# **BUILDINGENERGY BOSTON**

#### A Total Carbon Analysis Conversation: Balancing Operational and Embodied Carbon

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Northeast Sustainable Energy Association (NESEA) | March 20, 2025

#### Let's Talk About

- RESNET Standard 1550
- Analysis Tools
- Operational and Embodied Carbon: Modeled Versus Actual
- Drivers
- Action Items
- Case Studies
- Questions/Answers/Discussion

The RESNET/International Code Council *Standards Development Committee 1500 — Embodied Carbon* is responsible for proposed **Standard RESNET/ICC 1550 to provide a standardized method to calculate and report the embodied carbon impact of homes.**  HERS ratings and the HERS carbon index are a very large and growing part of the residential market.

Raters also provide services for PHIUS, Energy Star and DOE Zero Ready Homes programs.

Creating a standard that enables **HERS raters** to create an embodied carbon assessment using the **same area-based models they already build to do their energy ratings**.

#### **RESNET/ANSI Standard 1550**

# Massachusetts 100-Home Embodied Carbon Study (on going)

- designed an beta integration tool between HERS modeling software and the BEAM tool to quickly report on materials carbon
- tested raters' workflow and enhanced workforce development through training
- **Result: establish a baseline** for embodied carbon of homes in Massachusetts

TOOL	Early Design Hotspot	Enclosure Comparison	Individual Material Comparison	LCCA + ESG Net Zero Carbon		Residential	Retrofit Avoided Carbon	Whole Building LCA
Autocase	83			x				
BEAM	x	x	x			x		s
Building Ease			×					
CARE	<u>8</u>					9	x	
<u>COVE</u>	x							
EC3		7	x					
eTool	x	x	x	x	x	x	x	x
<u>Kaleidoscope</u>		x						
<u>OneClick</u>	x	x	x	x	x	x	x	x
PH Ribbon		x		2	x			
Tally	x	x	x	x	x	x	x	x
ZGF	3		x			3 5		

- Direct side-by-side material comparisons
- Assembly comparisons
- Design development
- Whole building models and comparisons
- "Alternative" materials with EPDs or LCA studies



#### 1- INPUT DIMENSIONS on the project sheet.

ex: 100 m<sup>2</sup> of exterior walls.

Project Information     Basic Instructions       Project Information     Insulation Comparison     Construction Year       Designer     Number of Bedrooms     Insulation Comparison       Building / Development Project     Tatal Floor Area     min       Address     Below Grade Conditioned Area     min       Development Project     Above Grade Conditioned Area     min       Address     Below Grade Conditioned Area     min       Development Project     Above Grade Conditioned Area     min       Address     Below Grade Conditioned Area     min       Development Project     Above Grade Conditioned Area     min       Building Type     Single Detached House     Single Detached House       Construction Type     New Construction -     Project Development Stage       Building Dimension Inputs (Excluding Garage)     DIMENSION NAME     QTY       DIMENSION INAME     QTY     UNIT     Description       Continuous Footnikes Volume     0.0     min     Length (m)     X     Exclude grage       Continuous Footnikes Volume     min     Tatal Place (centerling length is length (m)     Continuous footing (etc. and interior)       Continuous Footnikes Volume     min     Tatal Floor Area     Continuous footing (etc. and interior)
Project Name     Insulation Comparaison     Construction Year       Designer     Number of Bedrooms       Engineer     Stories Above Grade       Builder / Developer     Total Voltage       Development Project     Above Grade Conditioned Area       Address     Below Grade Conditioned Area       Province / State (Can./US only)     Stories Above Grade Conditioned Area       Province / State (Can./US only)     Stories Above Grade Conditioned Area       Country     Canada       Province / State (Can./US only)     Stories Above Grade Conditioned Area       Development Stage     Schematic Design       Building Type     Single Detached House       Province / State (Can./US only)     For full instructions and more, see th BEAM User's Canida       Province / State (Can./US only)     For full instructions and more, see th BEAM User's Canida       Dimension Inputs (Excluding Garage)     Schematic Design       DIMENSION NAME     QTY     UNIT       DIMENSION NAME     QTY     USED TO CALCULATE TAKE-OFFS       CONTINUOUS FOOTINGS VOLUME     0.0 m²     Length (m)     X       Column PADS & PIERS VOLUME     m²     Total volume of discontinuous column footings, pad, piers, etc       COLUMN PADS & PIERS VOLUME     m²     Total volume of discontinuous column footings, pad, piers, etc
Designer     Number of Bedrooms       Engineer     Stories Above Grade       Builder / Developer     Total Floor Area       Development Project     Total Floor Area       Address     Total Floor Area       Address     Below Grade Conditioned Area       Province / State (Can./US only)     Province / State (Can./US only)       Country     Canada       Province / State (Can./US only)     Province / State (Can./US only)       Construction Type     Nigle Detached House       Project Development Stage     Schematic Design       Building Dimension Inputs (Excluding Garage)     DIMENSION NAME       OLIMP ADS & PIERS VOLUME     0.0       0.0     m²       Country Canada     X       Construction on type     Store (Can./US and/Or (Can./US and/Or (Can./US and (Can.
Engineer Builder / Developer Builder / Developer Builder / Developer Builder / Developer Stories Above Grade Total Floor Area
Builder / Developer     Total Floor Area     mp     IPDETion       Development Project     Above Grade Conditioned Area     mp       Address     Above Grade Conditioned Area     mp       City     Bellow Grade Conditioned Area     mp       Province / State (Can./US only)     Below Grade Conditioned Area     mp       Country     Canada     Canada       Province / State (Can./US only)     Canada     Province / State (Can./US only)       Country     Canada     Canada       Project Development Stage     Schematic Design        Project Development Stage     Schematic Design        Building Dimension Inputs (Excluding Garage)     DIMENSION NAME       QUY     UNIT     DESCRIPTION       USED TO CALCULATE TAKE-OFFE     Continuous (aka "strip") foundation wall foo (enterior)       CONTINUOUS FOOTINGS VOLUME     0.0 m*     Length (m) x     Lexible grage       CONTINUOUS FOOTINGS VOLUME     0.0 m*     Length (m) x     Exclude grage     Continuous (aka "strip") foundation wall foo (enterior)       COULMIN PAGS & PIERS VOLUME     ms     Total volume of discontinuous column footings, pad, piers, etc.     Continuous footings (etc. and interior)
Development Project     Above Grade Conditioned Area     m <sup>2</sup> Address     Below Grade Conditioned Area     m <sup>2</sup> City     Below Grade Conditioned Area     m <sup>2</sup> Province / State (Can,/US only)     -     -       Country     Canada     -       Building Type     Single Detached House     -       Building Type     Single Detached House     -       Canstruction Type     New Construction - +     -       Project Development Stage     Schematic Design - +     -       Building Dimension Inputs (Excluding Garage)     -     -       DIMENSION NAME     QTY     UNIT     DESCRIPTION       Continuous Footnings Volume     0.0 m <sup>*</sup> Length (m)     ×       Column PADS & PIERS Volume     m <sup>*</sup> Total volume of discontinuous column footings, pad, pies, etc.       Column PADS & PIERS Volume     m <sup>*</sup> Total volume and garage     Continuous footings (etc. and interior)
Address     Image: Conditioned Area     m <sup>2</sup> The sequence is not important.       City     City
City
Province / State (Can./US only) Country Canada Country
Country         Canada            Building Type         Single Detached House            Construction Type         New Construction            Project Development Stage         Schematic Design             Building Dimension Inputs (Excluding Garage)          DIMENSION NAME         QTY         UNIT         DESCRIPTION         USED TO CALCULATE TAKE-OFFS           CONTINUOUS FOOTINGS VOLUME         0.0         m²         Length (m)         X         Exclude garage         Continuous (aka "strip") foundation wall foo (exterior and interior)           COULUMA PADS & PIERS VOLUME         0.0         m²         Length (m)         X         Exclude garage         Continuous footing, pad, pier, exclude garage         Continuous footing (ext. and interior)         Continuous footing (ext. and interior)         Exclude garage         Continuous footing (ext. and interior)         Continuous footing (ext. and interior)         Exclude garage         Continuous footing (ext. and interior)         Continuous footi
Building Type     Single Detached House       Canstruction Type     New Construction       Project Development Stage     Schematic Design       Building Dimension Inputs (Excluding Garage)     EXAM User's Duide       DIMENSION NAME     QTY     UNIT     DESCRIPTION       CONTINUOUS FOOTINGS VOLUME     0.0     max     Length (m)     x       CONTINUOUS FOOTINGS VOLUME     0.0     max     Length (m)     x       COLUMN PADS & PIERS VOLUME     max     Total volume of discontinuous column footings, pad, piers, etc.     Continuous (eka "strip") foundation wall footing continuous column footings, pad, piers, etc.
Construction Type         New Construction         For full instructions and more, see the BEAM User's Guide           Project Development Stage         Schematic Design         Building Dimension Inputs (Excluding Garage)           Building Dimension Inputs (Excluding Garage)         DIMENSION NAME         QTY         UNIT         DESCRIPTION         USED TO CALCULATE TAKE-OFFS           CONTINUOUS FOOTINGS VOLUME         0.0         m*         Length (m) x         x         Exclude: guage         Continuous (ake "strip") foundation wall foo (exterior and interior)           COLUMN PADS & PIERS VOLUME         m*         Total volume of discontinuous column footings, pad, piers, etc.         Discontinuous footing (etc. and int.)         Exclude: guage           Continuous footing volume         m*         Total volume of discontinuous column footings, pad, piers, etc.         Discontinuous footing (etc. and int.)
Project Development Stage Schematic Design    Building Dimension Inputs (Excluding Garage)  DIMENSION NAME QTY UNIT DESCRIPTION USED TO CALCULATE TAKE-OFFS  CONTINUOUS FOOTINGS VOLUME 0.0 m <sup>a</sup> Length (m) x Height (m) x Exclude: garage  COULUMN PADS & PIERS VOLUME m <sup>a</sup> Total volume of discontinuous column footings, pad, piers, etc.  COLUMN PADS & PIERS VOLUME m <sup>a</sup> Total volume of discontinuous column footings, pad, piers, etc.  COLUMN PADS & PIERS VOLUME m <sup>a</sup> Total volume of discontinuous column footings, pad, piers, etc.  COLUMN PADS & PIERS VOLUME m <sup>a</sup> Total volume of discontinuous footings, pad, piers, etc.  COLUMN PADS & PIERS VOLUME m <sup>a</sup> Total volume of discontinuous column footings, pad, piers, etc.  COLUMN PADS & PIERS VOLUME m <sup>a</sup> Total volume of discontinuous footings (ext. and int.)  Continuous footing cent. and foundation and sufface area (centreling length ty height) Excludes parage
COLUMN PADS & PIERS VOLUME Table Continuous column footings, pad, piers, etc. Discontinuous footings (ext. and int.) Fixed data: garage Continuous column footings, pad, piers, etc. Discontinuous footings (ext. and int.) Total (unordation and surface area (contentine length x heidh) - Evendetion & Abasenaeu well insultation (ort
COLUMN PADS & PIERS VOLUME m <sup>3</sup> Total volume of alsocontinuous could be followed by the second back of also continuous could be followed by the second back of the se
Total foundation wall surface area (centerline length x height) Foundation & hasament wall insulation (avt
FOUNDATION WALL AREA 100.0 m <sup>2</sup> Includes basement, party water, Scaludes, opening, parge foundation in interior family, and wall calding
FOUNDATION SLAB AREA 100.0 m <sup>2</sup> Total foundation slab surface area Aggregate base, sub-slab insulation, slab, an Endeds cararge slab basement flooring
EXTERIOR WALL AREA 100.0 m <sup>2</sup> Surface area of exterior walls. Includes: gabie ends. Excludes: window & door openings, party walls, garage walls interior cladding of exterior walls
WINDOW AREA me Area of window frames (preferable) or rough openings Windows of main building Includes fulledation area skylothes. Encludes: canopa windows
PARTY WALL AREA Wall area that partitions this unit from others Party wall framing, insulation, sheathing, an Typical for townhouses & apartment units cladding
INTERIOR WALL AREA De side only (i.e. centerline) of all interior walls. Interior wall framing and cladding (assumes includes: interior door area. Excludes: enterior, garage partition and party walls sides of walls are finished by default)
FRAMED FLOOR AREA Max Above grade flooring area Excludes: basement floor slab, and floor openings. Floor framing, subfloor, floor insulation, finite
FINISHED CEILING AREA Total finished ceiling area Includes: basement ceilings. Excludes: garage ceilings Ceiling cladding
ROOF INSULATION AREA 100.0 m <sup>2</sup> Area associated with roof insulation Typically equal to the celling uses directly below the roof Flat or sloped roof insulation
Destine and are calculated with each site
ROOF SURFACE AREA m <sup>a</sup> kooming surface area. Laiculated with root pirch koor framing, decking, rooting, and insulati Evalutes: overhangs to roof surface

#### 2- SPECIFY + SELECT on the section sheets,

Specify additional factors -> e.i.

ex: Compare 100m<sup>2</sup> of different cavity insulation with R-Value: 20 and select materials by checking the box.

	EXTERIOR WALLS		_		SUBTOTA	L (kg CO <sub>2</sub> e)	С	LIMATE
		SECTION COMPLETE?			2	271		ACTION
CATEGORY	MATERIAL	QUANTITY UI	IITS	2	SELECT	IET EMISSIONS (kg CO2e)	EMISSIONS (kg CO2e)	STORAGE (kg CO2e)
STRUCTURAL S	SHEATHING							
GYPSUM PANELS								-
	Gypsum panels - glass mat / USG / Securock ExoAir 430 / 1/2"	100.0 m	2 10	0%		611	611	0
	Gypsum panels - glass mat / 5/8" Type X / Gypsum Association [Industry Avg   N.America]	<b>100.0</b> m	2 10	10%		542	542	0
	Gypsum panels - glass mat / 1/2" / Gypsum Association [Industry Avg   N.America]	<b>100.0</b> m	2 10	0%		471	471	0
ORIENTED STRAND	BOARD (OSB)							
	OSB sheathing / 5/8" / AWC & CWC [Industry Avg   US & CA]	100.0 m	10	10%		385	385	0
	OSB sheathing / 1/2" / AWC & CWC [Industry Avg   US & CA]	100.0 m	10	10%		308	308	0
PLYWOOD								
	Plywood / 3/4" / AWC & CWC [Industry Avg   US & CA]	100.0 m	2 10	10%		418	418	0
	Plywood / 5/8" / AWC & CWC [Industry Ava LUS & col	100.0 m	2 10	0%		349	349	0
	DL / RWC & CWC [Industry Avg   US & CA]	100.0 m	10	0%		279	279	0
WOOD BOARDS	Wood / SPE / 2// <sup>a</sup> boards / AWC & CWC [Industry Ave   IIS & CA]	<b>V</b> 100.0 m	1	10%		120	120	0
CAVITY INCLU		100.0 m		0 /5	0	120	120	U
CAVILY INSULA	ATION	R-VALUE 2	0.0					
HIGH R-VALUE CAV	TTY INSULATION	100.0		0.0	-	6 400	6.400	0
	Aerogei blanket / Aspen Aerogeis / K9.6/Inch	100.0 m		10%	U	6,499	6,499	U
SPRAY PULYURE IN	ANE FUAM - HIGH DENSITY Spray polyurethane foam - High Density (HEC gas) / R 6.3/inch / SPEA				-			
	[Industry Avg   US & CA]	100.0 m	10	10%		5,995	5,995	0
	Spray polyurethane foam - High Density (HFO gas) / R 6.5/inch / SPFA Industry Avg   US & CA]	100.0 m	2 10	10%		1,744	1,744	0
SPRAY POLYURETH	ANE FOAM - CLOSED CELL							
	Spray polyurethane foam - Closed Cell (HFC gas) / R 6.6/inch / SPFA	100 0 m	2 10	10%		4 635	4 635	0
	[Industry Avg   US & CA] Spray polyurethane foam - Closed Cell (HEO gas) / B 6 6/inch / SPEA				-	1,000	1,000	
	[Industry Avg   US & CA]	<b>100.0</b> m	2 10	10%		1,465	1,465	0
	Spray polyurethane foam - Closed Cell (HFO gas) / Huntsman / Heatlok Soya HFO & Heatlok HFO / R 6.5/inch	100.0 m	10	0%		882	882	0
SPRAY POLYURETH	ANE FOAM - OPEN CELL							
	Spray polyurethane toam - open cen / K 4. mich / or the processing root -	100.0 m	10	10%		500	500	0
SHEED WOOL INSU	ATION							
	Wool / Havelock Wool / Loose-fill / R 4.4/inch	100.0 m	2 10	0%		271	620	349
	Wool / Havelock Wool / Batts / R 3.6/inch	100.0 m	2 10	0%		354	926	573
MINERAL WOOL BA	TT INSULATION						7	
	Mineral wool batt / Owens Corning / Thermafiber UltraBatt / R 4.3/inch	100.0 m	10	0%		1,409	1,409	0
	Mineral wool batt / Rockwool / ComfortBatt R24 (5.5") / R 4.4/inch	100.0 m	10	0%		600	600	0
	Mineral wool batt / [BEAM Avg]	100.0 m	2 10	0%		597	597	0
	Mineral wool batt / Rockwool / ComfortBatt R15 (3.5") / R 4.3/inch	100.0 m	10	10%		461	461	0
	Mineral wool batt / Rockwool / Safe'n'Sound, ComfortBatt / R 3.8/inch	100.0 m	2 10	10%		461	461	0
	Mineral wool batt / Rockwool / ComfortBatt R14 (3.5") / R 4.0/inch	100.0 m	10	10%		415	415	0
	Mineral wool batt / Rockwool / ComfortBatt R22 (5.5") / R 4.0/inch	100.0 m	2 10	10%		415	415	0
	Mineral wool batt / Rockwool / ComfortBatt R24 SS (6" Steel Studs) / R	100.0 m	2 10	10%		415	415	0
PROJECT	Footings & Slabs Toundation Walls	s 👻 🙆 Stru	ctural	Ele	ments		t. Walls -	B Pa

#### **3- REVIEW** materials selection on the **review sheet**.

*Quickly identify selected materials with highest and lowest carbon footprint* 

BEAM	CLIMATE	REVIEW PROJECT MATERIALS	11,745	13,519	1,774
SECTION	CATEGORY	MATERIAL	NET EMISSIONS (kg CO <sub>2</sub> e)	CARBON EMISSIONS (kg COze)	CARBON STORAGE (kg CO2e)
ootings & Slabs	CONTINUOUS CONCRETE FOOTINGS	Concrete – 0-25 MPa, 0-14% FA/SL, GU / CRMCA [industry Avg   CA]	1,225	1,225	0
ootings & Slabs	CONCRETE SLABS	Concrete - 0-25 MPa, 0-14% FA/SL, GU / CRMCA [Industry Avg   CA]	2,645	2,645	0
ootings & Slabs	REBAR FOR CONTINUOUS FOOTINGS	Rebar / Concrete Reinforcing Steel Institute [Industry Avg   N.America] / 10M	60	60	0
ootings & Slabs	REINFORCING MESH FOR SLAB	Welded wire mesh / Serfas / 6' x 6'' x 6/6g / Norway	107	107	0
ootings & Slabs	SUB-SLAB INSULATION	EPS foam board / R 4.0/inch avg [BEAM Avg   US & CA]	656	656	0
ootings & Slabs	AGGREGATE BASE	Aggregate / US Average [Industry Avg]	106	106	0
oundation Walls	CONCRETE FOUNDATION WALLS	Concrete - 0-25 MPa, D-14% FA/SL, GU / CRMCA [Industry Avg   CA]	928	928	0
oundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Concrete Reinforcing Steel Institute [Industry Avg   N.America] / 10M	90	90	0
oundation Walls	CONTINUOUS INSULATION	XPS foam board / R 5.0/inch [BEAM Avg   US & CA]	328	328	0
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x8 Lumber / AWC & CWC [Industry Avg   US & CA]	256	256	0
Exterior Walls	STRUCTURAL SHEATHING	Pfywood / 1/2" / AWC & CWC [Industry Avg   US & CA]	279	279	0
Exterior Walls	CAVITY INSULATION	Wool / Havelock Wool / Loose-fill / R 4.4/inch	271	620	349
exterior Walls	CONTINUOUS INSULATION	Wood fiber board / GUTEX / Multi-Therm / R 3.6/inch, 40, 60, 80, 100, 120, 140, 160, 180, 200 mm	-382	387	769
Exterior Walls	ADDITIONAL MATERIALS	Mineral wool batt / [BEAM Avg]	383	383	0
Exterior Wall Cladding	EXTERIOR WALL CLADDING	Fiber Cement Cladding / James Hardie / HardiePlank / 8 mm	681	734	53
Exterior Wall Cladding	STRAPPING / FURRING	Wood / SPF / 1x2 Lumber / AWC & GWC [Industry Avg   US & CA]	11	11	0
Exterior Wall Cladding	INTERIOR CLADDING FOR EXTERIOR WALLS	Drywall 1/2" [BEAM Avg   US & CA]	163	163	0
Exterior Wall Cladding	INTERIOR CLADDING FOR EXTERIOR WALLS	Drywall 5/8" Type X / Gypsum Association [Industry Avg   US & CA]	98	98	0
Vindows	WINDOWS - DOUBLE-GLAZED	Window - double-glazed / Vinyl frame / BfCA Study [US & CA]	1,770	1,770	0
nterior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg   US & CA]	16	16	0
nterior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg   US & CA]	83	83	0
nterior Walls	CLADDING FOR INTERIOR WALLS	Drywall 1/2" [BEAM Avg   US & CA]	370	370	0
Floors	LIGHT WOOD FLOOR FRAMING	Wood I joist / TJI 230/360 / 9-1/2" Depth / AWC & CWC [Industry Avg   US & CA]	129	129	0
Roors	SUB FLOORING	Plywood / 1/2" / AWC & CWC [Industry Avg   US & CA]	75	75	0
loors	FLOOR CAVITY INSULATION	Fiberglass batt / R 3.6/inch [BEAM Avg]	20	20	0
Ceilings	CEILING FINISHES	Drywall 1/2" [BEAM Avg   US & CA]	253	253	0
loof	WOOD ROOF FRAMING	Wood / SPF / 2x12 Lumber / AWC & CWC [Industry Avg   US & CA]	134	134	0
Roof	ROOFING	Metal Panels - Steel / Canadian Sheet Steel Building Institute / 24 gauge [Industry Avg   CA]	1,182	1,182	0
Roof	ROOF CAVITY INSULATION	Cellulose / loose fill / R 3.7/inch / CIMA [Industry Avg   US & CA]	-414	190	604
Root	ADDITIONAL MATERIALS	Plywood / 1/2" / AWC & CWC [Industry Avg   US & CA]	220	220	0
indows - 🔒	Int. Walls 👻 🔒 Floors 👻	🔒 Ceilings - 🔒 Roof - 🔒 Garage -		N - 🔒 RE	ESULTS -

#### **4-** SHARE

materials carbon results from the **results sheet**.

Represents the carbon footprint for the structure, enclosure and partitions of the whole building.



Energy Use Intensity Carbon Equivalent Usage Embodied Carbon Accounting

#### **Energy: Modeled vs. Actual Emissions**

					Columbus Commons		Cornell Tech			
	211 W	29th	511 E	511 E 86th Columbus Common		Commons	Cornell Tech		Hotel M	larcel
		Site Energy Consumption kBt		Imption kBtu	.Btu/sf.yr					
	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual
Heating	0.42	3.75	0.81	1.36	0.6	1.1	1.06	5.2	5.55	7.2
Cooling	0.79	1.09	1.18	1.39	0.4	4.1	0.92	1.9	1.34	3.8
Domestic Hot Water	4.53	9.4	5.81	10.04	4.4	9.1	5.88	7.8	2.69	8.4
Lighting and Plug Loads	8.48	16.63	7.21	20.02	9.7	8.9	9.81	16.94	20.49	42.9
Total EUI	14.2	30.69	15.0	33.1	15.1	23.2	17.7	31.8	30.1	62.3

#### **Energy: Actual Emissions After a Year of Cx**



Columbus	Commons	Hotel N	Narcel	Canaan Parish			
5 Stories over Amenity/Ret	ail, 80 units, 110,600 GSF	Renovated 165 Room	Hotel, 111,000 GSF	4 story MF, 40 units, 61,500 GSF			
ASHP, NG Cent	ral DHW, ERV	VRF, HPV	VH, ERV	ASHP, NG Tankless, Exhaust Only			
HEDC Pango	27 12	Modeled EUI	30.1	HERS Range	49 - 60		
Carbon Index	48 - 53	First Year, Actual EUI	62.3	Carbon Index	70 - 89		
Modeled Total Building EUI	15.0			Modeled EUI	35.0		
Actual Total Building EUI*	18.0	Second Year, Actual EUI*	42.0	Actual Total Building EUI*	45.0		
* July 2023 -	June 2024	*After Final Cx, and HP Drye	ers replaced Electric Dryers	* July 2023 - June 2024			

#### Hotel Marcel: Modeled vs. Actual Emissions



#### Hotel Marcel: Modeled vs. Actual Emissions



#### **Operational Carbon Emissions**

Columbus Commons								
5 Stories over Amenity/Ret	ail, 80 units, 110,600 GSF							
Operational Carbon Emissions (kg CO₂e ·yr)	148,948							
Operational Carbon Emissions (kg CO2e/sf ·yr)	1.35							

FF FE **Canaan Parish** 4 story MF, 40 units, 61,500 GSF

Operational Carbon Emissions (kg CO <sub>2</sub> e ·yr)	207,984
Operational Carbon Emissions (kg CO <sub>2</sub> e/sf ·yr)	3.38

Actual kBtu/sf·yr 45

Actual kBtu/sf·yr 18

#### **Embodied Carbon Emissions vs EUI**



Footings & Slabs	97,535 kg CO <sub>2</sub> e
Foundation Walls	24,004 kg CO <sub>2</sub> e
Structural Elements	29,112 kg CO2e
Exterior Walls	50,984 kg CO2e
Party Walls	19,625 kg CO2e
Exterior Wall Cladding	45,234 kg CO2e
Windows	55,620 kg CO2e
Interior Walls	36,908 kg CO2e
Floors	65,009 kg CO2e
Ceilings	18,212 kg CO2e
Roof	64,584 kg CO2e
Garage	0
NET TOTAL	644,717 kg CO <sub>2</sub> e

Embodied Carbon Emissions (kg  $CO_2e/sf$ ) = **10.48** 

### **Embodied Carbon Emissions vs Average**

#### **RMI Low-rise Residential Study**

Average home ~184 kg  $CO_2e/m^2$ 

- New low-rise residential homes (SF, duplexes, townhomes, and apartments buildings <3 stories)</li>
- ~5 occupants
- Based on 921 homes in US, Canada and Europe
- Includes structure, enclosure and partitions



#### **Canaan Parish**

Canaan Parish ~113 kg CO<sub>2</sub>e/m<sup>2</sup>

- 40 units, 4 stories
- ~130 occupants
- Includes structure, enclosure and partitions
- Excludes parking garage structure



## Drivers

#### Code



#### Code



2027 IECC Commercial & Residential Scope & Intent

Draft for Public Comment





#### 2024 IECC - What Happened?

https://bit.ly/4hldWPZ

July 15, 2024 www.iccsafe.org





### **Mass Stretch Embodied Carbon Credit**

Clean Energy Application	HERS Target	HERS Target with R406.5.2 EC Credit
Mixed Fuel Building	42	45
All-Electric Building	45	48

#### Add Subsection R406.5.2, Embodied Carbon Credit

1. Insulation: new single dwelling units that demonstrate a calculated insulation GWP intensity (kg CO2e/m2) less than 0... based on table default values, or product specific EPDs or calculations in the approved tools: EC3 and BEAM, may be used ... OR

2. Low GWP Concrete Mix Credit: new single dwelling units that demonstrate a calculated concrete mix GWP  $\leq$  100% of the 2022 NRMCA Northeast Benchmark average . . .

#### **DOER regulations went into effect in February 14, 2025**

#### **Mass Save Proposed Incentives**

We further see merit in the Program Administrators continuing to On 2/28/25... coordinate their energy efficiency programs with other building decarbonization programs initiated by the Commonwealth, such as the embodied carbon intergovernmental coordinating council, and we remain open to the future possibility of stacking energy efficiency funds with other funds focused on embodied carbon measures. However, for the reasons discussed above, we find that consideration of an Embodied Carbon measure in the context of the Three-Year Plans is premature.

Source: MA DPU order: <u>https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/19886002</u>

#### **Embodied Carbon Education in Massachusetts**



## **EMBODIED CARBON** REDUCTION CHALLENGE

THE CHALLENGE: REDUCE UPFRONT CARBON OF BUILDINGS

ENTRIES DUE APRIL 3, 2024 | 5:00 PM

~\$400,000 in cash prizes awarded to 11 lead applicants

#### **BERDO and BEUDO**

Boston's Building Emissions Reduction and Disclosure Ordinance (**BERDO**) - requirements for large existing buildings to reduce their greenhouse gas

The Building Energy Use Disclosure Ordinance (**BEUDO**) – enacted by the Cambridge City Council

Estimated average ranges for compliance (2025-2050)



📕 Min Cost 📕 Max Cost

#### **Boston Net Zero Carbon Zoning Proposal**



- Passed in January of this year
- Starting July 1, 2025, new project filings will be required to be Net Zero Ready through BERDO at day of opening
- Requires reporting on embodied carbon
- Applies to new buildings with 15+ units or 20,000+ SF and additions of 50,000+ SF

Source: <u>https://www.bostonplans.org/getattachment/e7692da5-746b-4037-962a-a0cd43747205</u>

#### **Embodied Carbon Carrots and Sticks Timeline**



# Action

- 1. Retrofit / Reuse material
- 2. Design to minimize:

the size of your building, the concrete use and loads, the need of finishes

- 3. Choose lower emission / carbon storing material (insulation)
- 4. Consider circular design :

reusability, recyclability, design for disassembly and durability

5. Sourcing : sustainable, regenerative and/or local materials

#### Net Zero As-Built - MCE Results per material

Concrete Cladding Insulation **83%** MCE from 4 material categories : Concrete 6,100 10,390 Cladding Insulation **Interior Surfaces** 15,797 Interior Surfaces Roofs Framing 2,067 1,726 5,858 Structural... 1,486 Windows

Net Zero As-Built - Total : 45,998 kg CO2e



#### Concrete

- → Reduce massing
- → Optimize required strength



- → Optimize formulations: SCMs, PLC/Type 1L (Limestone), Gap-Graded Aggregate
- → Engage SE, CM, Ready Mix to secure lowest % GWP reduction at best cost
- → Emerging tech: Pozzotive, Biochar, Natural SCMs/LC3, CarbonCure/Solidia
- → Novel tech: Sublime Systems, Prometheus Materials, Blue Planet



## **Framing and Cladding**

→ Reduce Massing



- → Optimize Required Strength (framing) / Optimize durability with rainscreens, species selection, etc. (cladding)
- → Wood Studs vs Steel Studs / Wood vs Fiber Cement
- → Do The Math and Know The Source: Mass Timber GWP Can Vary, Impacts Beyond GWP

## Framing

OATEOODY	MATERIAL		UNUTO	۵v		NET EMISSIONS	GROSS EMISSIONS	STORAGE Short Cycle	STORAGE Long Cycle	SELECT Long
CATEGORT	MATERIAL	QUANTIT	UNIIS	76	SELECT	kg c∪₂e	kg CO₂e	Kg CU <sub>2</sub>	kg CO <sub>2</sub> 🦦	Cycle
LIGHT ST	EEL FRAME WALLS	FRAMING SPACING	16 -	in						
LIGHT STEEL	L FRAMING – 16 GAUGE (2X6)									
	Steel studs - Load bearing / Steel Framing Industry Assn / 600-S-137-54, 16 gauge [Industry Avg, US & CA]	200.0	ft²	100%		449	449	0	0	
	Steel studs - Load bearing / Scafco / 600-S-137-54, 16 gauge	200.0	ft²	100%		605	605	0	0	
	Steel studs - Load bearing / MarinoWARE / Structural stud and track / 600-S-137-54, 16 gauge	200.0	ft²	100%		456	456	0	0	
	Steel studs - Load bearing / ClarkDietrich / 600-S-137-54, 16 gauge	200.0	ft²	100%		438	438	0	0	
LIGHT STEEL	L FRAMING – 20 GAUGE (2X4)									
	Steel studs - Non-loadbearing / Steel Framing Industry Assn / 362-S-137-54 20EQ gauge [Industry Avg, US+Can]	200.0	ft²	100%		108	108	0	0	
	Steel studs - Non-loadbearing / Scafco / 362VS125-18, 20EQ gauge	200.0	ft²	100%		146	146	0	0	
	Steel studs - Non-loadbearing / MarinoWARE / Viper Stud Viper 20 / 20EQ gauge	200.0	ft²	100%		110	110	0	0	
	Steel studs - Non-loadbearing / ClarkDietrich / 362-S-125-18, 20EQ gauge	200.0	ft²	100%		106	106	0	0	
LIGHT WO	OOD FRAME WALLS	FRAMING SPACING	16.0	in						
FRAMING LU	IMBER – SPRUCE-PINE-FIR									
	Wood / SPF / 2x8 Lumber / AWC & CWC [Industry Avg   US & CA]	200.0	ft²	100%		54	54	0	650	
	Wood / SPF / 2x8 Lumber / Surfaced Dry Softwood Lumber Produced in British Columbia	200.0	ft²	100%		39	39	0	605	
	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg   US & CA]	200.0	ft²	100%		41	41	0	493	
	Wood / SPF / 2x6 Lumber / Surfaced Dry Softwood Lumber Produced in British Columbia	200.0	ft²	100%		30	30	0	459	
	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg   US & CA]	200.0	ft²	100%		26	26	0	314	

## Cladding

CATEGORY	MATERIAI		%	SELECT	NET EMISSIONS ka.CO.e	GROSS EMISSIONS kg.CO.e	STORAGE Short Cycle	STORAGE Long Cycle	SELECT Long Cycle
onicooni					· j= · -	* 1= * =	Ng 002	Ng 002	ejele
FIBER CEME	NT SIDING								
	Fiber Cement siding [BEAM Avg]	187.8 m <sup>2</sup>	100%		1,248	1,555	307	0	
	Fiber Cement siding / Equitone / Pictura, Natura Pro, sheets / 8 mm [EU]	187.8 m²	100%		2,626	3,062	436	0	
	Fiber Cement siding / Equitone / Linea Lunara sheets / 10 mm [EU]	187.8 m <sup>2</sup>	100%		1,209	1,465	256	0	
	Fiber Cement siding / JamesHardie / Hardie Plank HZ5, Hardie Panel HZ5, Hardie Architectural Panel HZ5 / 8 mm	<b>187.8</b> m <sup>2</sup>	100%		1,107	1,433	326	0	
	Fiber Cement siding / JamesHardie / Hardie Plank HZ10, Hardie Panel HZ10, Hardie Architectural Panel HZ10 / 8 mm	<b>187.8</b> m <sup>2</sup>	100%		957	1,285	328	0	
	Fiber Cement siding / JamesHardie / Hardie Shingle HZ5 / 6.3 mm	187.8 m <sup>2</sup>	100%		859	1,123	264	0	
	Fiber Cement siding / JamesHardie / Hardie Shingle HZ10 / 6.3 mm	187.8 m <sup>2</sup>	100%		730	960	230	0	
NATURAL W	DOD SIDING								
	Cedar Siding / Western Red Cedar Lumber Assn / 1x6 Boards [Industry Avg   CA]	187.8 m <sup>2</sup>	100%		324	324	0	1,235	
	Wood / SPF / 3/4" boards / AWC & CWC [Industry Avg   US & CA]	187.8 m <sup>2</sup>	100%		226	226	0	2,718	
	Wood cladding / BurntWood / ReUse with linseed oil treatment / 18 mm [EU]	187.8 m <sup>2</sup>	100%		635	1,095	460	5,628	
	Wood cladding / BurntWood / ReUse without surface treatment / 18 mm [EU]	187.8 m <sup>2</sup>	100%		449	449	0	5,628	
NATURAL W	DOD SIDING								
	Cedar Siding / Western Red Cedar Lumber Assn / 1x6 Boards [Industry Avg   CA]	187.8 m <sup>2</sup>	100%		-911	324	0	1,235	
	Wood / SPF / 3/4" boards / AWC & CWC [Industry Avg   US & CA]	187.8 m <sup>2</sup>	100%		-2,492	226	0	2,718	
	Wood cladding / BurntWood / ReUse with linseed oil treatment / 18 mm [EU]	187.8 m <sup>2</sup>	100%		-4,994	1,095	460	5,628	
	Wood cladding / BurntWood / ReUse without surface treatment / 18 mm [EU]	187.8 m <sup>2</sup>	100%		-5,180	449	0	5,628	

### **Wood Carbon Storage**



harvested during growth period

#### **Wood Carbon Storage**

#### Short Cycle Carbon Storage





#### Wood Carbon Storage

#### BEAM v1.1 enables selective carbon storage for timber

											1
	PROJECT NAME: SCENARIO: BEAM VERSION:	Sample Project DOE Prototype Baseline V1.1	SECTION COMPLETE	?			0	0	0	0	
CATEGORY		MATERIAL	QUANTITY	UNITS	٩	SELECT	NET EMISSIONS kg CO2e	GROSS EMISSIONS kg CO2e	STORAGE Short Cycle kg CO <sub>2</sub>	STORAGE Long Cycle kg CO <sub>2</sub>	SELECT Long Cycle
LIGHT WO	DOD FRAME	WALLS	FRAMING SPACIN	G 16.0	in						
FRAMING LU	JMBER - SPRU	CE-PINE-FIR							1	()	_
	Wood / SPF / 2x8 Lumber / AWC & CWC [Industry Avg   US & CA]			) ft²	100%		-298	27	0	325	
	Wood / SPF / 2x8 Lumber / Surfaced Dry Softwood Lumber Produced in British Columbia			0 ft²	100%		20	20	0	302	
	Wood / SPF / 2x	6 Lumber / AWC & CWC [Industry Avg   US & CA	100.0	) ft²	100%		20	20	0	246	
	Wood / SPF / 2x6 Lumber / Surfaced Dry Softwood Lumber Produced in British Columbia			<b>)</b> ft²	100%		15	15	0	229	



#### Insulation

- → Find the Optimal Thermal Value (don't over-insulate)
- → Choose Plant Based Products
- → Avoid Plastic Based Products
- → Pay attention to the Chemicals (Binders, Fire Retarders, VOC's)

![](_page_43_Picture_5.jpeg)

![](_page_44_Figure_0.jpeg)

![](_page_45_Figure_1.jpeg)

Net Zero As-Built - Total : 45,998 kg CO2e

## Drywall

- → Specify Lightweight Gypsum Board ~ 550 kg/m<sup>3</sup> instead of 800 kg/m<sup>3</sup>
- → Specify the Correct & Smallest Thickness
- → Reduce Waste

![](_page_46_Picture_4.jpeg)

#### Paint

![](_page_47_Figure_1.jpeg)

#### Paint

![](_page_48_Figure_1.jpeg)

## **Case Studies**

![](_page_50_Picture_1.jpeg)

#### **EMBODIED CARBON** REDUCTION CHALLENGE

![](_page_50_Figure_3.jpeg)

Red = Steel

![](_page_50_Picture_5.jpeg)

Yellow = Wood

![](_page_50_Picture_7.jpeg)

![](_page_51_Figure_1.jpeg)

**Embodied Carbon Comparison** 

![](_page_52_Figure_2.jpeg)

Concrete	Cladding	Insulation		
15,797	10,390	6,100		
	Interior Surfaces	Roofs	Framing	
		2,067	1,726	
	5,858	Structural		
I		1,486	Windows	

![](_page_53_Figure_1.jpeg)

![](_page_54_Picture_1.jpeg)

![](_page_54_Figure_2.jpeg)

![](_page_55_Figure_1.jpeg)

![](_page_55_Picture_2.jpeg)

#### CARBON IMPACTS OF INSULATION

![](_page_55_Figure_4.jpeg)

![](_page_56_Picture_1.jpeg)

	Manufacturer	Product	R-value per inch	Global Warming Potential* (A1- A3) per 1m2			
	TimberHP	TimberBoard	3.6	- 10.3 kg CO2e			
	Gutex	Thermowall	5.7	- 1.2 kg CO2e			
	Rockwool	Comfortboard 80	4.2	4.937 kg CO2e			
Ń	naufInsulatior	Earthwool®Insulation Board	4.3	6.075 kg CO2e			
	bhns Manville	JMCladstone 80	4.2	8.02 kg CO2 e			
C	)wens Corning	Thermafiber®Fire& Sound Guard®Plus	3.5-4.2	1.33 kg CO2e (Wabash plant) 8.78 kg CO2e (Joplin plant)			

MA			1331014	SDIS	ECTION
Footings & Slabs	48,230	kg CO₂e			
Foundation Walls	0	kg CO₂e			
Structural Elements	0	kg CO₂e			
Exterior Walls	-8,024	kg CO₂e			
Party Walls	8,786	kg CO₂e			
Cladding	8,093	kg CO₂e			
Windows	9,902	kg CO₂e			
Interior Walls	9,406	kg CO₂e			
Floors	4,296	kg CO₂e			
Ceilings	8,167	kg CO₂e			
Roof	4,951	kg CO₂e			
Garage	0	kg CO₂e			
NET TOTAL	93,806	kg CO₂e	-10,000		MCE (kg C

FLUCOLONIC DV

Average home is ~184 kg  $CO_2 e/m^2$ Eagleville Green ~169 kg  $CO_2 e/m^2$ 

Average home is 4 beds (5 ppl) Eagleville is 8 beds (14 ppl)

50,000

#### Sample Case Study "Wrap Up" Slide

#### Net Zero As-Built - MCE Results per material

![](_page_58_Figure_2.jpeg)

Net Zero As-Built - Total : 45,998 kg CO2e

#### Sample Case Study "Wrap Up" Slide

Material Carbon Intensities of Different Scenarios

![](_page_59_Figure_2.jpeg)

#### Sample Case Study "Wrap Up" Slide

![](_page_60_Figure_1.jpeg)

MCE per Material

## Key Takeaways

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	E	h
-	12	- I

We can reduce BOTH operational & embodied emissions! It's not an either/or decision.

![](_page_61_Picture_3.jpeg)

Stay ahead! New standards, policies and incentives are in development to support EC reduction efforts.

![](_page_61_Picture_5.jpeg)

Leverage existing tools integrate EC assessment seamlessly into existing workflows.

![](_page_61_Picture_7.jpeg)

Act early! Use life cycle analysis from the start to shape low-carbon design decisions.

![](_page_61_Picture_9.jpeg)

#### **Reduction opportunities vary** by building typology—tailor strategies accordingly.

![](_page_61_Picture_11.jpeg)

#### Focus on high-impact

**materials**—a small proportion of building materials drive the biggest results.

![](_page_62_Picture_0.jpeg)

TOOL	Early Design Hotspot	Enclosure Comparison	Individual Material Comparison	LCCA + ESG	Net Zero Carbon	Residential	Retrofit Avoided Carbon	Whole Building LCA
Autocase	13			x				
BEAM	x	x	x			x		s
Building Ease			x					
CARE	97 					9	x	
COVE	x							
EC3		1	x					
eTool	x	x	x	х	x	x	x	x
<u>Kaleidoscope</u>	54. 197	x						
<u>OneClick</u>	x	x	x	x	x	x	x	x
PH Ribbon		x			x			
Tally	x	x	x	x	x	x	x	x
ZGF	3		x			2 5		

### **Sample Workflow Slide**

![](_page_63_Figure_1.jpeg)

#### Decision tree for embodied carbon analysis

### Sample Workflow Slide

considered? WLCA Compare Compare retrofit to new building CARE tool **Project stage** new build options Are you looking for Carbon rough idea or higher Avoided: resolution data? Retrofit Estimator EARLY GUIDANCE DETAILED GUIDANCE Indicators Indicators Rough High idea resolution Are you seeking holistic Are you seeking holistic environmental impacts environmental impacts or carbon only? or carbon only? CARBON WLCA ACCOUNTING WBLCA WBLCA **EPIC tool** CO2 ALL EcoCalculato CO2 ALL Early Phase Integrated **Revit-integrated** Carbon tool Simplified EPD LCA tool LCA for early database estimates and carbon WBLCA CARBON ACCOUNTING calculator **OneClick LCA** Comparison of Web-based LCA tool building systems CARBON ACCOUNTING WBLCA **Carbon Designer 3D** Impact Estimator Early estimations on carbon hot spots Desktop app for LCA

Build Necessity

Source: Tracy Huynh, Chris Magwood, Victor Olgyay, Laurie Kerr, and Wes Sullens, Driving Action on Embodied Carbon in Buildings, RMI and U.S. Green Building Council (USGBC), 2023,

https://rmi.org/insight/drivingaction-on-embodied-carbon-in-buildings/ and https://www.usgbc.org/resources/driving-actionembodied-carbon-buildings.