BUILDINGENERGY BOSTON

Retrofitting Existing Buildings into Low-Carbon Assets

Eva Rosenbloom (RMI)
Chris Magwood (Builders for Climate Action)

Curated by Clay Tilton

Northeast Sustainable Energy Association (NESEA)
March 29, 2023

Learning Objectives

Comprehend the differences and relationship between embodied carbon and operating carbon emissions in building retrofits

Amortize the upfront embodied carbon emissions costs associated with a deep energy retrofit with the anticipated operating carbon emissions savings.

Identify key components in exterior assemblies that benefit from the strategic use of low-embodied carbon materials and carbon storing materials.

Discuss policies and market development which support investment in low embodied carbon and carbon storing materials and deep energy retrofits solutions.

Agenda

20 min — Research & report background

20 min — Working session for group activity

20 min — Analyze results & discussion

We cannot solve the climate challenge without rapidly scaling solutions for existing buildings.

THE REALITY...

70%

of today's buildings will still be here in 2050

OUR MANDATE...

50%

of today's buildings stocks must be decarbonized by

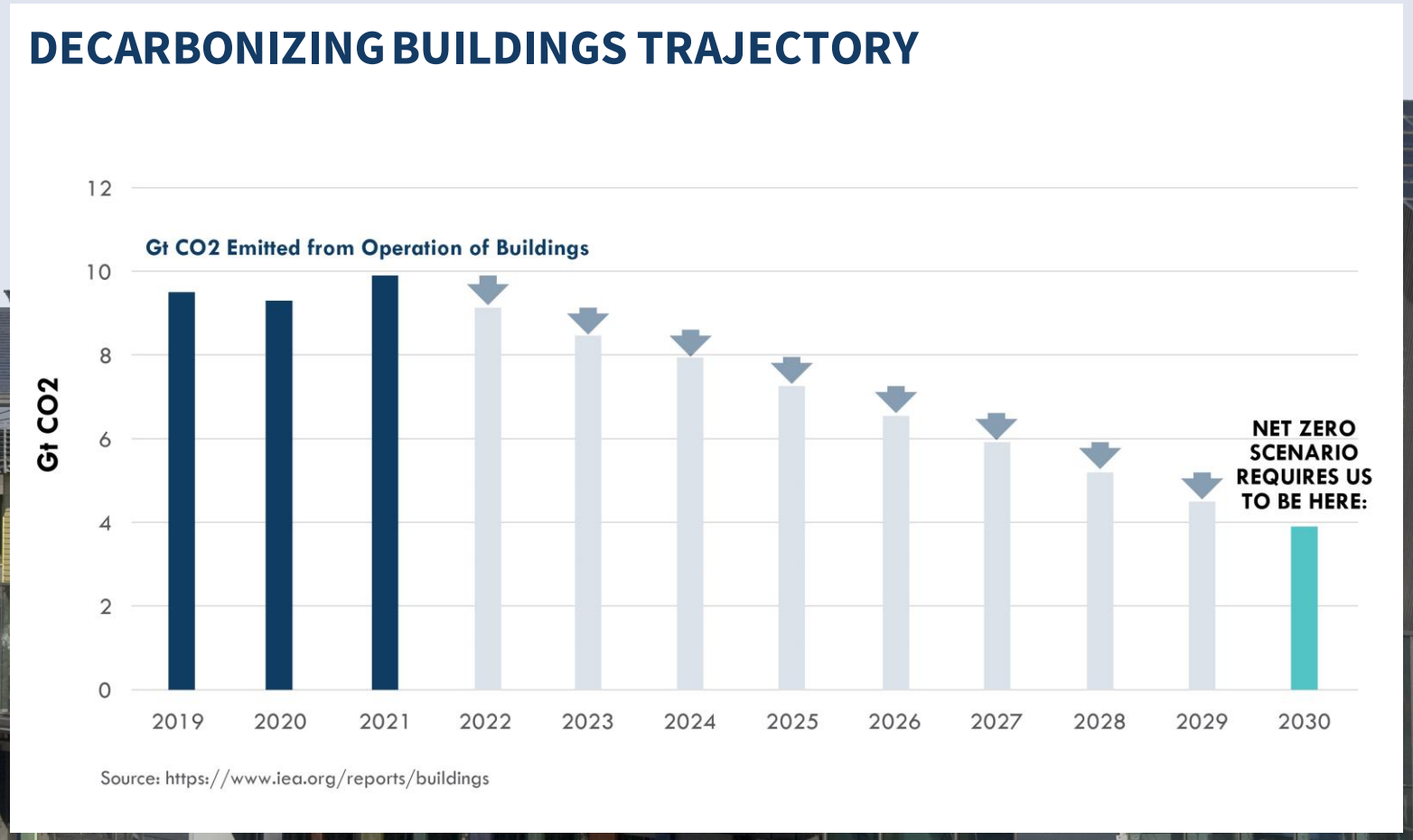
2030

TARGET RATE...

more than 5x

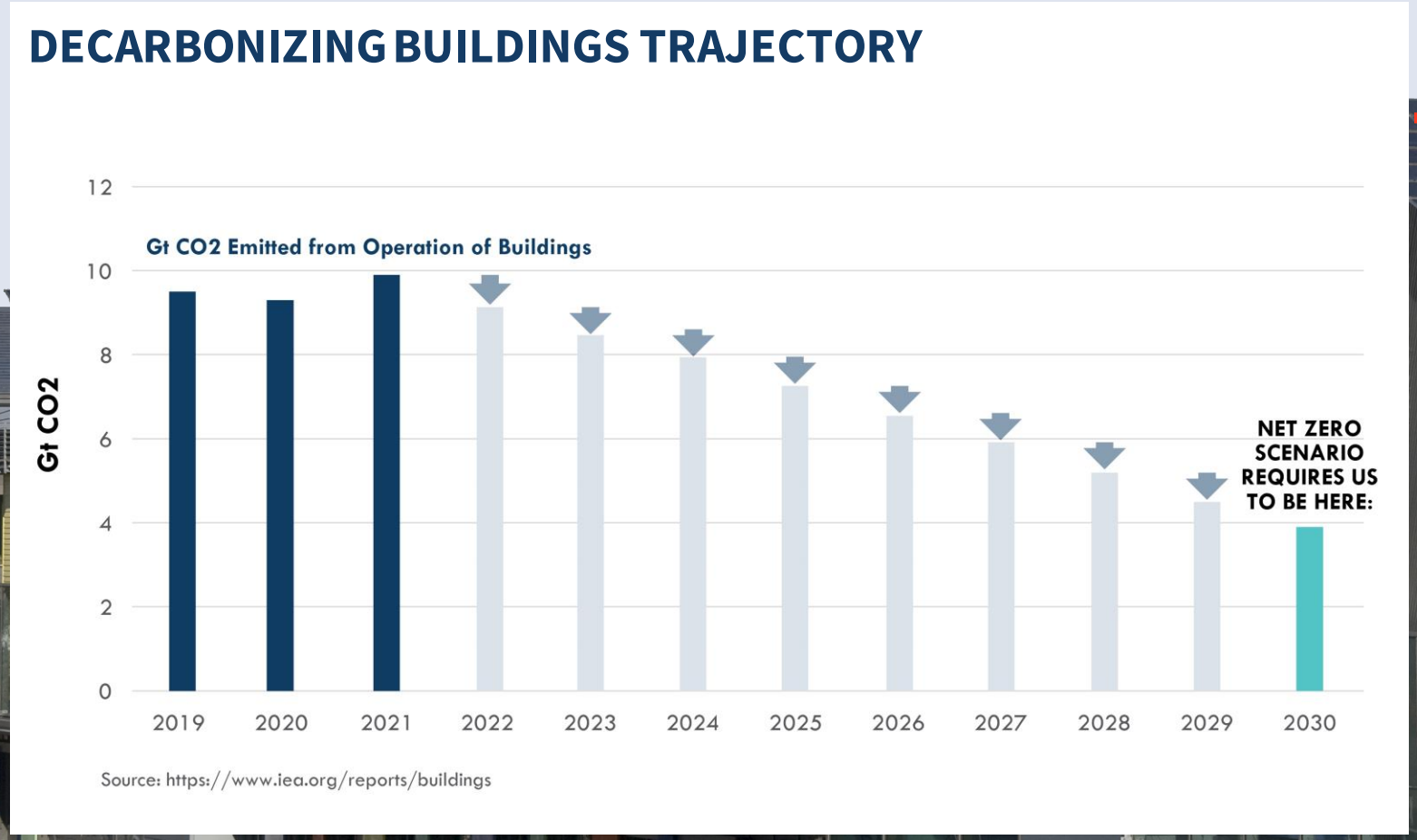
of today's zero-carbon retrofit rate must be achieved

We cannot solve the climate challenge without rapidly scaling solutions for existing buildings.



Can't meet climate goals without major reductions from retrofits

We cannot solve the climate challenge without rapidly scaling solutions for existing buildings.



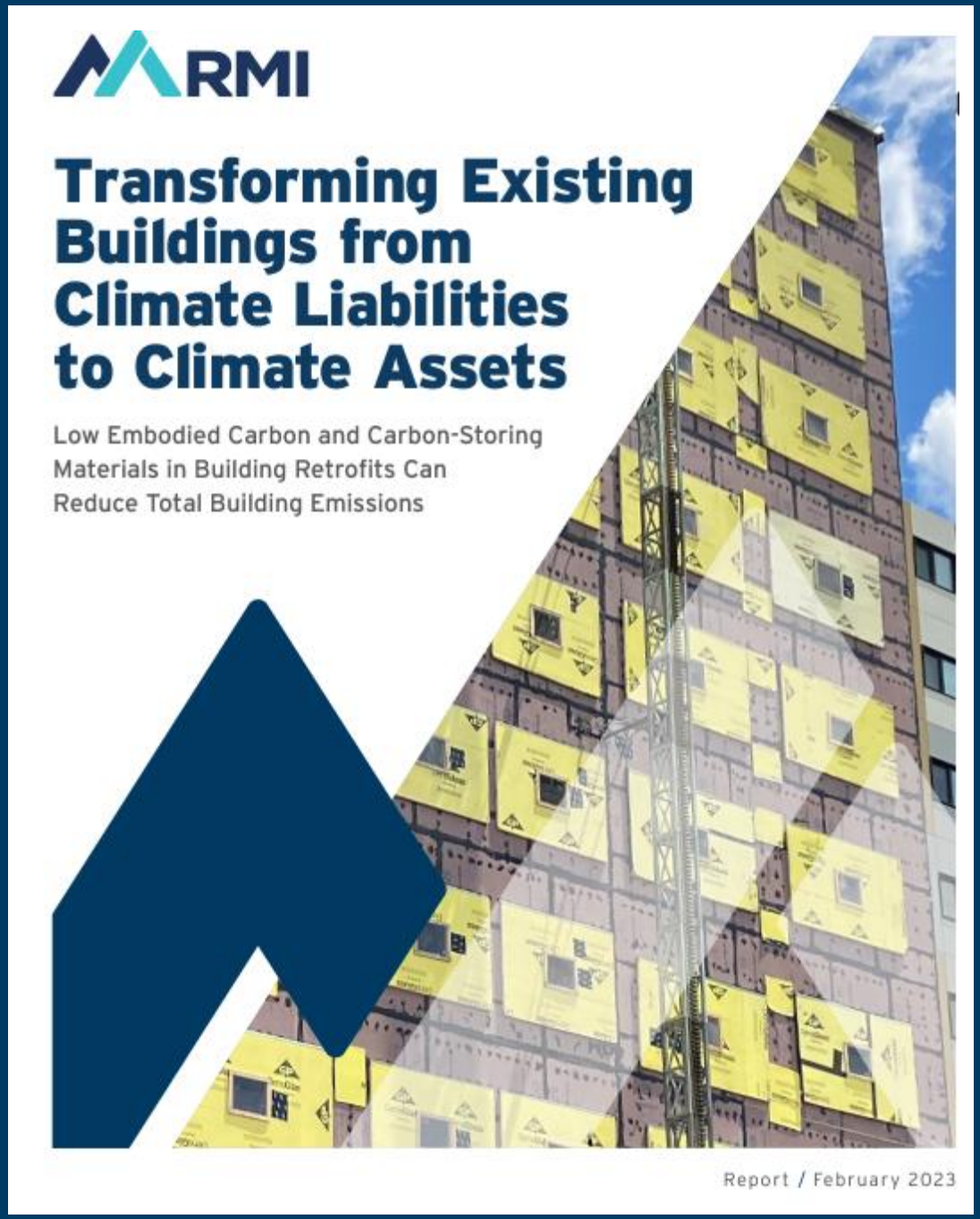
Don't want to erase gains by driving up embodied emissions

Hot off the presses…

Newly published report available

KEY TAKEAWAYS:

- ✓ Embodied carbon impacts can be equivalent of **2-7 years** of operational reductions
- ✓ Combined analysis enables **best achievable climate impact**
- ✓ Carbon-storing materials can enable realization of **immediate climate benefits**
- ✓ Embodied carbon analysis **maximizes climate benefits** of retrofits, but is **not a reason to avoid retrofits**



How to do analysis: operations

- 69% Energy Reduction
- 75.2 EUI to 23.2 EUI
- All-electric

Impact

- 52 tonnes CO2e annual OPERATING reduction

How to do analysis: materials

WALL GWP

R-30 Insulation + Exterior Cladding

X

Wall Surface SF

+

WINDOW GWP

U-0.16 Triple-paned windows

X

Window SF

+

ROOF GWP

R-60 Insulation + Membrane

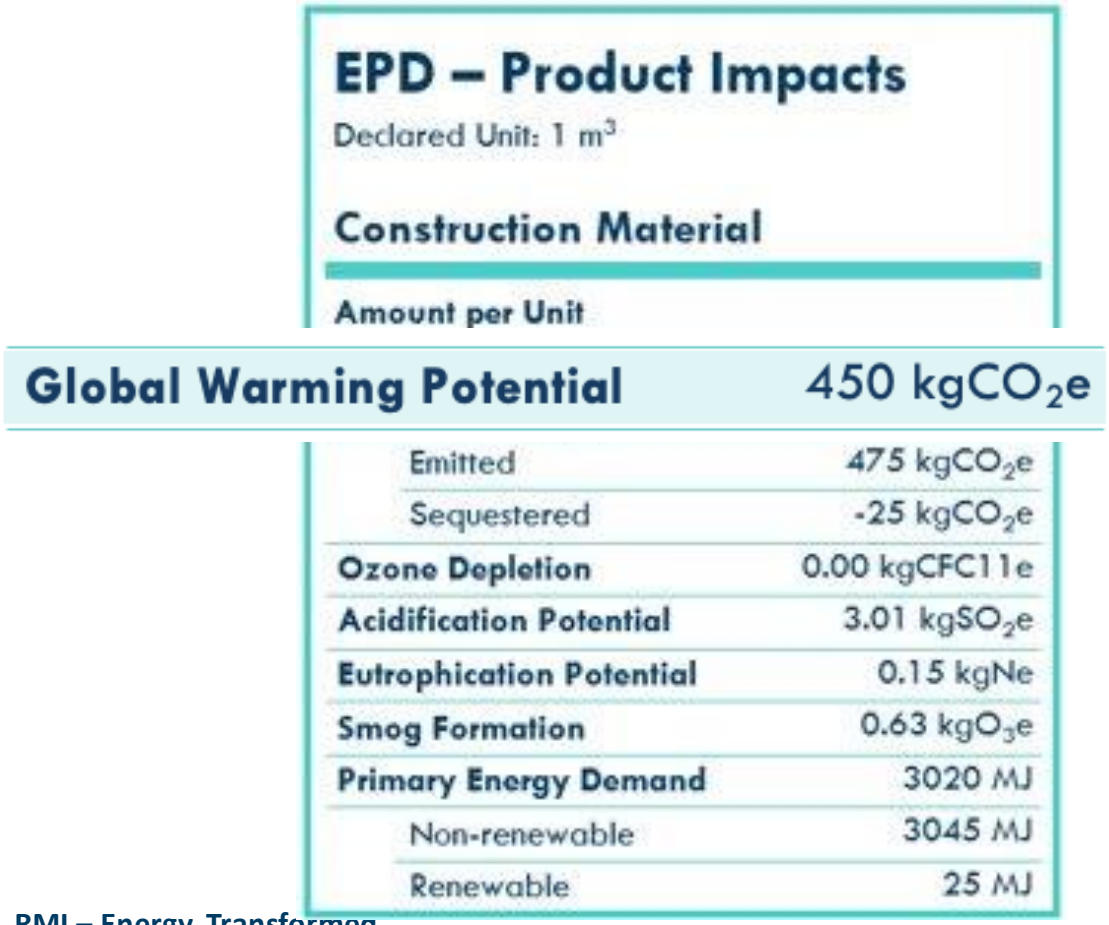
X

Roof surface SF

Total tonnes CO_2e

Estimating material carbon emissions

EPDs a “nutrition label” for building products



EPD – Product Impacts

Declared Unit: 1 m^3

Construction Material

Amount per Unit	
Global Warming Potential	**450 $kgCO_2e$**
Emitted	475 $kgCO_2e$
Sequestered	-25 $kgCO_2e$
Ozone Depletion	0.00 kgCFC11e
Acidification Potential	3.01 $kgSO_2e$
Eutrophication Potential	0.15 kgNe
Smog Formation	0.63 kgO_3e
Primary Energy Demand	3020 MJ
Non-renewable	3045 MJ
Renewable	25 MJ

Emissions are declared as kilograms of carbon dioxide equivalent (kg CO2e)/unit

RMI – Energy. Transformed.

Estimating material carbon emissions

Calculation for GWP for a particular building

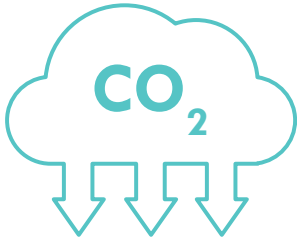
[A1-A3 GWP factors from EPDs **–** A1-A3 biogenic carbon storage –10% discount] **×** Material quantity **=** **Net emissions kg CO_2e**

EPD – Product Impacts

Declared Unit: 1 m^3

Construction Material

Amount per Unit	
Global Warming Potential	450 $kgCO_2e$
Emitted	4750 $kgCO_2e$
Sequestered	-25 $kgCO_2e$
Ozone Depletion	0.00 kgCFC11e
Acidification Potential	3.01 $kgSO_2e$
Eutrophication Potential	0.15 kgNe
Smog Formation	0.63 kgO_3e
Primary Energy Demand	3020 MJ
Non-renewable	3045 MJ
Renewable	25 MJ



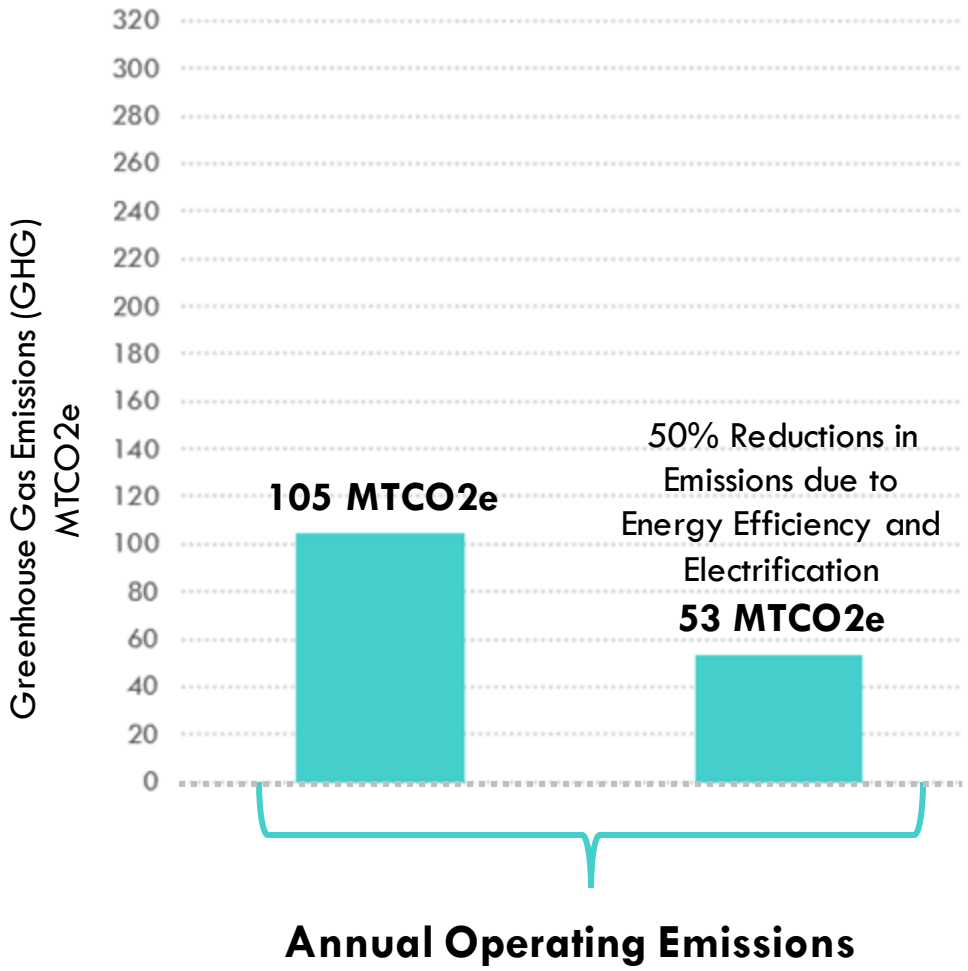
How does embodied carbon relate to operating?

- 52 MT CO2e annual OPERATING emission reductions

+

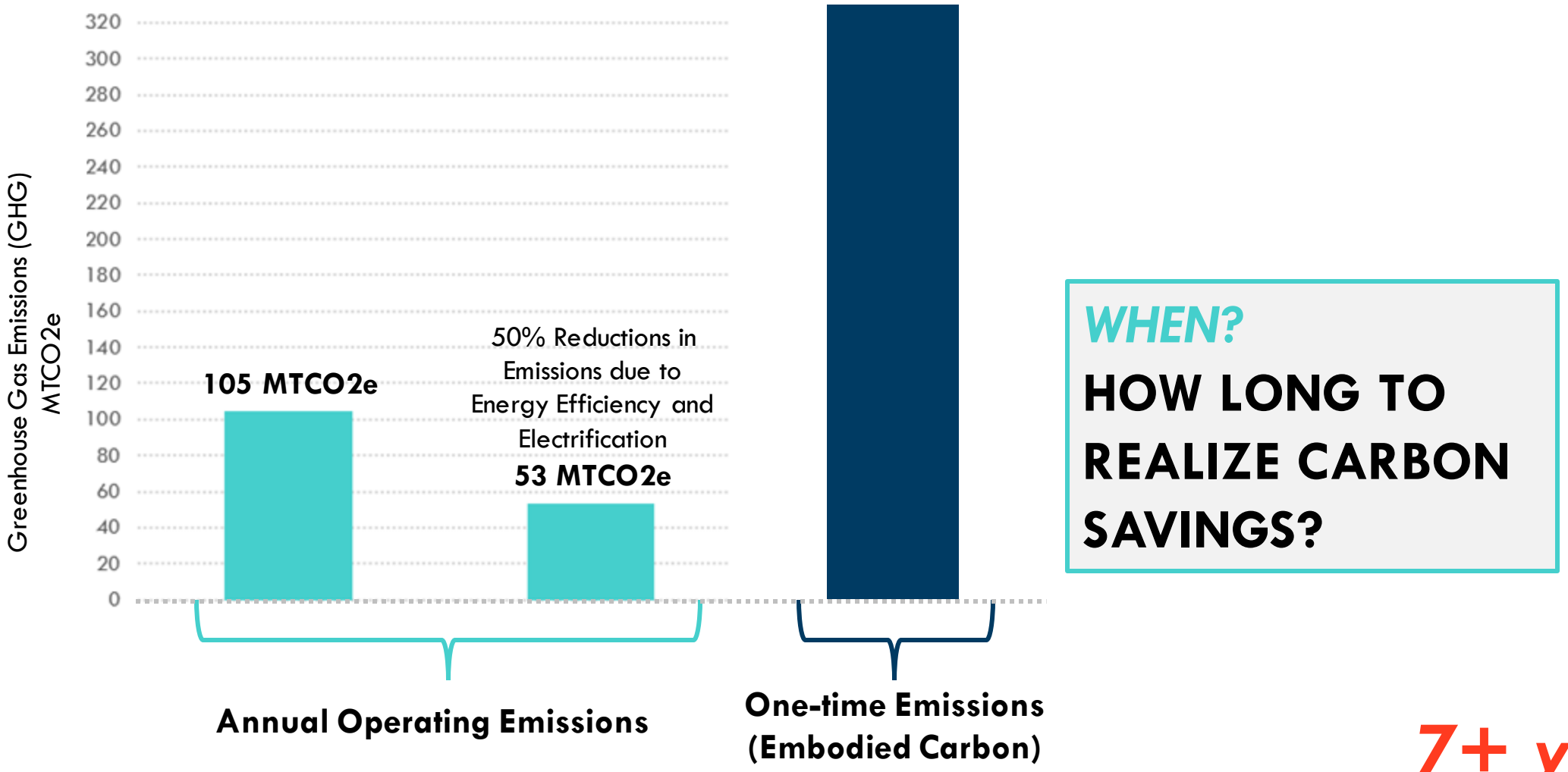
- High embodied
- Moderate embodied
- Low embodied

Operational reductions



52 MT CO2e ANNUAL OPERATING CARBON SAVINGS

High embodied carbon materials

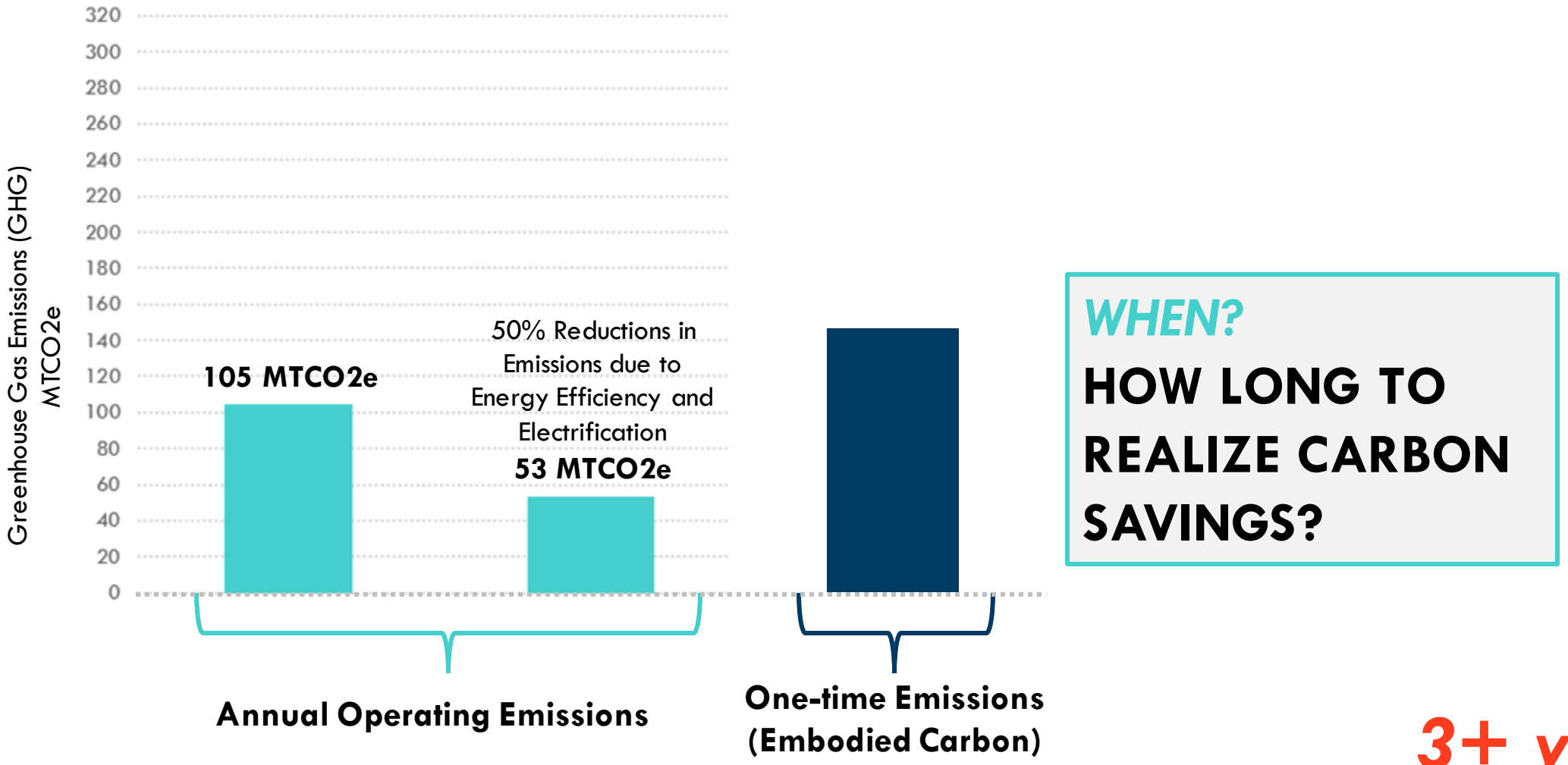


WHEN?

HOW LONG TO REALIZE CARBON SAVINGS?

7+ years?

Moderate embodied carbon materials

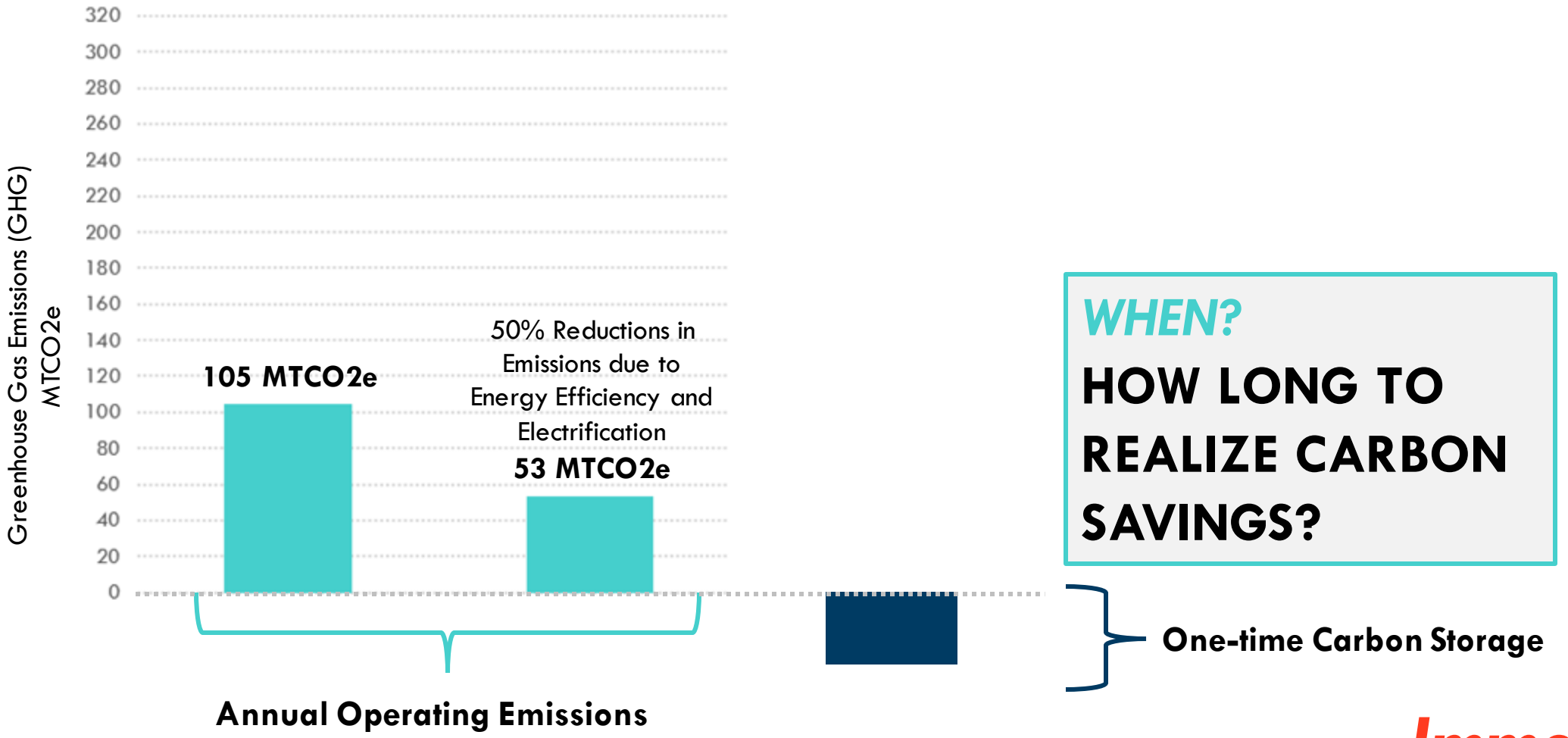


WHEN?

HOW LONG TO REALIZE CARBON SAVINGS?

3+ years?

Net negative embodied carbon materials

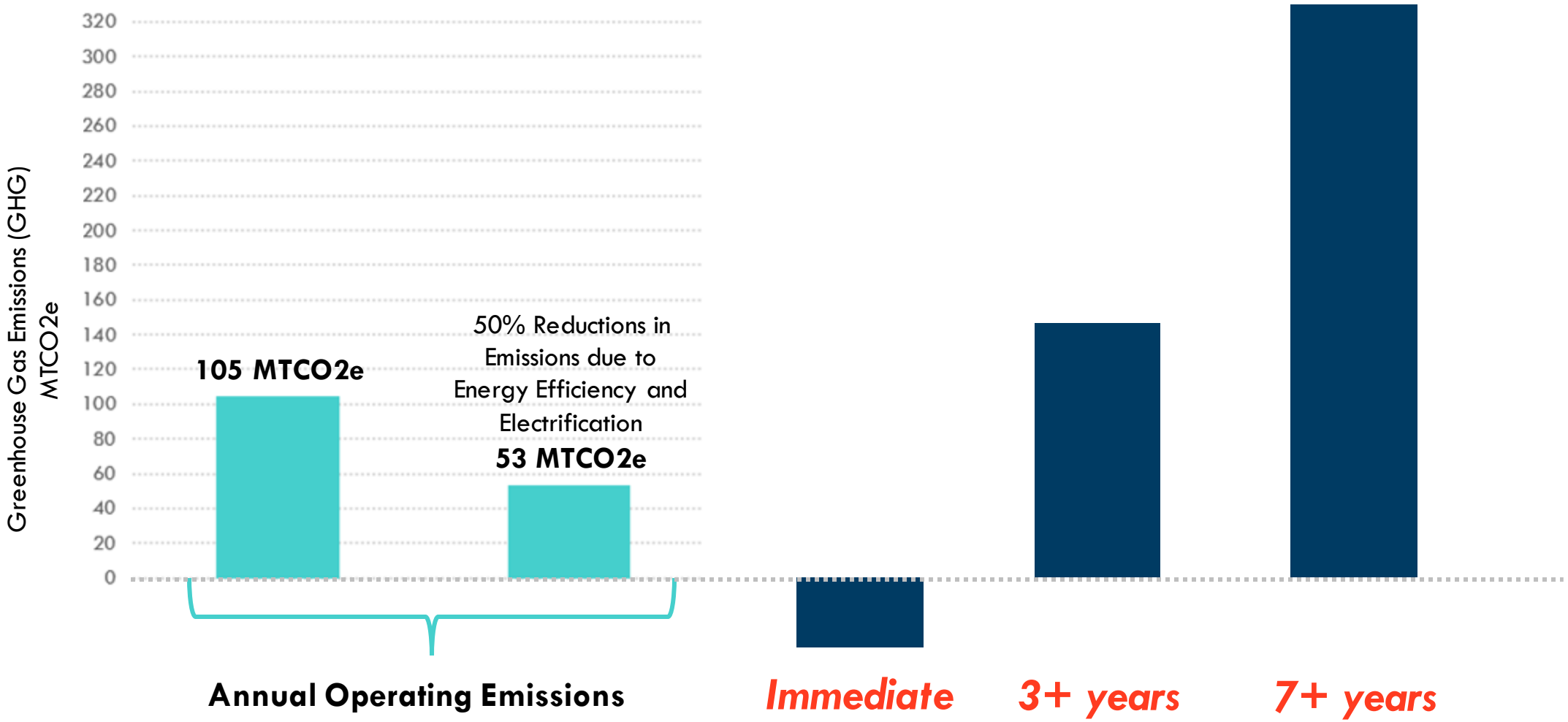


WHEN?

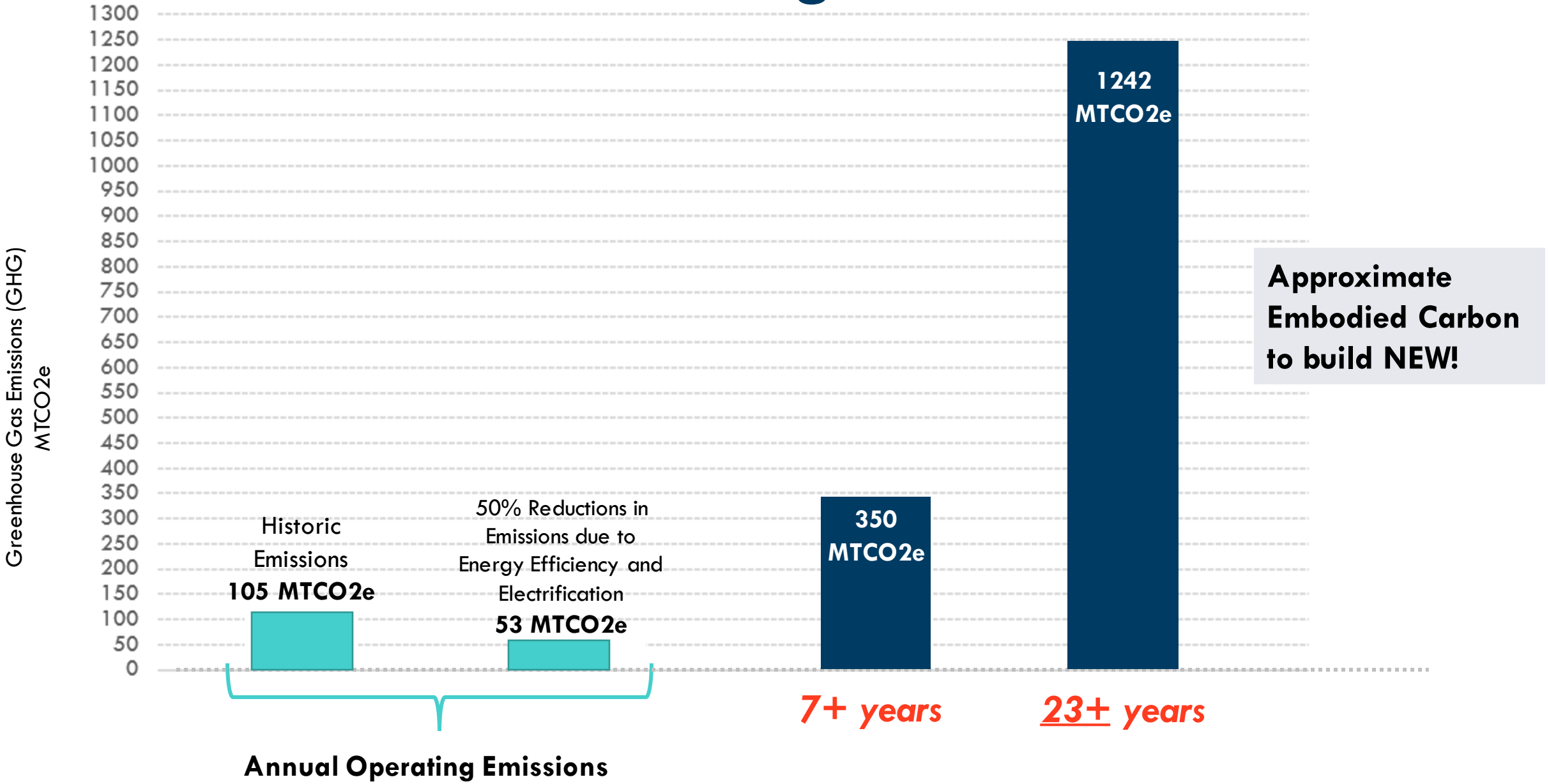
HOW LONG TO REALIZE CARBON SAVINGS?

Immediately

If we can achieve better results, we should!



Don't tear the old building down...

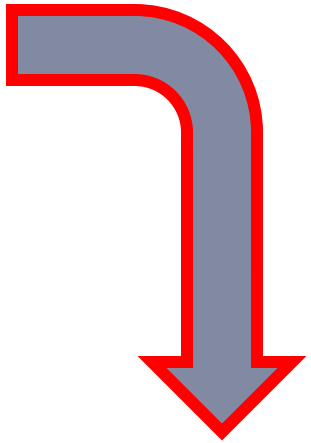


Maximize operating carbon savings with low impact retrofit assemblies

KEY STRATEGIES

1. Create the most impact with the least amount of materials

2. Reduce materials with high embodied carbon



- Concrete
- Metals
- Plastic / Foams
- Glass

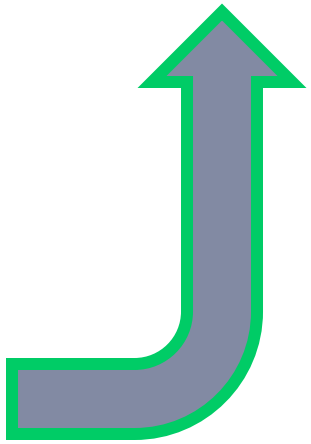
Maximize operating carbon savings with low impact retrofit assemblies

KEY STRATEGIES

1. Create the most impact with the least amount of materials

2. Reduce materials with high embodied carbon

3. Increase materials with “negative” emissions



- Agricultural residues
- Waste & recycling stream fibers
- Purpose grown crops
- Timber

Biogenic carbon

Interrupting the carbon cycle to remove CO_2 from the atmosphere

CO_2
absorption

delayed

CO_2
returns after 60-200 years

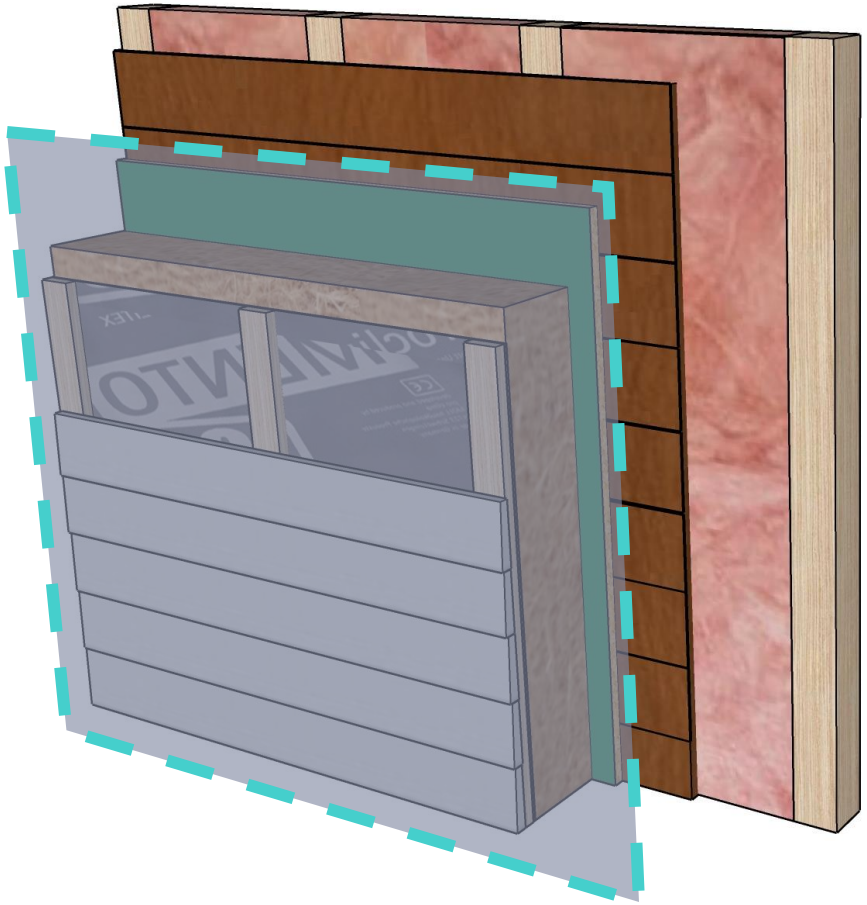


Bio-based materials, e.g., straw, bamboo, lumber, etc.

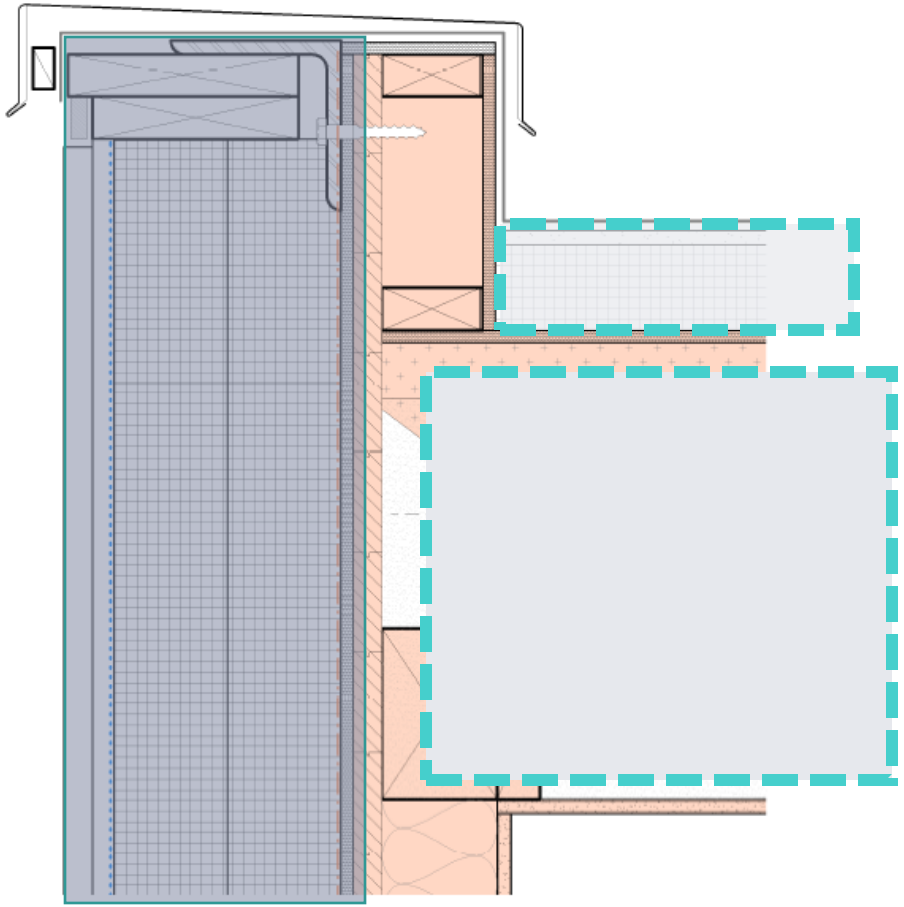
transformed into building material

M&S Flagship Store Cheshire Oaks, 2012

Retrofit Embodied Carbon Calculation Exercise



WALL ASSEMBLY



ROOF ASSEMBLY

Retrofit Embodied Carbon Calculation Exercise

BUILDINGENERGY BOSTON

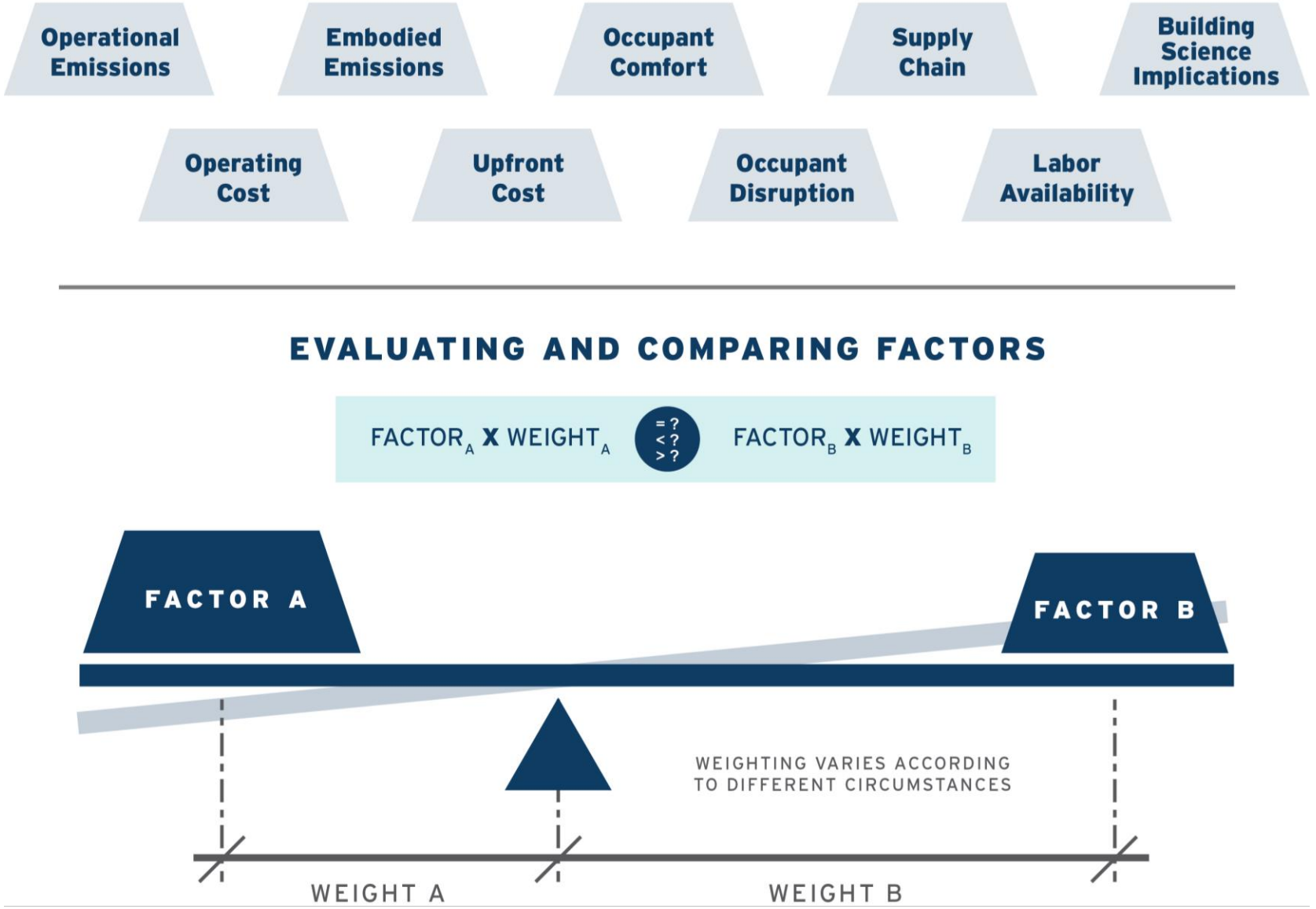
Retrofitting Existing Buildings into Low-Carbon Assets

EMBODIED CARBON WORKSHEET: RETROFIT ASSEMBLY

Type/Model	Materials	Net GWP kg CO_2e /SF	Cost	Codes	Material or Labor Availability	Building Science Pros/ Cons	Notes/ Comments/ Questions
WALL ASSEMBLY: R30							
Cavity/Continuous Insulation							
Framing / Furring							
Structural Sheathing							
Barriers: A/V/WR							
Exterior Finish							
Other							
	Wall Assembly TOTAL						
ROOF ASSEMBLY: R60							
Cavity Insulation/Attic							
Barriers: A/V/WR							
Continuous Insulation							
Roof Decking/Cover Board							
Roofing Membrane							
Other							
	Roof Assembly TOTAL						
WINDOWS / GLAZING							
Glazing + Frame							
	Window Assembly TOTAL						

Factors to consider in an energy retrofit

- COSTS
- CODE COMPLIIANCES
- AVAILABLE LABOR
- SUPPLY CHAIN
- BUILDING SCIENCE CONCERNS



Case Study: Sundance Housing Co-op

Edmonton, Alberta

- Prefabricated 2x4" wooden framed panel and sheathing
- 8" cavity site-filled with dense packed cellulose insulation (R-26 effective)
- Vapor open water-resistive air barrier
- Rainscreen, furring, and fiber cement siding


Credit: Bensonwood


Credit: Retrofit Canada


Credit: Retrofit Canada

Case Study: De Roomley Sports Hall

Udenhout, Netherlands

- Prefabricated wood-framed panels 7 x 3 meters (~23 x 10 feet) (~15 inches thick)
- Panels filled with dense-packed straw insulation (R-36)
- Panels enclosed with wood fiberboard insulation (R-10)
- Charred wood siding

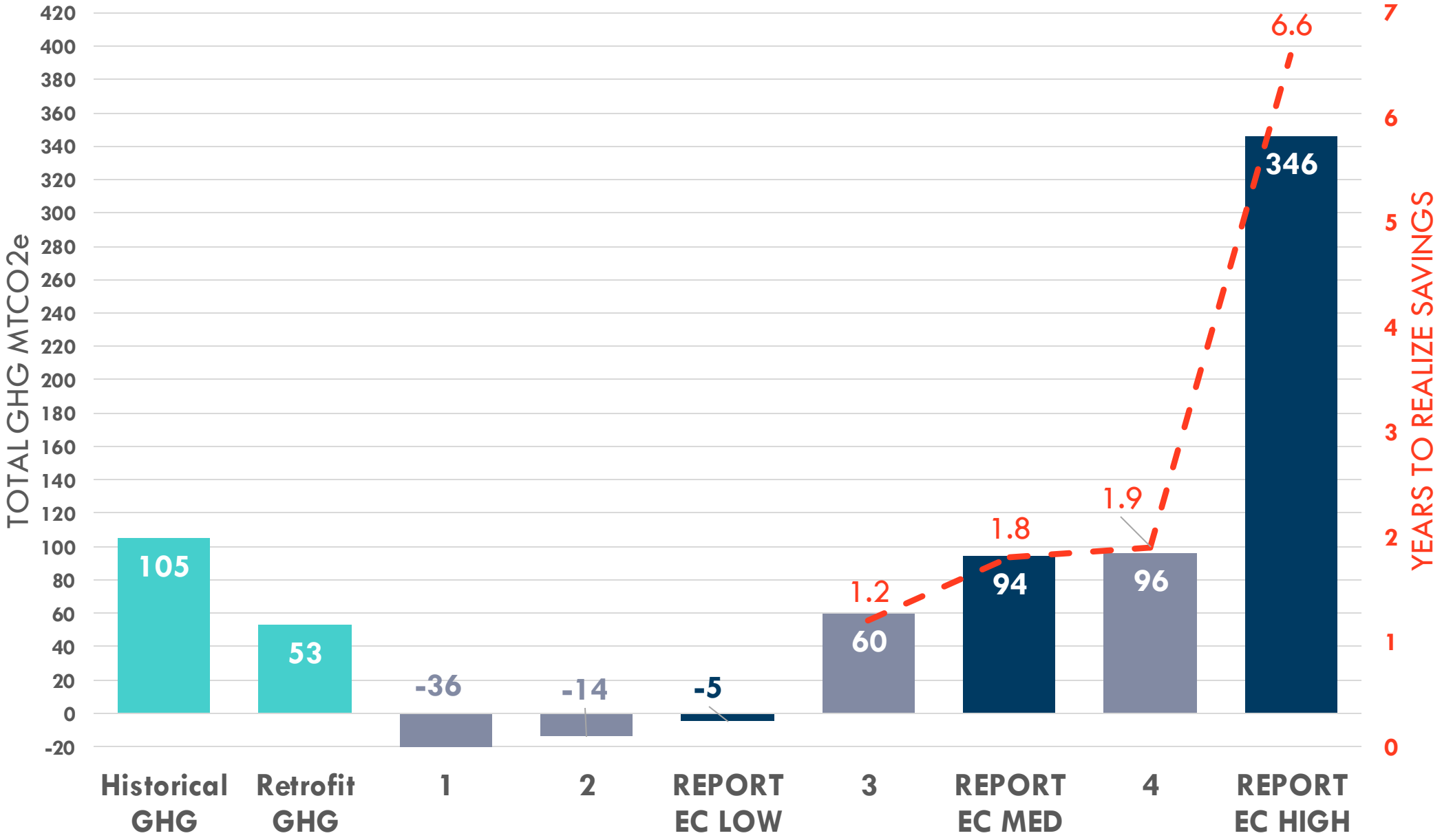
Credit: UpStraw Yearbook 2019


Credit: UpStraw Yearbook 2019


Credit: Michael Burchert

Live Results

*Please note: Grey bars are the results from the in-person session group exercise. Material selections and calculations have not been verified. This is for review & reference only.



Bio-based products

Credit: Iso-Stroh


Credit: IsoHemp

Credit: VestaEco


Credit: Ekopanely

Credit: Calmura Natural Walls

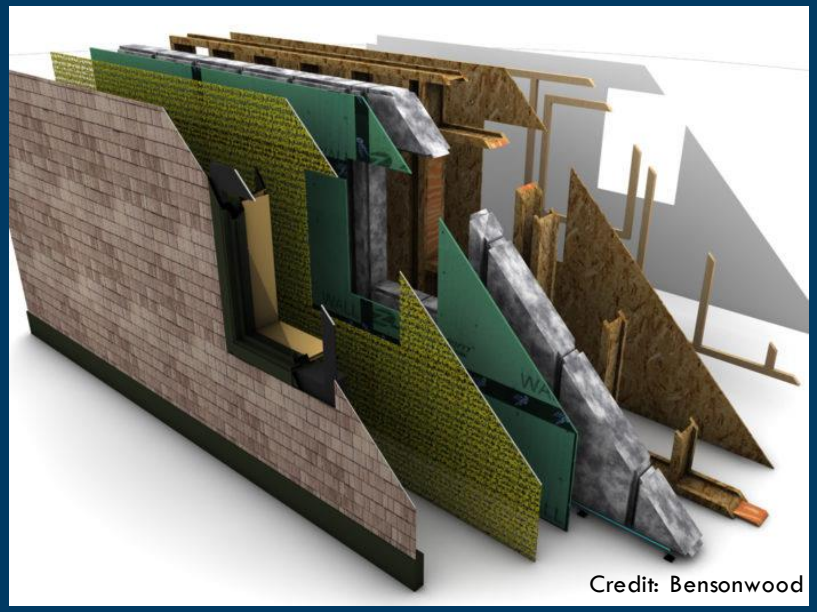

Credit: Oryzatech

Dozens of available and forthcoming materials offering net carbon storage...

Panelized solutions using bio-based insulation, structure and cladding are feasible, practical & affordable


Credit: Ecococon


Credit: HempLogic


Credit: Bensonwood

Credit: Agriboard

Embodied Carbon Reduction Challenge

- 11 Prizes of $30,000 -$50,000
- New construction or substantial renovation 20,000+ sq. ft. in design development or recently completed
- Free trainings, Life Cycle Analysis tool access, and competition guidelines coordinated by Built Environment Plus (BE+) – see website and express interest form for access
- Submissions due end of March 2024
- 5 Prizes held for Lead Applicants who haven't produced an LCA for a client before

MASSACHUSETTS CLEAN ENERGY CENTER®

Concrete EPD Kickstarter: Environmental Product Declarations

- $3,000 grant for each Massachusetts ready-mix concrete plants; extra $1,000 for small companies (1-2 plants)
- To partially offset costs for third-party verified site specific instant EPDs for any mix
- Begins May 2023
- hq@macapa.org

MASSACHUSETTS CLEAN ENERGY CENTER®

BUILDINGENERGY BOSTON

Thank You!

Questions?

Eva Rosenbloom
erosenbloom@rmi.org

Chris Magwood
cmagwood@rmi.org

Northeast Sustainable Energy Association (NESEA)
March 29, 2023