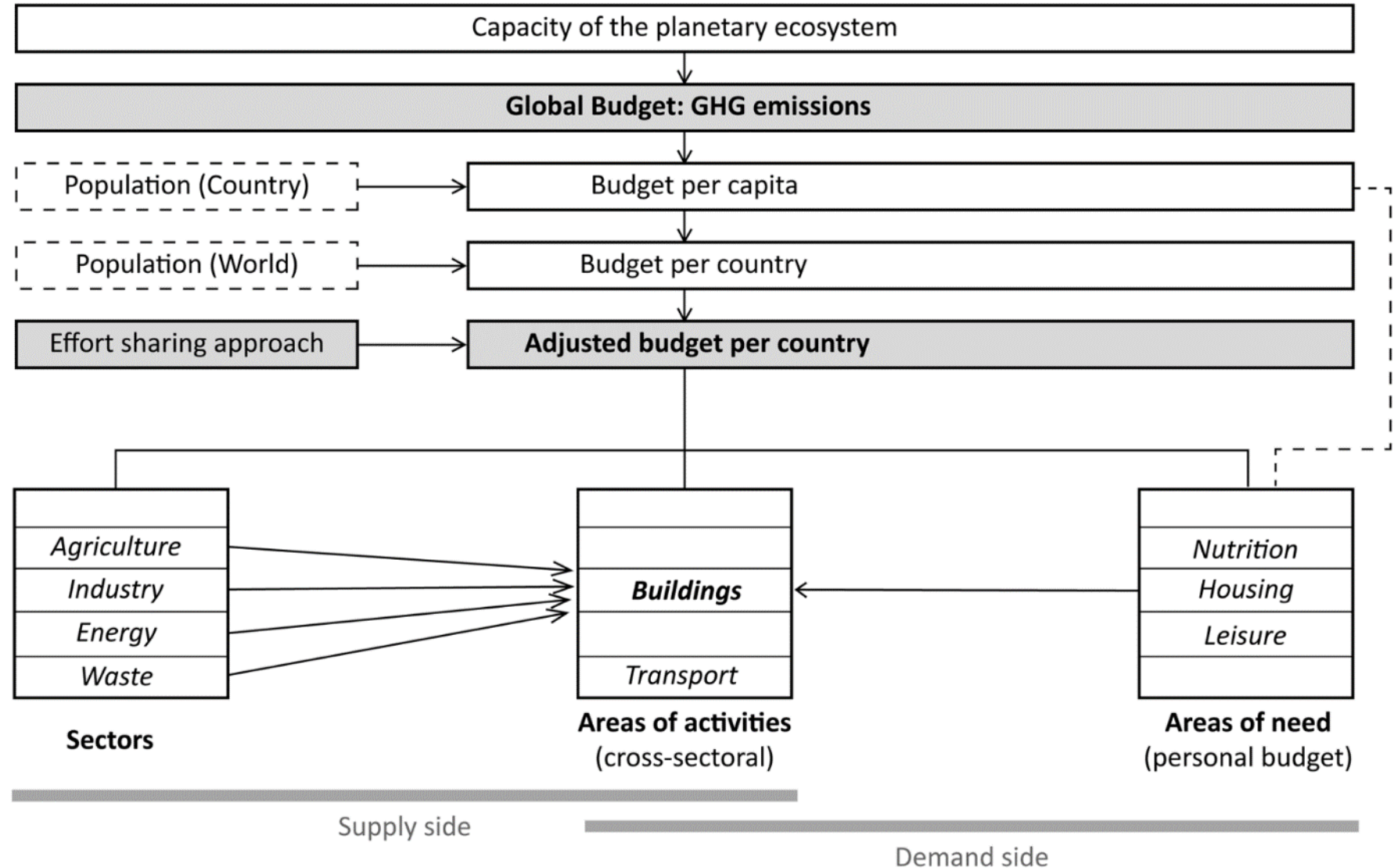
Whole life carbon
assessment
(WLCA) for the
built environment



Standard 240P:
Quantification of life
cycle GHG emissions



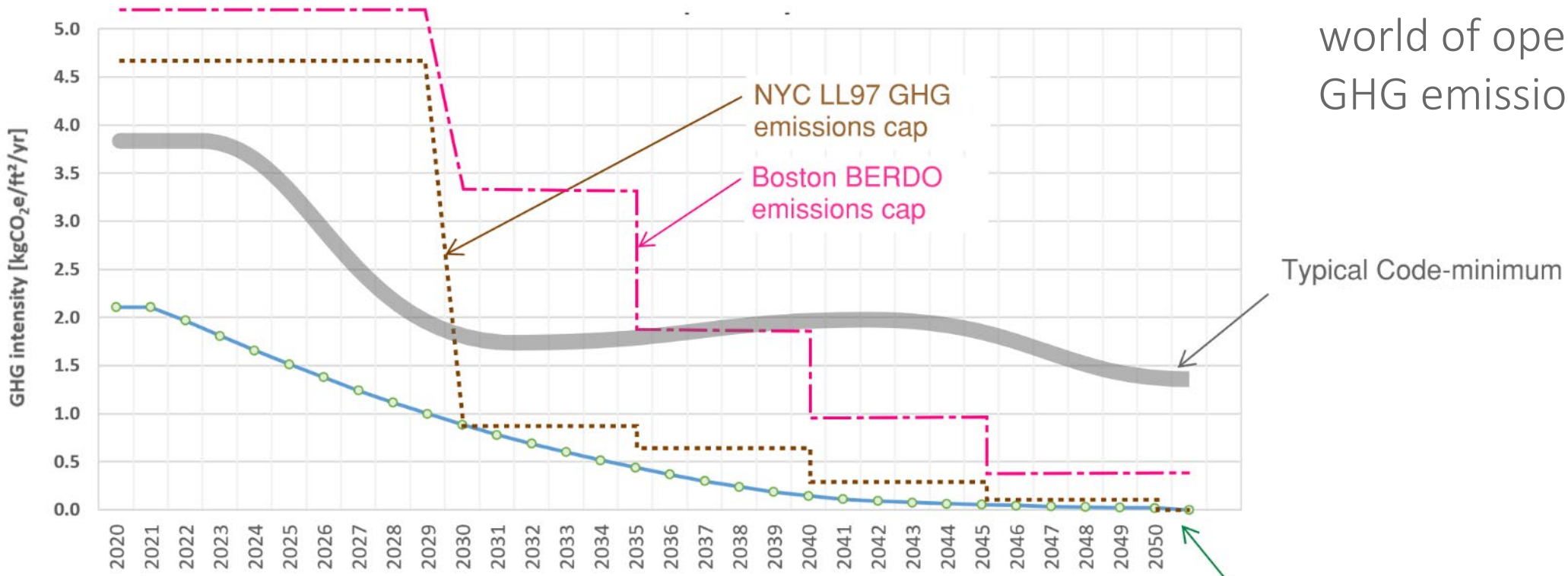
Paris Agreement



Habert, G., Röck, M., Steininger, K., Lupisek, A., Birgisdottir, H., Desing, H., ... & Lützkendorf, T. (2020). Carbon budgets for buildings: harmonising temporal, spatial and sectoral dimensions. *Buildings and Cities*, 1(S 1), 429-452.



Climate Risk Real Estate Monitor



Reference from the world of operational GHG emissions

Typical Code-minimum

Paris Agreement aligned reduction (model for regulations)

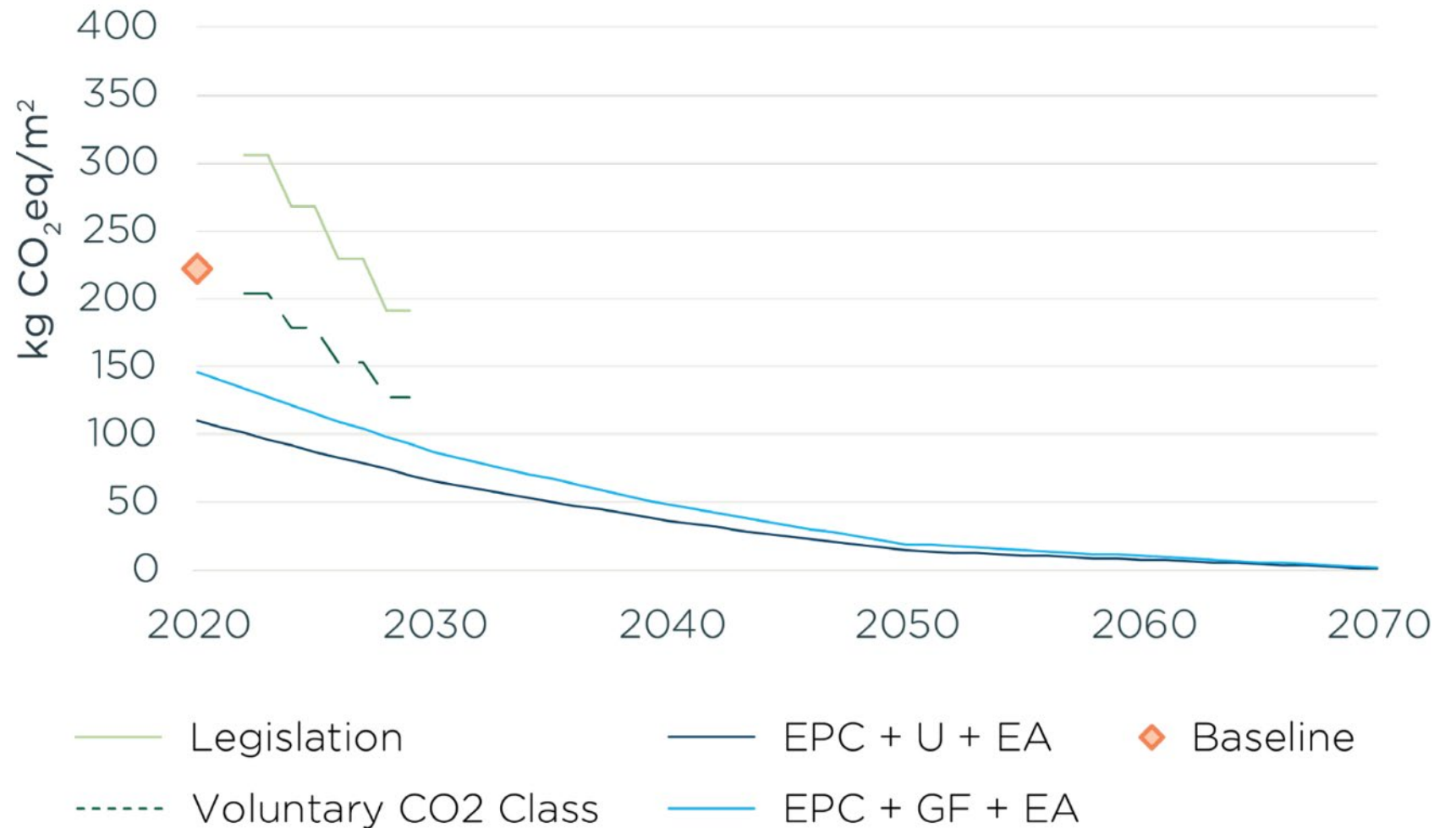
Carbon Risk Real Estate Monitor
 Global warming target: 1.5°C
 Country: USA Average





Denmark Embodied Carbon Limits

Establishing benchmark values for use to determine compliance is an area of focus for embodied carbon research



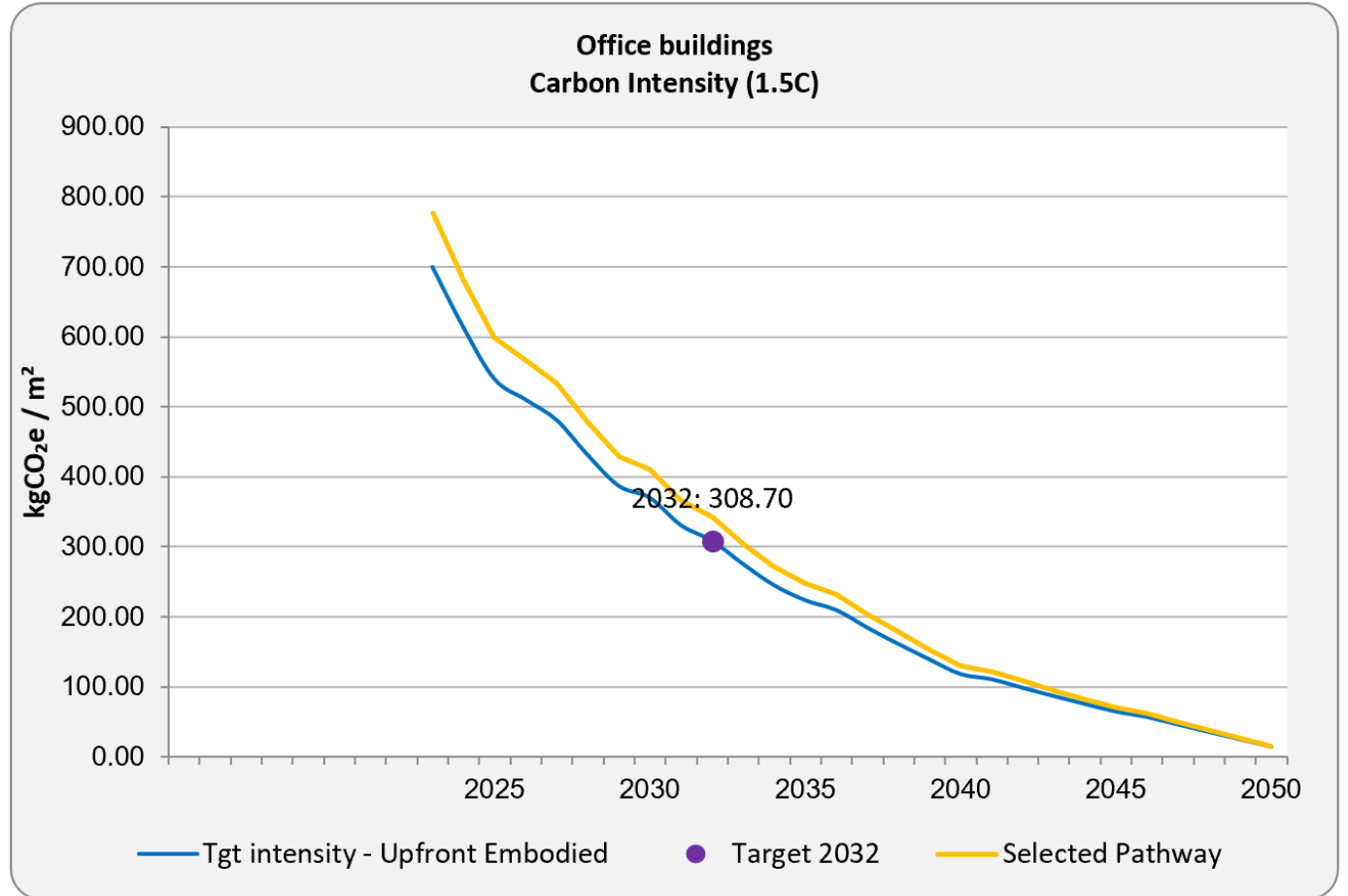


Consensus Tool for Establishing Targets



SCIENCE
BASED
TARGETS

The embodied carbon target-setting tool is currently in pilot phase





Thank You

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