Low-Rise Residential

Embodied Carbon

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What's Included?

The 2025 Massachusetts Stretch and Specialized Code for Low-Rise Residential now includes optional measures for embodied carbon.

This review guide offers code users and code enforcement officials guidance on how to understand and use the new embodied carbon optional code measures.

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What is Embodied Carbon?

Embodied carbon refers to the **Greenhouse Gas (GHG)** emissions associated with the manufacturing, transportation, installation, maintenance, and disposal of construction materials used in the built environment. Embodied carbon accounts for **11% of the total global emissions**, as shown in Figure 1.

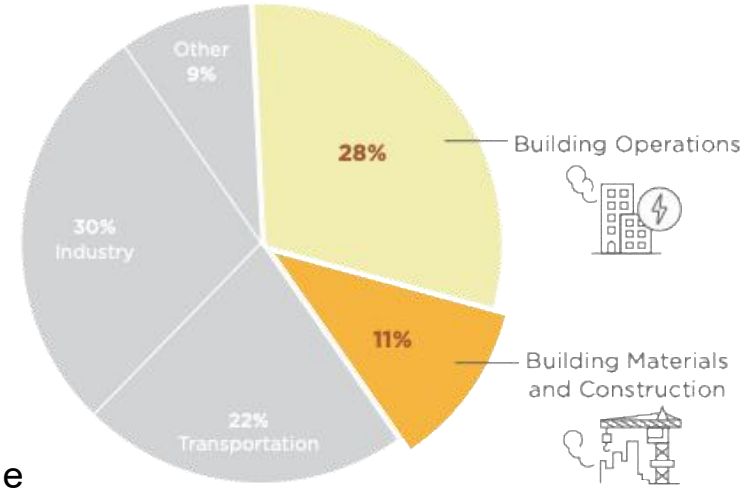


Figure 1: **Global Co2 Emissions by Sector**
Emissions from buildings comprise **39%** of total global greenhouse gas emissions.

Embodied carbon is quantified using **Global Warming Potential (GWP)**, which is reported in kilograms of CO_2 equivalent ($kgCO_2e$). To calculate the total GWP, a method called **Life Cycle Assessment (LCA)** is used, which evaluates the environmental impacts of various construction materials.

Figure 2 graphically illustrates a “cradle-to-grave” LCA approach, which starts with the initial extraction of raw materials and ends with the anticipated disposal or end-of-life process.

This information serves as a standardized metric for determining a product’s carbon footprint, which is documented by way of an **Environmental Product Declaration (EPD)**. EPDs should be third-party verified (Type III) and can either be industry-wide for a typical product, or product specific from a manufacturer.

Figure 2: **Building Material Life Cycle**
Cradle-to-grave embodied carbon emissions vs. operational emissions from buildings.

Product Stage	Construction	Use	End-of-Life	Beyond
▪ Raw Material Supply ▪ Material Transportation ▪ Manufacturing	▪ Transportation to Site ▪ Construction	▪ Energy, Water, and Regular Operations ▪ Maintenance, Repair, and Replacement	▪ Demolition ▪ Transport of Materials ▪ Waste Disposal	▪ Reuse ▪ Recovery ▪ Recycling

What Are The Codes and How Does R406 Work?

The **Stretch Energy Code** and **Municipal Opt-In Specialized Code** are available for municipalities to go beyond the **Base Code** – 2021 IECC with MA amendments: 780 CMR Chapter 11R (Residential). Over 300 cities and towns have adopted either the stretch or specialized code. More information can be found at mass.gov/doc/building-energy-code-adoption-by-municipality/download.

The 2025 Massachusetts Stretch and Specialized Code for Low Rise Residential now includes optional measures for embodied carbon.

R406 Energy Rating Index Compliance Alternative

New residential units shall meet the maximum Energy Rating Index (ERI) score listed in **Table R406.5** where the scores within the table are differentiated by fuel type.

By using section **R406.5.2 Embodied carbon credit,** new construction homes may increase the maximum allowable HERS rating for each unit by 3 HERS* points as shown in Table R406.5.

The following slides will show you how to document and earn the HERS point increase, from **either, but not both,** of the following:

R406.5.3 Insulation Embodied Carbon Credit

R406.5.4 Low GWP Concrete Mix Credit

***A maximum of 3 HERS points can be earned regardless of the methods used.

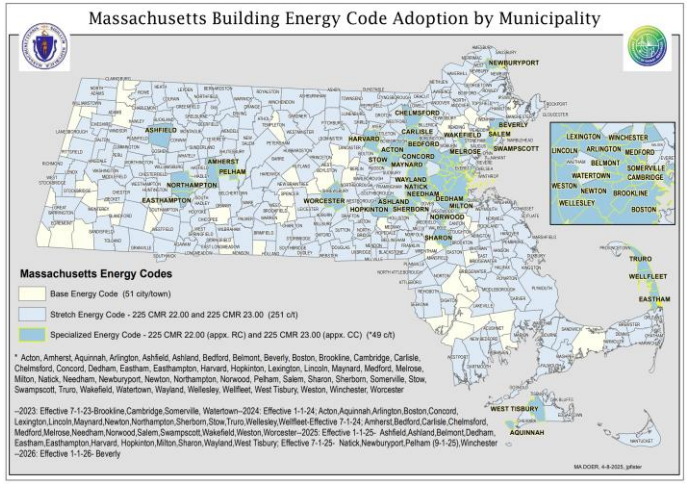


Figure 3: **Massachusetts Building Energy Code Adoption by Municipality**
Massachusetts Department of Energy Resources (DOER)
mass.gov/orgs/massachusetts-department-of-energy-resources

TABLE R406.5 MAXIMUM ENERGY RATING INDEX

	Maximum HERS Index score [a,b]			
	New construction permits after July 1, 2024	New Construction with R406.5.2 embodied carbon credit	Accessory Dwelling Units	Major alterations, additions, or change of use[c]
Mixed-Fuel Building	42	45	52	65
Solar Electric Generation	42	45	55	70
All-Electric Building	45	48	55	70
Solar Electric & *All-Electric Building*	45	48	58	75

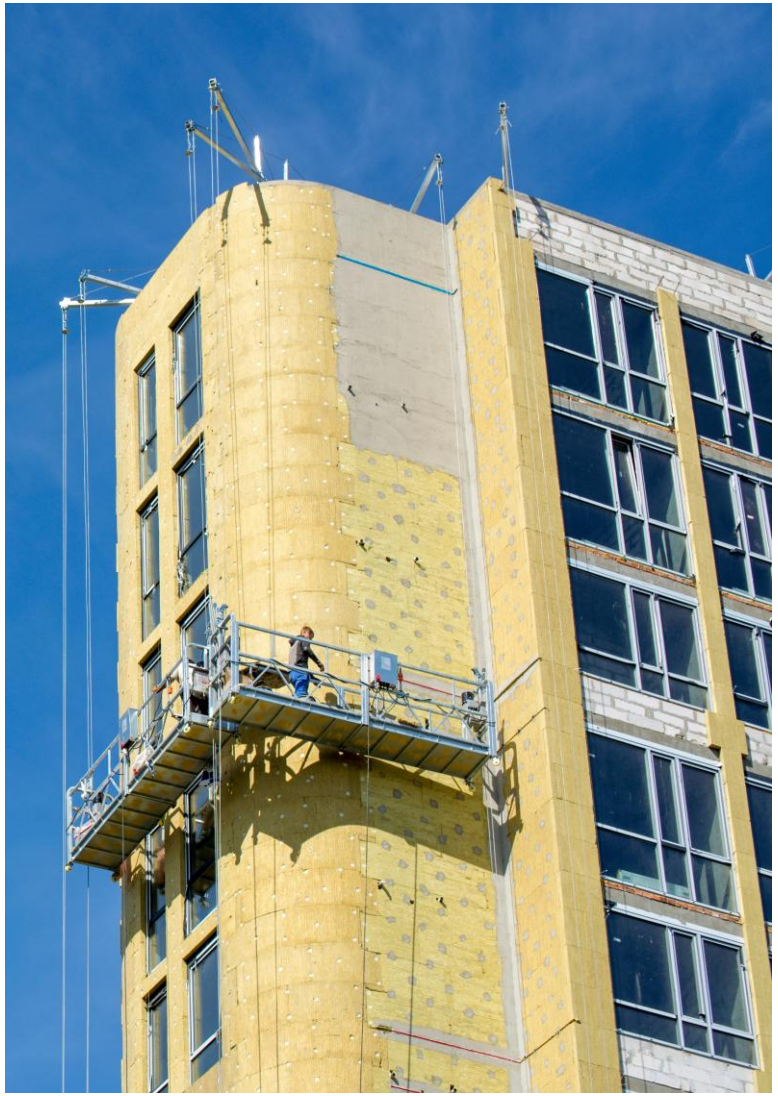
Figure 5: **Table R406.5**
Massachusetts Department of Energy Resources (DOER)
mass.gov/doc/stretch-specialized-code-residential/download

Insulation Embodied Carbon Credit

R406.5.2 Embodied Carbon Credit, Insulation: new single *dwelling units* or R-use buildings containing multiple *dwelling units* that demonstrate an average calculated insulation **Global Warming Potential (GWP)** intensity (kg CO2e/m2) less than 0 across the whole building envelope shall **offset 3 HERS points** for each applicable dwelling unit of new construction. GWP intensity shall be based on the default values in **Table R406.5.3**, or product specific EPDs or calculations in the approved tools: EC3 and BEAM, may be used in place of default table values.

R406.5.3 Documentation for insulation embodied carbon credit: credit: In order to apply the insulation embodied carbon credit for a new *dwelling unit* or averaged across a *multi-dwelling unit* building, the HERS rater of the unit or building must **submit a complete calculation** to summarize estimated embodied carbon emissions from all insulation materials used in the project. The output metric for this measure shall be **Global Warming Potential (GWP) intensity**, capturing insulation GWP per conditioned square meter of project area.

Projects may substitute product-specific data for the default GWP value if the specified product has a lower reported GWP than the default value. Substitution of default GWP values is only allowed when **type III product-specific EPDs** are sourced and noted. Projects shall use GWP values that include **A1-A3 lifecycle stages**, as documented in product-specific EPDs, with the exception of SPF and XPS products. For these products, the **A5 and B1** values shall be included in the documented GWP value to account for the on-site and off-gassing impact of blowing agents. Projects shall provide the EPDs declaration number in product-specific data substitution.



Default GWP (kg CO_2e) for Insulation

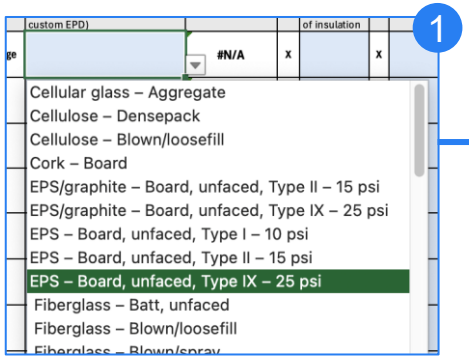
Adapted from Table R406.5.3. See Stretch & Specialized Code – Low Rise Residential on the Resources page for more information.

Insulation Material		Default GWP (kg CO_2e per m^2 RSI-1)
Cellular Glass	Aggregate	3.93
Cellulose	Densepack	-2.00
	Blown/Loose fill	-0.90
Cork	Board	-4.30
EPS/Graphite	Board, Unfaced, Type II – 15 psi	2.30
	Board, Unfaced, Type IX – 25 psi	3.10
EPS	Board, Unfaced, Type I – 10 psi	2.50
	Board, Unfaced, Type Ii – 15 psi	3.40
	Board, Unfaced, Type IX – 25 psi	4.30
Fiberglass	Batt, Unfaced	1.00
	Blown/Loose fill	1.00
	Blown/Spray	1.93
Hemp	Batt	-0.50
	HempCrete	-4.10
Mineral Wool	Batt, Unfaced	1.50
	Blown loose fill	1.90
	Board, Unfaced, “Light” density	2.70
	Board, Unfaced, “Heavy” density	6.90
Phenolic Foam	Board	1.54
Polyiso	Wall Board	4.10
	Roof Board (GRF facer)	2.11
	Roof Board (CGF facer)	2.95
SPF, Spray	Open Cell	1.40
	Closed Cell HFO	3.50
	High Density HFO	4.00
	Closed Cell HFC	13.10
	High Density HFC	17.00
Straw	Panel	-5.45
Vacuum Insulated	Panel	7.40
Wood Fiber	Board, Unfaced, European	-4.38
	Board, Unfaced, North American	-10.30
	Batt, Unfaced	-1.60
Wool (Sheep)	Batt	0.20
	Loosefill	0.80
XPS	Board, 25 psi HFC	55.5
	Board, 25 psi, “Low GWP” (HFO/HFC)	5.50

Guidance For Using The Net Zero GWP Insulation Measure

Attachment E: Embodied Carbon Insulation Calculator is an excel tool from Massachusetts Department of Energy Resources (DOER) at mass.gov that assists building owners, designers, and general contractors with **R406.5.3 Documentation for insulation embodied carbon credit** compliance. Follow the steps below to evaluate compliance for your project. **HERS Raters** are responsible for completing this document.

1. Select insulation type from the dropdown in Column B
2. Input total R-Value for the specific insulation application in Column C
3. Input Total Surface Area in gross square feet in Column D
4. Check to see if Total Net Insulation GWP is negative and points are earned for Section R406*



1

2

3

A	B		C		D		E		F	G (option instead of B)	H		I
Portion of building assembly	Insulation Material type used	Default Global Warming Potential (kg CO2e / sq m RSI-1) (from table)	Product R-Value		Surface Area (gross square feet)		Conversion factor (square feet to square		Framing Factor ("1.0" for continuous insulation, "0.8" for cavity insulation)	Project has sourced a Type III - Product specific Environmental Product Declaration (EPD)	Product Specific Global Warming Potential (kg CO_2e / sq m RSI-1)		GWP Result (kg CO_2e)
Notes:	Select insulation material type from List (or Other if using a custom EPD)		To account for thickness of insulation							Insulation material & EPD Number (if applicable)	Add product specific EPD GWP value if using:		
Below grade, slab, slab edge	EPS – Board, unfaced, Type IX – 25 psi	4.30	10.0		1200		0.0929		1.0			=	4793.6
Basement walls (1)	EPS – Board, unfaced, Type I – 10 psi	2.50	15.0		1800		0.0929		1.0			=	6270.8
Above grade walls, cavity	Cellulose – Densepack	-2.00	19.0		2400		0.0929		0.8			=	-6778.0
Above grade walls, continuous	Polyiso – Wall Board	4.10	5.0		2400		0.0929		1.0			=	4570.7
Roof, flat	Cellulose – Densepack	-2.00	48.0		1300		0.0929		1.0			=	-11593.9
Roof, sloped cavity		#N/A					0.0929		0.8			=	#N/A
Roof, sloped, continuous		#N/A					0.0929		1.0			=	#N/A
Other: add rows above here		#N/A					0.0929		1.0			=	#N/A
Insert additional rows as needed											Total net Insulation GWP (kg CO_2e)		-2,736.8
	HERS rater signature				6/23/25		Date signed				HERS points credit		3
											Section C406 Points		8

4

mass.gov/doc/embodied-carbon-insulation-calculator/download

*Code officials are responsible for verifying the 'Total net insulation GWP' is negative and that the type of insulation entered by the HERS Rater matches the as-built conditions.

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Low GWP Concrete Mix

R406.5.2 Embodied Carbon Credit, Low GWP Concrete Mix: new single dwelling units or R-use buildings containing multiple dwelling units that demonstrate an average calculated concrete mix **Global Warming Potential (GWP) for at least 90% of all concrete mix** used in the building of not more than **100% of the 2022 NRMCA Northeast Benchmark** average values shown in **Table R406.5.4** shall offset 3 HERS points for each applicable dwelling unit of new construction.

R406.5.4 Documentation for Low GWP Concrete Mix credit: In order to apply the **low GWP concrete mix** credit for one or more new dwelling units, the HERS rater of the unit must submit **specific EPDs for concrete** used in the unit. Where multiple concrete mixes are used, a **complete calculation** to summarize estimated embodied carbon emissions from **at least 90% of all concrete materials used** in the project is required. The output metric for this measure shall be **Global Warming Potential (GWP)** per cubic meter as supplied, with the EPD verified by the concrete ready-mix provider. The 3 HERS point credit shall be applied when the GWP per cubic meter is demonstrated to be less than the Maximum GWP per cubic meter value shown in **Table R406.5.4**. for **at least 90% of all concrete used** for that unit or building as appropriate.

Maximum GWP (kg CO_2e) Limits for Concrete Adapted from Table R406.5.4

Normal Weight Concrete	
Specified Compressive Strength (fc in psi)	**GWP per cubic meter***
0 – 2,500	240
2,501 – 3,000	264
3,001 – 4,000	314
4,001 – 5,000	378
5,001 – 6,000	399
6,001 – 8,000	472

Light Weight Concrete	
Specified Compressive Strength (fc in psi)	**GWP per cubic meter***
0 – 3,000	517
3,001 – 4,000	573
4,001 – 5,000	628

*These numbers are 100% of the Eastern Region average GWP figures from the National Ready Mix Concrete Associations' "A Cradle-to-Gate Life Cycle Assessment of Ready-Mixed Concrete Manufactured by NRMCA Members, Version 3.2," (July 2022), pg. 65.NRMCA LCAReportV3-2_ 20220224.pdf

Guidance For Using The Low GWP Concrete Measure

Compare the ready-mix concrete product's **GWP** stated from its respective **EPD** against the maximum allowed **GWP** from **Table R406.5.4 Default Concrete Global Warming Potential Values.**

In the example below, a 3,000 psi ready-mix concrete product from Boston Concrete **(1)** is compared against the maximum GWP limit for 3,000 psi concrete from **Table R406.5.4 (2)** Default Concrete Global Warming Potential Values. The Table R406.5.4 values are established using the 2022 NRMCA Northeast Benchmark dataset.

1. Find the 3,000 psi ready-mix concrete GWP (Row 1, Column "Per M3")
2. Compare to the maximum GWP limit in **Table R406.5.4 (2)** for 3,000 psi concrete mix (Row 2)

The GWP on the EPD should be less than the GWP from Table R406.5.4. In this example, Boston Concrete's 252.07 is less than the max GWP of 264, which successfully contributes credit towards meeting the credit measure.

1

BOSTON CONCRETE

EPD

ENVIRONMENTAL PRODUCT DECLARATION

ALLOCATION

The allocation of co-products or secondary flows cross the system boundary conforms with the ISO 21930: 2017 Section 7.2.4. Specifically, the allocation criteria were applied as follows:

- Allocation was not applied to any of the gate-to-gate production facilities.
- For Secondary Data sources, the NSF PCR default allocation selection (i.e., "Cut-off" or "Alloc Rec") was applied.
- The product category rules for this EPD recognize fly ash, silica fume and slag as recovered materials and thus the environmental impacts allocated to these materials are limited to the treatment and transportation required to use as a concrete material input.
- A portion (30%) of the reported fleet energy use for truck mixing plants was allocated to the mixing facility.

CALCULATED RESULTS A1- A3

CORE MANDATORY IMPACT INDICATOR			PER YD3	PER M3
Global warming potential	GWP	kg C02e	192.72	252.07
Depletion potential of the stratospheric ozone layer	ODP	kg CFC11e	6.31E-06	8.26E-06
Acidification potential of soil and water sources	AP	kg SO2e	1.05	1.37
Eutrophication potential	EP	kg Ne	0.24	0.32
Formation potential of tropospheric ozone	POCP	kg 03e	24.17	31.62
Abiotic depletion potential for fossil resources	ADPf	MJ, NCV	1289.45	1686.53
Abiotic depletion potential for non-fossil mineral resources *	ADPe	kg Sbe	1.03E-04	1.34E-04
Fossil fuel depletion	FFD	MJ Surplus	84.08	109.98

2

Maximum GWP (kg CO_2e) Limits for Concrete	
NORMAL WEIGHT CONCRETE	
Specified Compressive Strength (f'c in psi)	Maximum GWP per cubic meter[a]
0-2500	240
2501-3000	264
3001-4000	314
4001-5000	378
5001-6000	399

The identified value of 252.07 on the EDP is less than the maximum GWP allowed of 264 in Table R406.5.4, therefore the low GWP Concrete can be used for this project.

Note that the concrete mix and strength get identified at another location within the EPD and that not all EPDs look the same. Confirming concrete strength and GWP are the two parameters necessary for compliance.

Guidance For Using The Low GWP Concrete Measure

Attachment F: Low-Carbon Concrete Mixes available in MA is an excel database resource from from Massachusetts Department of Energy Resources (DOER) at mass.gov that provides approximately 1,000 ready mix concrete products with their associated GWP. This tool is a reference to ensure that building owners, designers, and general contractors can easily specify and procure ready mix concrete products that meet the GWP limits of **Table R406.5.4** Default Concrete GWP Values and earn credits under R406.

1. Ready-mix concrete product number (Column D)
2. Concrete compressive strength of the ready-mix (Column F)
3. Global Warming Potential (GWP) in $kgCO_2e$ (Column G)
4. If the ready-mix product falls under the GWP limit required in **Table R406.5.4** (Column H)

	A	B	C	1 D	E	2 F	3 G	4 H
1	**Category**	**Manufacturer**	**Plant/ Plant Group**	**Product**	**Description**	**Compressive Strength**	**GWP**	**HERS 3 Point Qualified**
2	Ready Mix	Boston Concrete Corporation	Boston Concrete	404E03MR	4000 3/4 Slag NA-MR	4000 psi	213.3 kgCO2e	Yes
3	Ready Mix	Boston Concrete Corporation	Boston Concrete	404E00MR	4000 50% slag- MR	4000 psi	215.2 kgCO2e	Yes
4	Ready Mix	Boston Concrete Corporation	Boston Concrete	604E403MR	6000 - 40% slag MR	6000 psi	296.1 kgCO2e	Yes
5	Ready Mix	Boston Concrete Corporation	Boston Concrete	604E400MR	6000 - 40% slag MR	6000 psi	292.4 kgCO2e	Yes
6	Ready Mix	Boston Concrete Corporation	Boston Concrete	604E303MR	6000 - 30% slag MR	6000 psi	329.1 kgCO2e	Yes
7	Ready Mix	Boston Concrete Corporation	Boston Concrete	604E300MR	6000 - 30% slag	6000 psi	323.4 kgCO2e	Yes
8	Ready Mix	Boston Concrete Corporation	Boston Concrete	504E400MR	5000 - 40% Slag MR	5000 psi	277.7 kgCO2e	Yes
9	Ready Mix	Boston Concrete Corporation	Boston Concrete	404E403MR	4000 - 40% slag MR	4000 psi	243.8 kgCO2e	Yes
10	Ready Mix	Boston Concrete Corporation	Boston Concrete	404E400MR	4000 - 40% slag MR	4000 psi	241.7 kgCO2e	Yes
11	Ready Mix	Boston Concrete Corporation	Boston Concrete	404E400	4000 - 40% slag	4000 psi	241.4 kgCO2e	Yes
12	Ready Mix	Boston Concrete Corporation	Boston Concrete	4.04E+02	4000 50% slag	4000 psi	215.2 kgCO2e	Yes
13	Ready Mix	Boston Concrete Corporation	Boston Concrete	4.54E+02	4500 -3/4 Air	4500 psi	228.4 kgCO2e	Yes
14	Ready Mix	Boston Concrete Corporation	Boston Concrete	2.54E+02	2500 3/4 Slag AE	2490 psi	153.6 kgCO2e	Yes
15	Ready Mix	Boston Concrete Corporation	Boston Concrete	404E00LAEA	4000 3/4 Slag 5% AE	4000 psi	215.2 kgCO2e	Yes
16	Ready Mix	Boston Concrete Corporation	Boston Concrete	4.04E+05	4000 3/4 Slag NA	4000 psi	213.3 kgCO2e	Yes

Massachusetts Department of Energy Resources (DOER)
mass.gov/doc/embodied-carbon-insulation-calculator/download

Summary

The **2025 Massachusetts Stretch Code** for Low Rise Residential now includes optional measures for Embodied Carbon.

The following **embodied carbon credits** can be used to **increase the maximum allowable HERS rating for each dwelling unit by 3 HERS points**:

- **R406.5.3 Insulation Embodied Carbon Credit**
- **R406.5.4 Low GWP Concrete Mix Credit**

Compliance for the new measures is made easy with the **Attachment E Embodied Carbon Insulation Calculator** and **Attachment F Low-Carbon Concrete Mixes available in MA** resources provided by Massachusetts Department of Energy Resources (DOER) at mass.gov.

Start incorporating embodied carbon measures into your projects today.

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Definition of Terms

Embodied Carbon – refers to the greenhouse gas emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building and infrastructure materials.

Environmental Product Declaration (EPD) – is a report that documents the ways in which a product, throughout its lifecycle, affects the environment, including resource use, greenhouse gas and other emissions, waste generation, and more.

Global Warming Potential (GWP) – is a common unit of measure, which allows analysts to add up emissions estimates of different gases, typically reported in $kgCO^2e$.

Greenhouse Gas Emissions (GHG) – are gases that trap heat in the atmosphere.

HERS – HERS, or Home Energy Rating System, is an industry standard by which a homes energy efficiency is measured.

Life Cycle Assessment (LCA) – is a systematic analysis of environmental impact over the course of the entire life cycle of a product, material, process, or other measurable activity.

Type III product-specific EPDs – are product-specific with a third-party certification, including external verification and external critical review. ISO 14025 is the standard used for Type III product-specific EPDs.

Whole Building Life Cycle Assessment (wbLCA) – is like an LCA, but specific to a building and its bill of materials.

Resources

Massachusetts Department of Energy Resources (DOER) | mass.gov:

Stretch & Specialized Code – Commercial: mass.gov/doc/stretch-specialized-code-commercial/download

Attachment E: Embodied Carbon Insulation Calculator: mass.gov/doc/embodied-carbon-insulation-calculator/download

Attachment F: Low-Carbon Concrete Mixes available in MA: mass.gov/doc/stretch-code-technical-documents-attachment-f-low-carbon-concrete-mixes-available-in-ma/download

Embodied Carbon Reduction Challenge:
masscec.com/sites/default/files/documents/BEPlusEmbodiedCarbonChallenge_16CaseStudies.pdf

Other Embodied Carbon Resources:

Carbon Leadership Forum (CLF): carbonleadershipforum.org/embodied-carbon-101-v2/

RMI: rmi.org/embodied-carbon-101/

Department of Energy: energy.gov/sites/default/files/2024-02/bto-abc-embodied-carbon-022624.pdf

Environmental Protection Agency: epa.gov/greenerproducts/cmore

EC3: buildingtransparency.org/tools/ec3/

BEAM: buildersforclimateaction.org/beam-estimator.html

ISO 14025: https://www.iso.org/standard/38131.html