BUILDERS FOR
CLIMATE
ACTION

Low-Rise Buildings as a **Climate Change Solution**

NEHERS webinar, 2020

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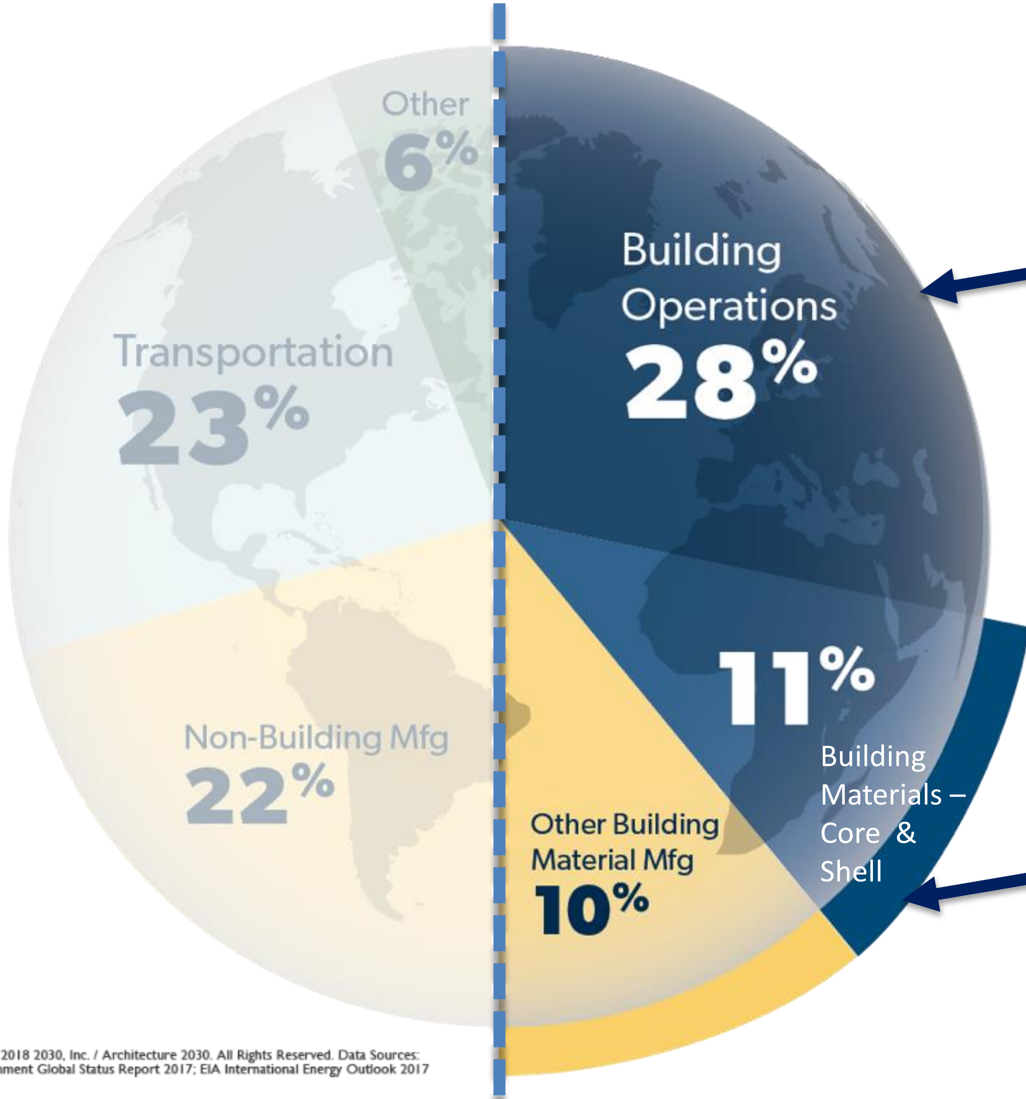
New Frameworks

How much do buildings contribute to **CLIMATE CHANGE**?

Total global emissions by sector, 2017



We've done a great job of making reductions here…

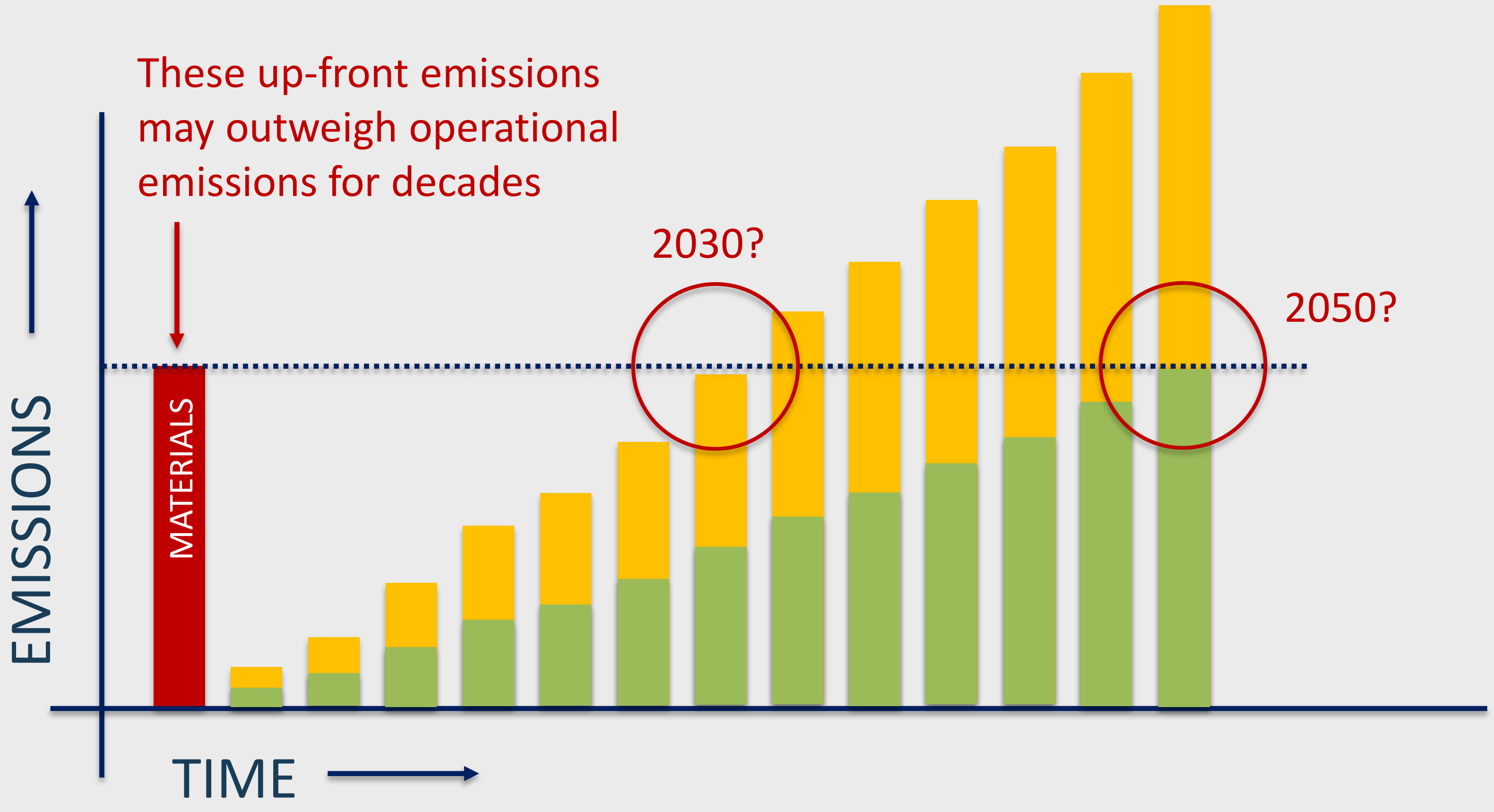
But so far we've largely ignored these emissions…

Ignoring materials is ignoring almost **HALF THE PROBLEM!**

Time Value of Carbon

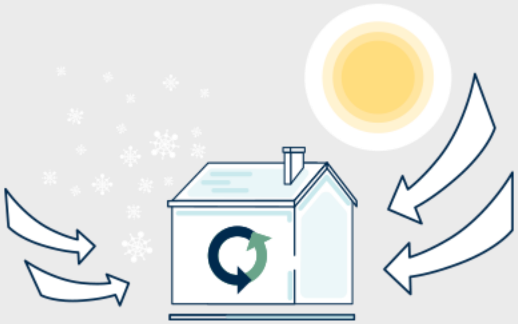
Definition of Terms

WE CAN'T "NET ZERO" OUR WAY OUT OF THIS !



Definition of Terms

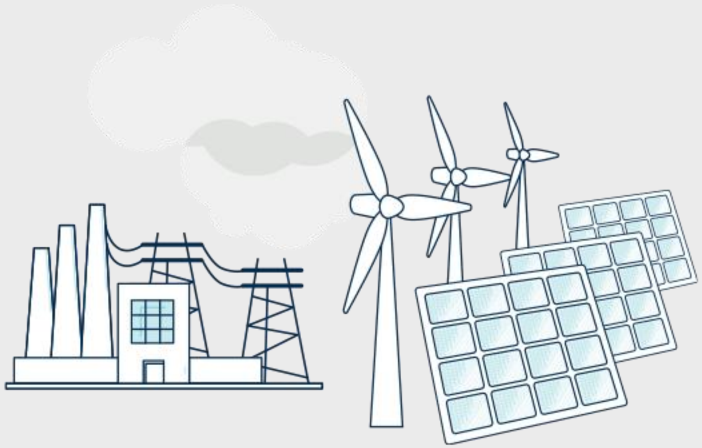
Net Zero Energy



ENERGY
USE INTENSITY

GJ or kWh

Net Zero Carbon



ENERGY
SOURCE EMISSIONS

GJ or kWh x CO_2e

Material Embodied Carbon

$kgCO_2e/m^2$

Definition of Terms

EXTRACTION + TRANSPORTATION + MANUFACTURING

"Cradle to Gate" Emissions

What do you want to understand?

Define your scope

It is critical to be clear about the impact categories that you want to understand.

When comparing studies, be sure to know what impact categories are being examined and the underlying assumptions used for each.

”Material” emissions represent 60-90% of full life cycle emissions

Biogenic Materials + Carbon Sink/Carbon Storage

Definition of Terms

Carbon Drawdown

Removal of atmospheric CO_2 during growth

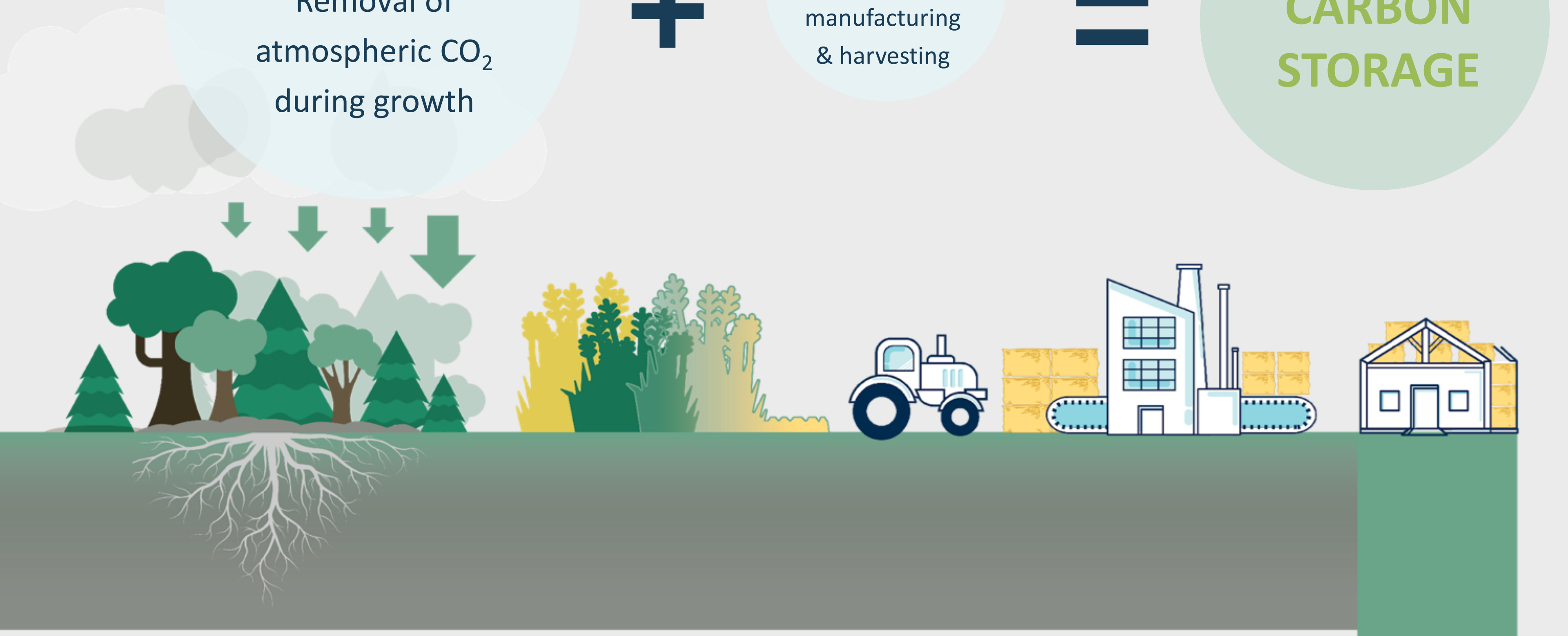
+

Carbon Emissions

Emissions from manufacturing & harvesting

=

NET CARBON STORAGE



During photosynthesis, plants capture gaseous carbon from the atmosphere. That carbon is stored in the plants themselves, as well as in the soil.

Carbon Storing Materials

Many options for carbon storing materials already exist...

Some are already common building materials.

Some have seen limited but successful use.

Others are in the R&D stage.

Material Embodied Carbon Comparison

Single Family Home

- High UEC **Code Compliant**
- Typical UEC **Code Compliant**
- Best Conventional UEC **Code Compliant**
- Best UEC **Code Compliant**

- High UEC **Net Zero Ready**
- Typical UEC **Net Zero Ready**
- Best Conventional UEC **Net Zero Ready**
- Best UEC **Net Zero Ready**

Multi-unit Building

- High UEC **Code Compliant**
- Typical UEC **Code Compliant**
- Best Conventional UEC **Code Compliant**
- Best UEC **Code Compliant**

- High UEC **Net Zero Ready**
- Typical UEC **Net Zero Ready**
- Best Conventional UEC **Net Zero Ready**
- Best UEC **Net Zero Ready**

Total Up-front embodied carbon emissions:
expressed as kilograms of CO_2 equivalent per square meter of floor area ($kgCO_2e/m^2$)

METHODOLOGY

- Eight examples of two types of common low-rise building
- Using Global Warming Potential (GWP) figures from an Environmental Product Declarations (EPDs)
- Over 350 materials modelled
- Four representative examples:
  - **High**
  - **Typical**
  - **Best Conventional**
  - **Best Possible**

Materials emissions

Concentrated on the "materials" emissions from the product stage, A1-A3.

Typically, these represent 60-90% of the total life cycle emissions from building materials.

But this does not mean we should ignore the other impact categories.

es and modules (MND = module not declared; MNR = module not relevant)

Product			Construction process		Use							End of life				Beyond the system boundary
Raw material supply	Transport	Manufacturing	Transport	Installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Re-use, recovery and recycling potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	MNR	MNR	MNR	MNR	MNR	MNR	MNR	MNR	X	X	X	X

Reading EPDs

Life Cycle Assessment – Product

Impact category	Unit	Total	Raw materials	Manufacturing	Transport	Installation, maintenance	End of life
Ozone depletion	kg CFC-11 eq	6.71E-04	6.71E-04	0	0	0	0
Global warming	kg CO2 eq	9.53E+01	9.03E+00	2.54E+01	1.90E-01	2.72E+01	3.33E+01
Smog	kg O3 eq	1.98E-01	3.38E-01	2.30E-02	3.50E-02	0	2.00E-03
Acidification	mol H+ eq	9.98E-01	7.48E-01	1.72E-01	6.50E-02	0	3.00E-03
Eutrophication	kg N eq	2.72E-03	1.85E-03	6.70E-04	1.10E-04	0	7.00E-05
Water use	kg	5.45E+00	1.45E+00	4.00E+00	0	0	0
Non-hazardous waste	kg	7.99E-01	1.60E-02	6.00E-03	0	0	7.77E-01
Hazardous waste	kg	2.70E-03	2.70E-03	0	0	0	0
Waste to energy	kg	7.80E-05	0	7.80E-05	0	0	0
Primary Energy	MJ	8.88E+01	7.48E+01	1.06E+01	3.20E+00	0	2.20E-01

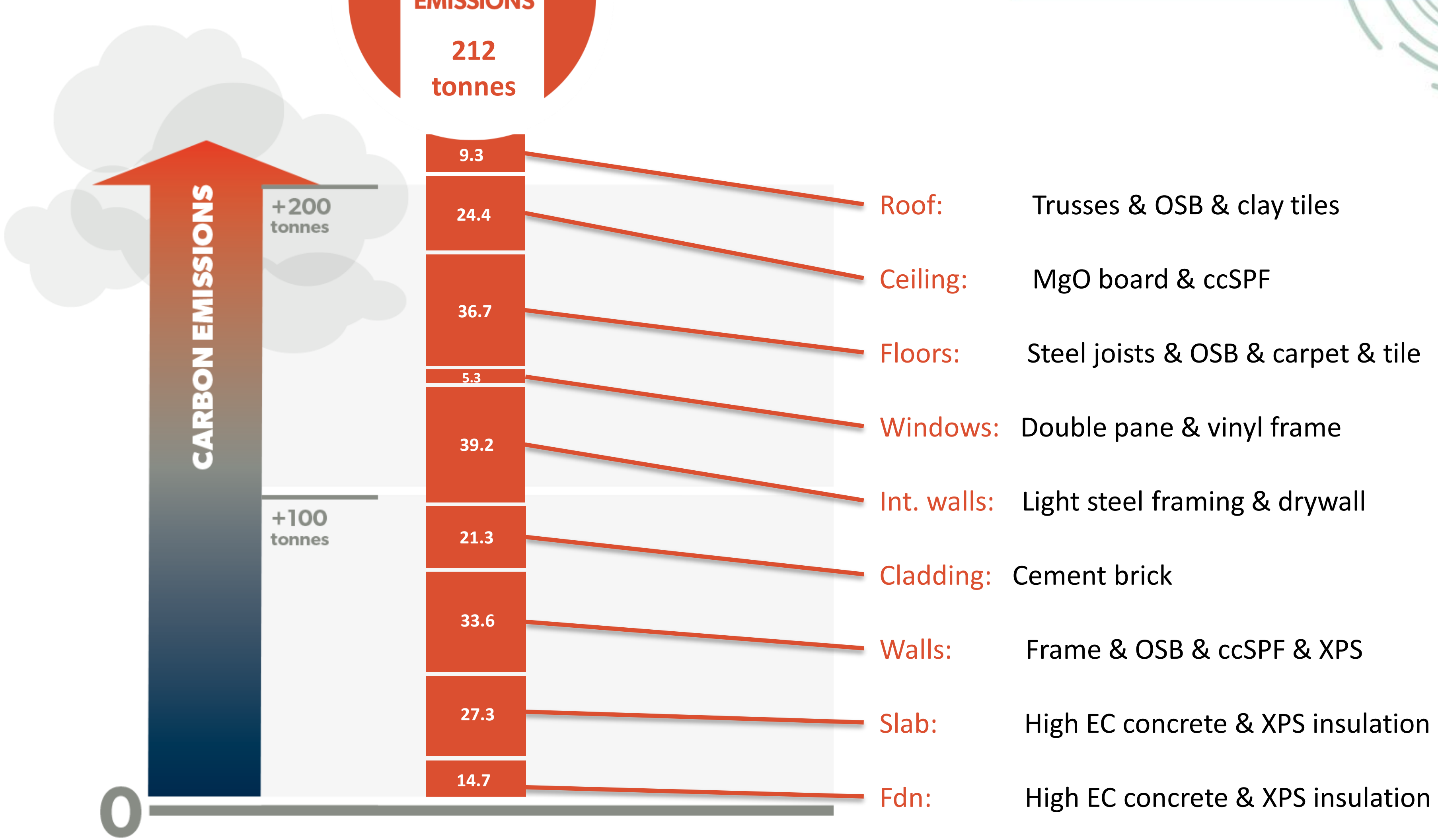
XPS = 120.7 kgCO2e

Mineral wool = 1.335 kgCO2e

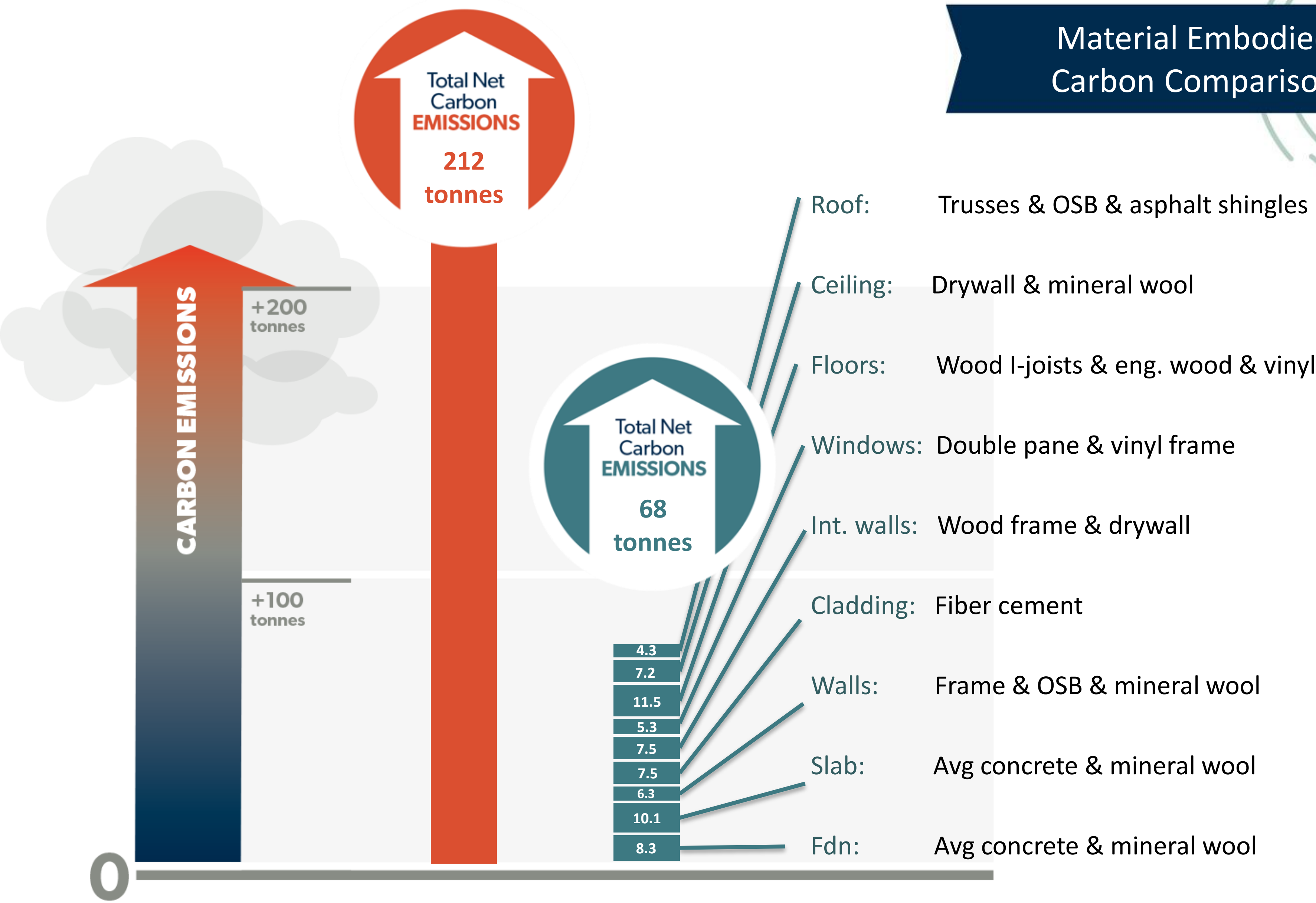
Table 4: Life cycle impact category results per functional unit (TRACI 2.0)

Impact Category	Units	Raw Materials	Production	Transport	Installation	End-of-Life	Total
Global Warming	kg CO_2 eq	6.47E-02	1.27E+00	3.34E-02	1.44E-02	4.03E-02	**1.42E+00**
Acidification	kg mol H^+ eq	2.21E-02	6.97E-01	2.33E-03	4.72E-03	5.92E-03	**7.32E-01**
Eutrophication	kg N eq	1.89E-05	9.93E-05	1.58E-06	1.53E-06	5.03E-06	**1.26E-04**
Smog Creation	kg O_3 eq	9.65E-03	5.20E-02	7.26E-04	6.51E-04	2.27E-03	**6.53E-02**
Ozone Depletion	kg CFC-11 eq	1.02E-09	1.47E-08	7.66E-11	9.67E-10	1.45E-10	**1.69E-08**
Waste to Landfill	kg	1.04E-05	3.65E-01	–	–	1.11E+00	**1.47E+00**
Metered Water	L	–	4.52E-01	–	–	–	**4.52E-01**
Primary Energy	MJ	1.00E+00	1.17E+01	4.74E-01	2.25E-01	4.46E-01	**1.39E+01**

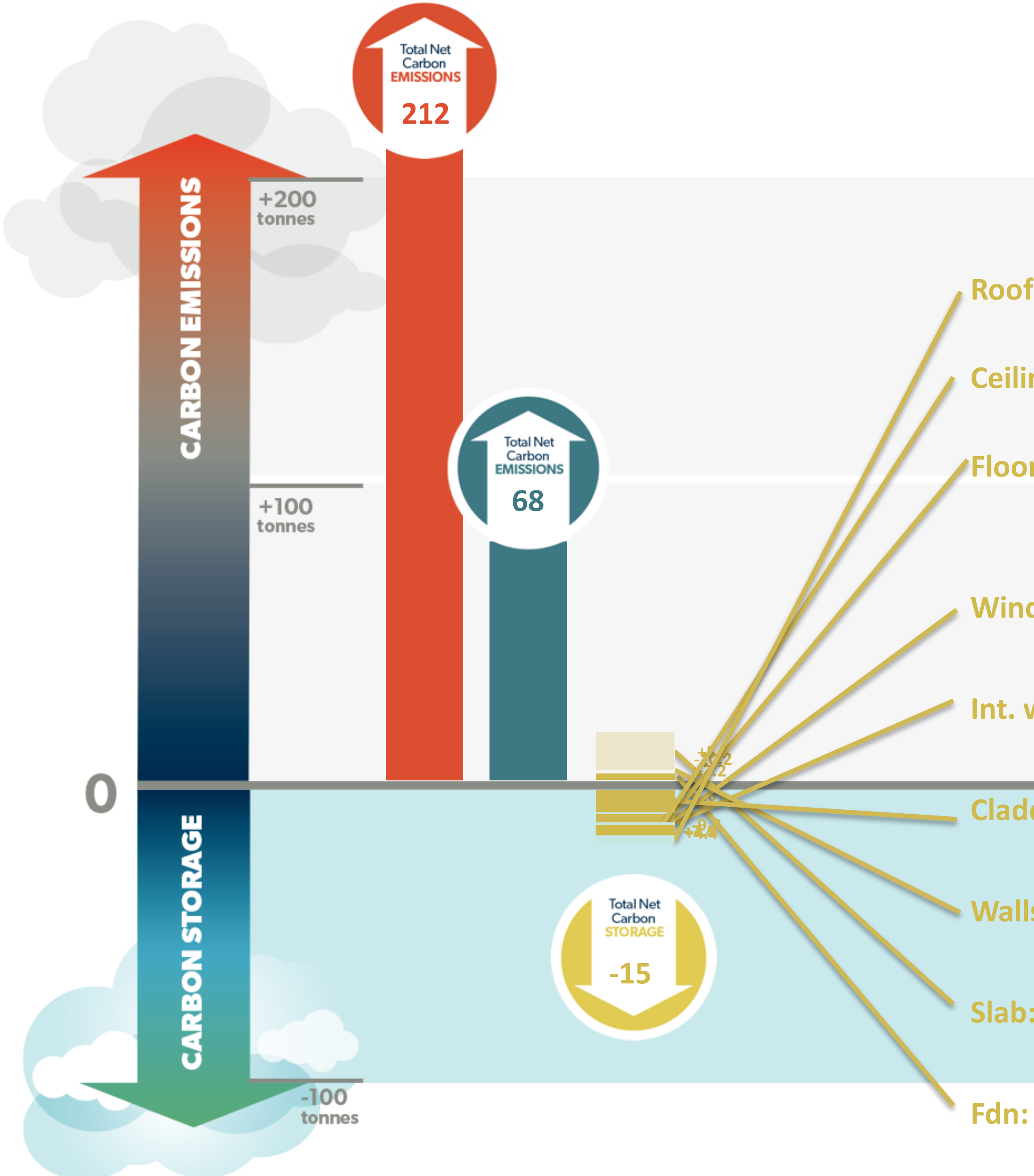
Material Embodied Carbon Comparison



Material Embodied Carbon Comparison



Material Embodied Carbon Comparison



Roof: Trusses + plywood+ steel

Ceiling: Drywall + FSC wood + cellulose

Floors: 2x12 + plywood + FSC hardwood + engineered wood

Windows: Double pane + alum. clad wood

Int. walls: Framing + drywall + FSC wood

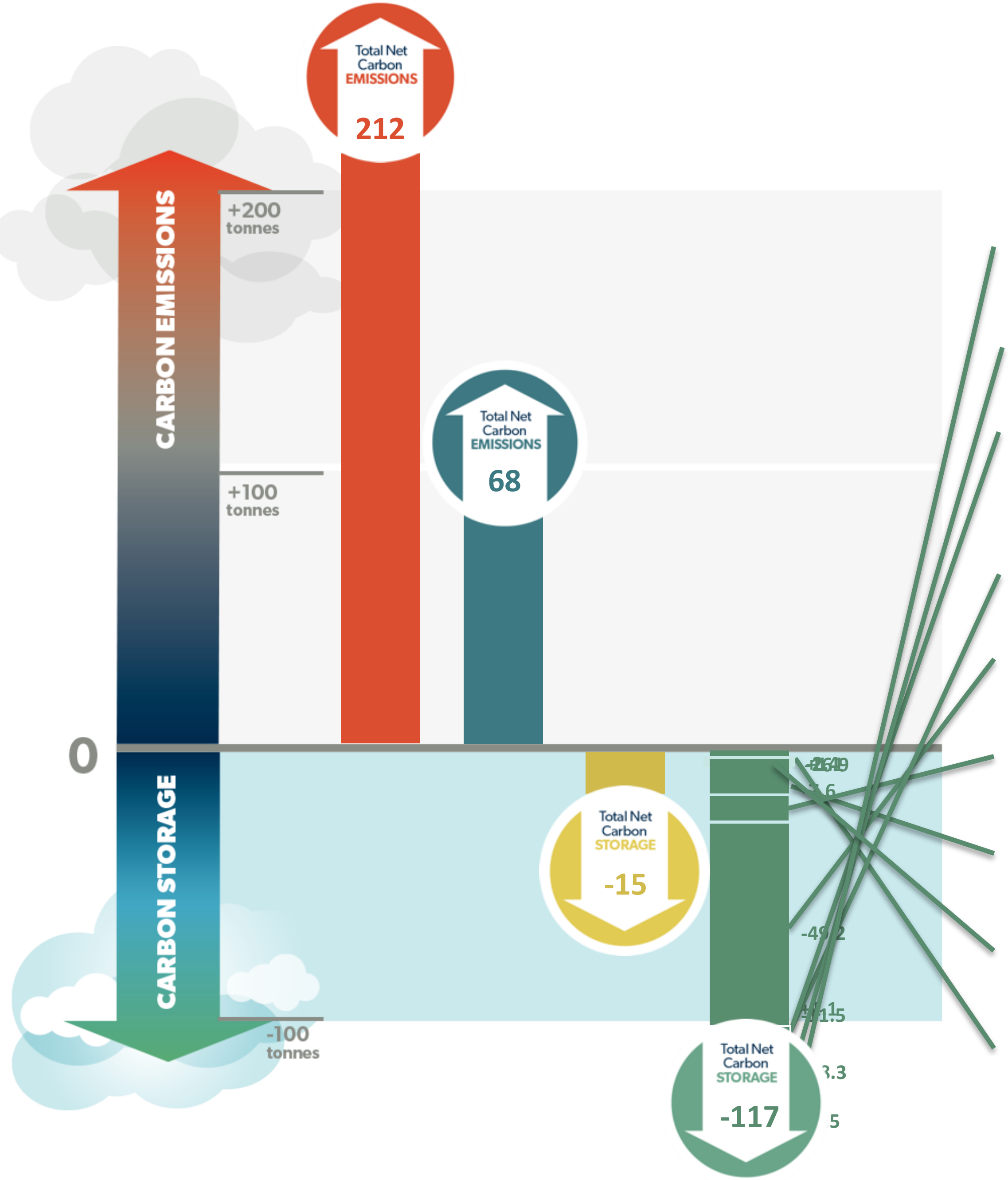
Cladding: FSC softwood

Walls: Frame + cellulose + wood fiberboard

Slab: High SCM concrete + EPS

Fdn: High SCM concrete + EPS

Material embodied carbon comparison



Roof: Trusses + FSC cedar shake

Ceiling: Straw insulation + ReWall

Floors: 2x12 + FSC plank + linoleum + FSC softwood

Windows: Double pane + wood frame

Int. walls: Compressed straw panels + ReWall

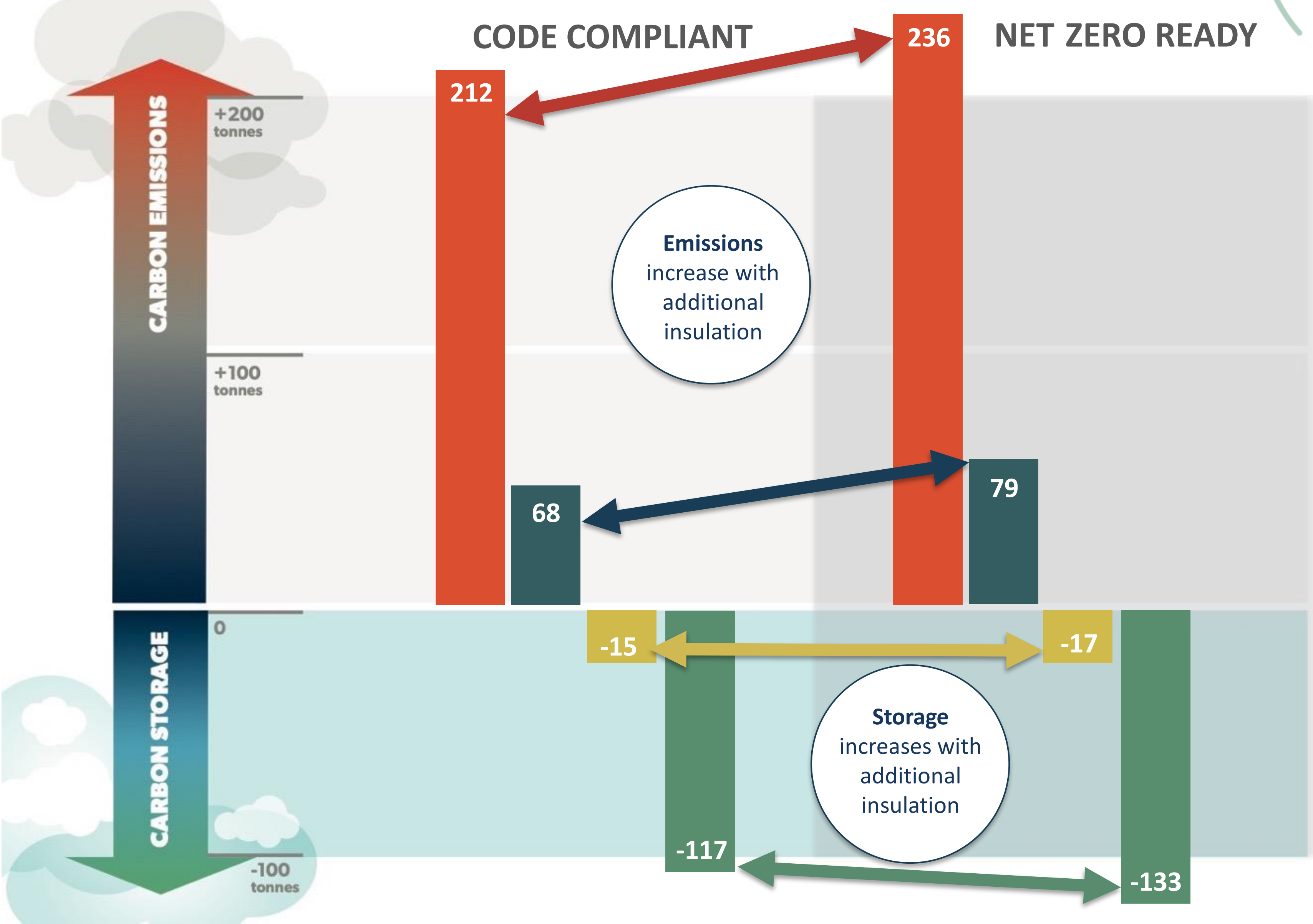
Cladding: FSC softwood

Walls: Double stud + straw + fiberboard

Slab: Adobe + expanded glass aggregate

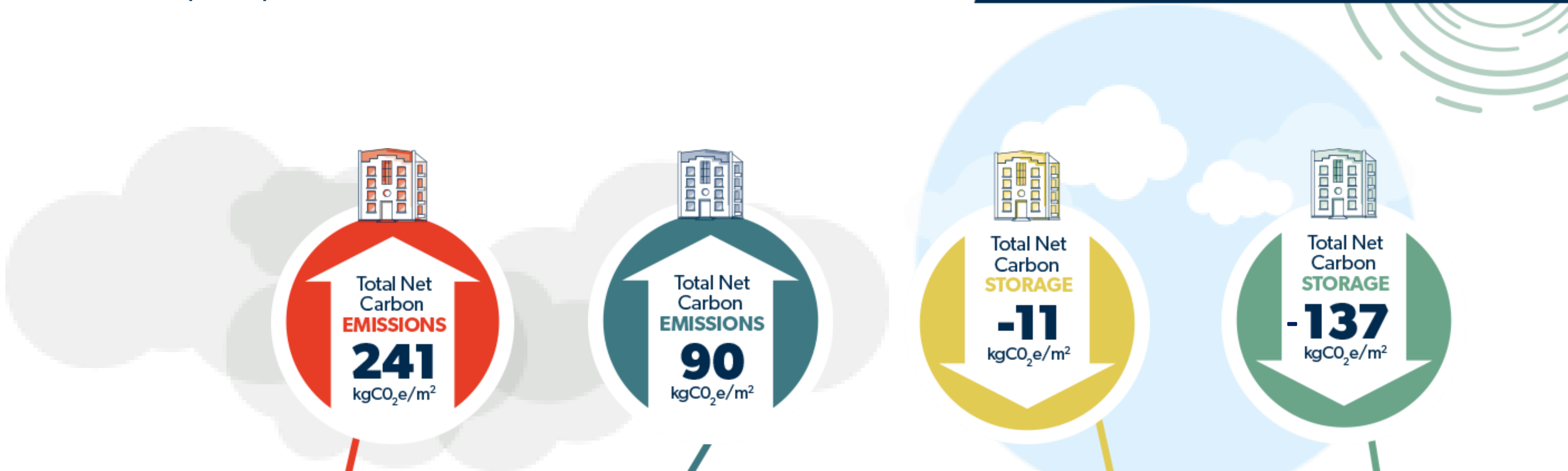
Fdn: Iso-span ICF with fiberboard

Material embodied carbon comparison



The same building can have very different up-front embodied carbon emissions (UEC)

Materials Matter



High UEC

Assembly includes:

- High carbon concrete
- XPS & closed cell spray foam
- Brick cladding
- Steel interior framing
- Drywall
- Vinyl windows
- Tile & carpet flooring
- Clay tile roofing

Typical UEC

Assembly includes:

- Average carbon concrete
- Mineral wool insulation
- Fiber cement cladding
- Wood & TJI interior framing
- Drywall
- Vinyl windows
- Engineered wood & vinyl flooring
- Asphalt shingle roofing

Best Conventional UEC

Assembly includes:

- High SCM concrete
- Cellulose & wood fiberboard insulation
- Wood cladding
- Wood interior framing
- Drywall & wood walls
- Aluminum clad wood windows
- Engineered wood & FSC hardwood flooring

Best UEC

Assembly includes:

- Iso-Span ICF with high SCM concrete
- Expanded glass sub-grade insulation
- Straw & wood fiberboard insulation
- Wood cladding
- Compressed straw panel interior walls
- ReWall interior cladding
- Wood windows
- Linoleum & FSC softwood flooring
- Cedar shake roofing

What This Means at Scale

Total 2017 U.S. low-rise construction:

241 MILLION M2

Business-as-usual will result in massive annual up-front emissions from materials.

Carbon-storing buildings can eliminate all material emissions and can result in meaningful carbon drawdown.

Yes, we need to learn to build with

2.16 billion tonnes

of grain straw annually =

8 billion tonnes of CO_2 drawdown =

All transportation GHG emissions!

Can replace all insulation materials

and still leave 20% to return to soils.

Products are already being made.

BIOGENIC MATERIALS!

Stacked benefits of biogenic materials

Occupant health & safety

No RED LIST chemicals
No toxic manufacturing

Local sourcing

Agricultural by-products
Forestry residues
Municipal recycling resources

Regional manufacturing

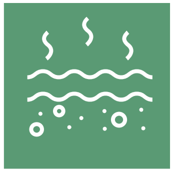
Small-medium sized facilities
Local jobs

Reduced waste

No RED LIST chemicals
Biodegradable

Global warming potential

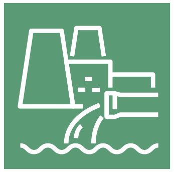
Ozone depletion



Eutrophication

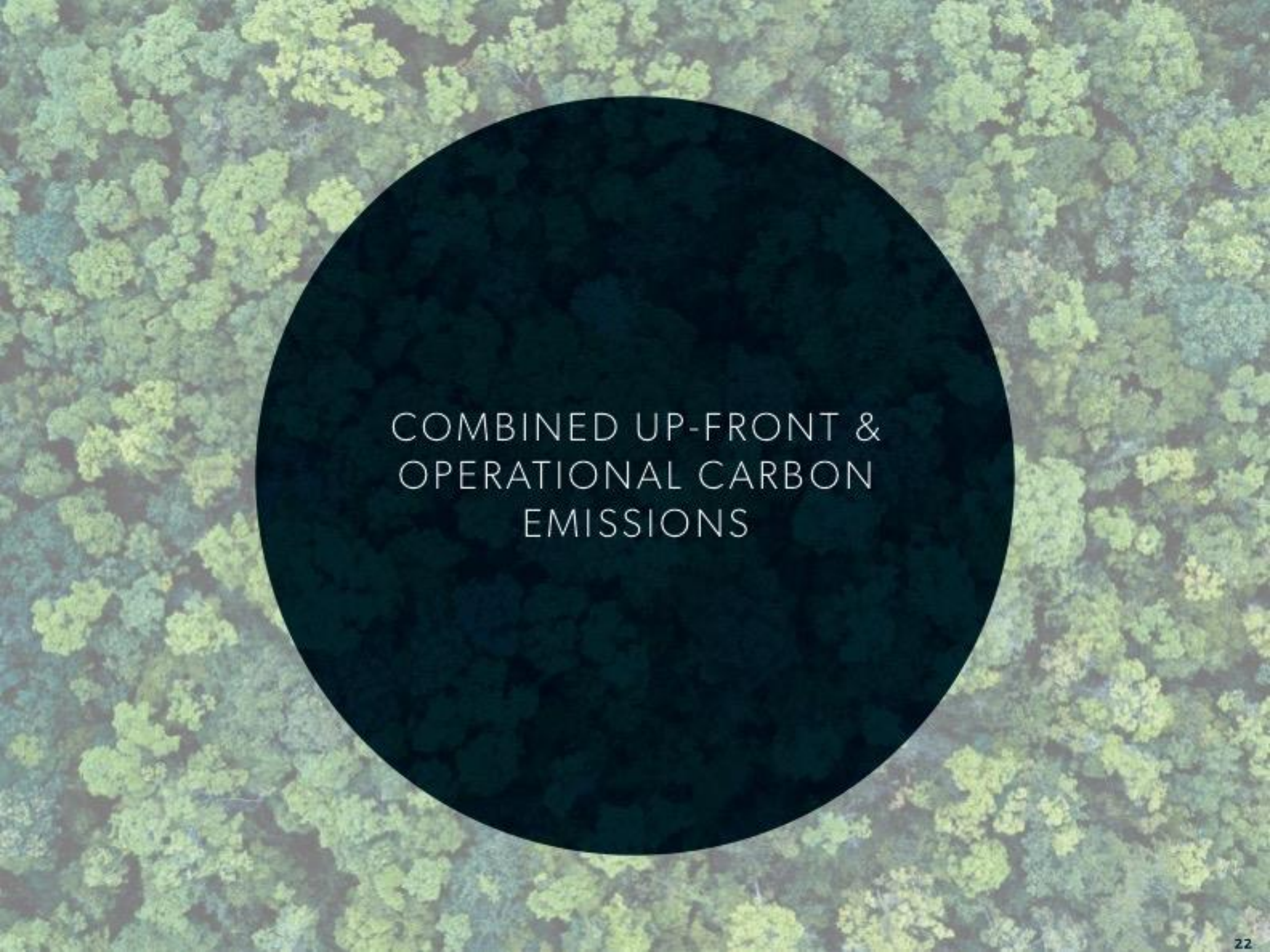
Acidification

Photochemical ozone creation



Depletion of abiotic resources

Depletion of fossil fuels



COMBINED UP-FRONT & OPERATIONAL CARBON EMISSIONS

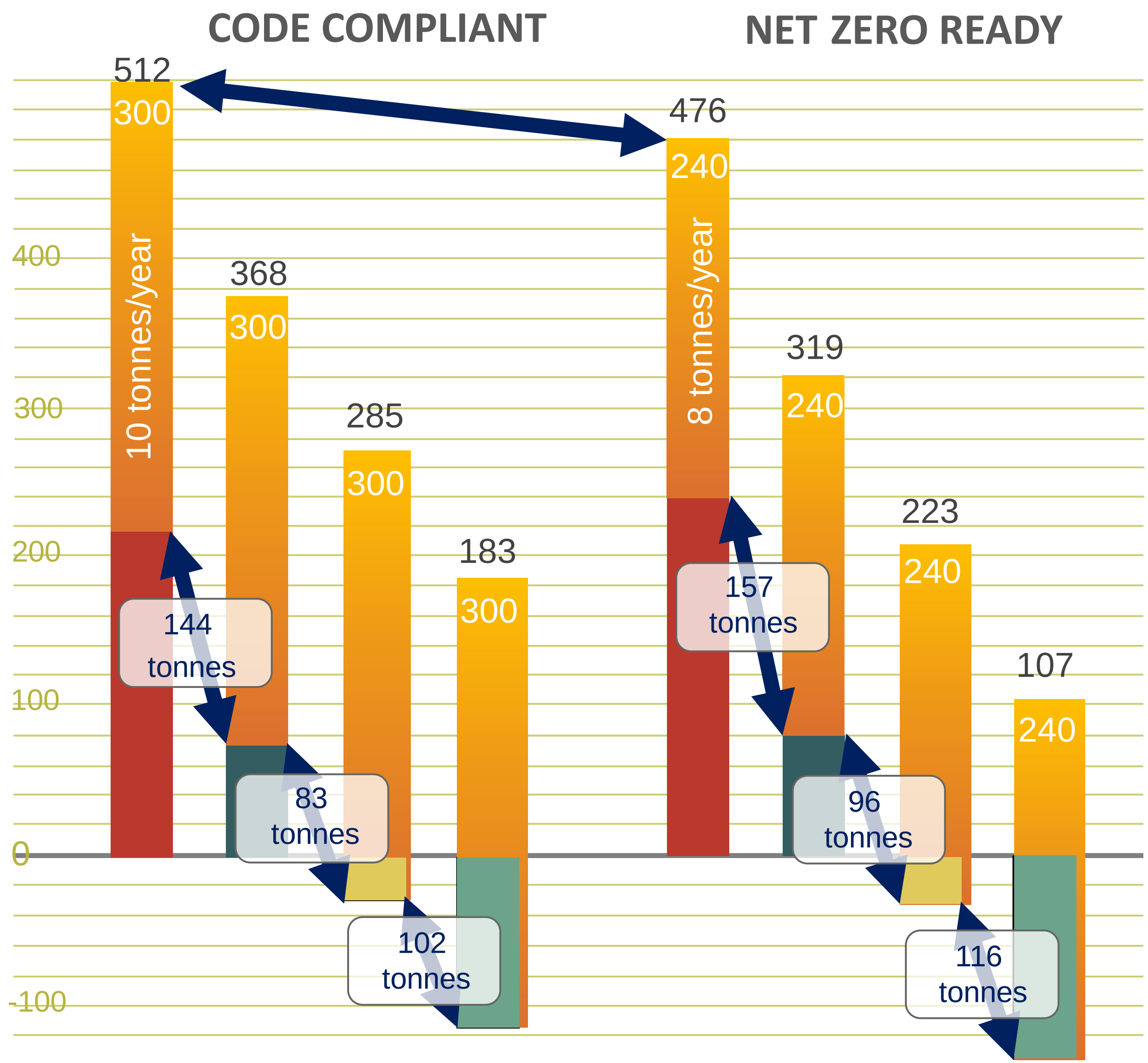
Natural gas heating,

Toronto, 2020-2050

Operational carbon comparison

60 tonne reduction over 30 years

Minimum **83 tonne** reduction immediately

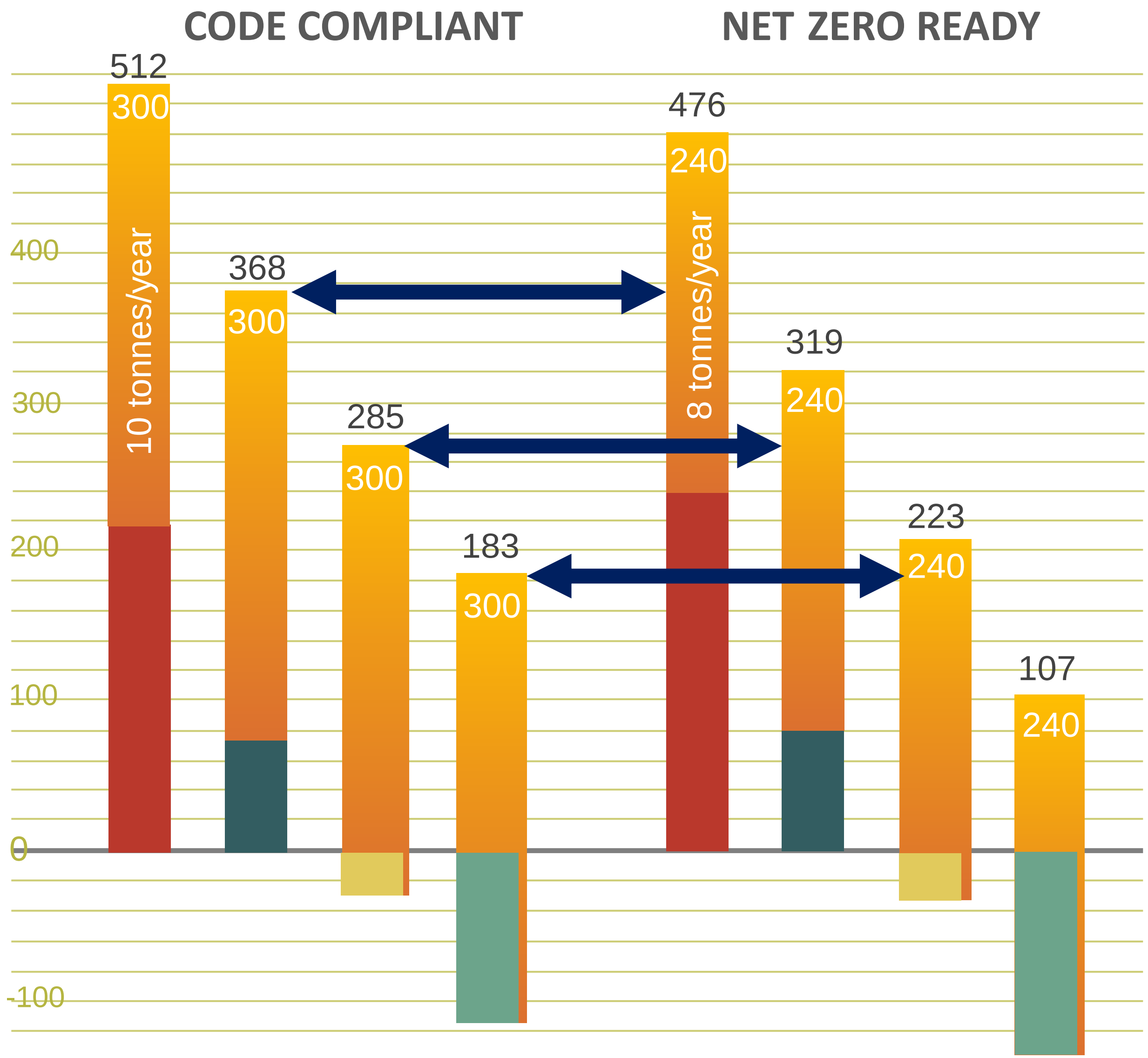


Natural gas heating,

Toronto, 2020-2050

Operational carbon comparison

Better to be code minimum than use High EC materials

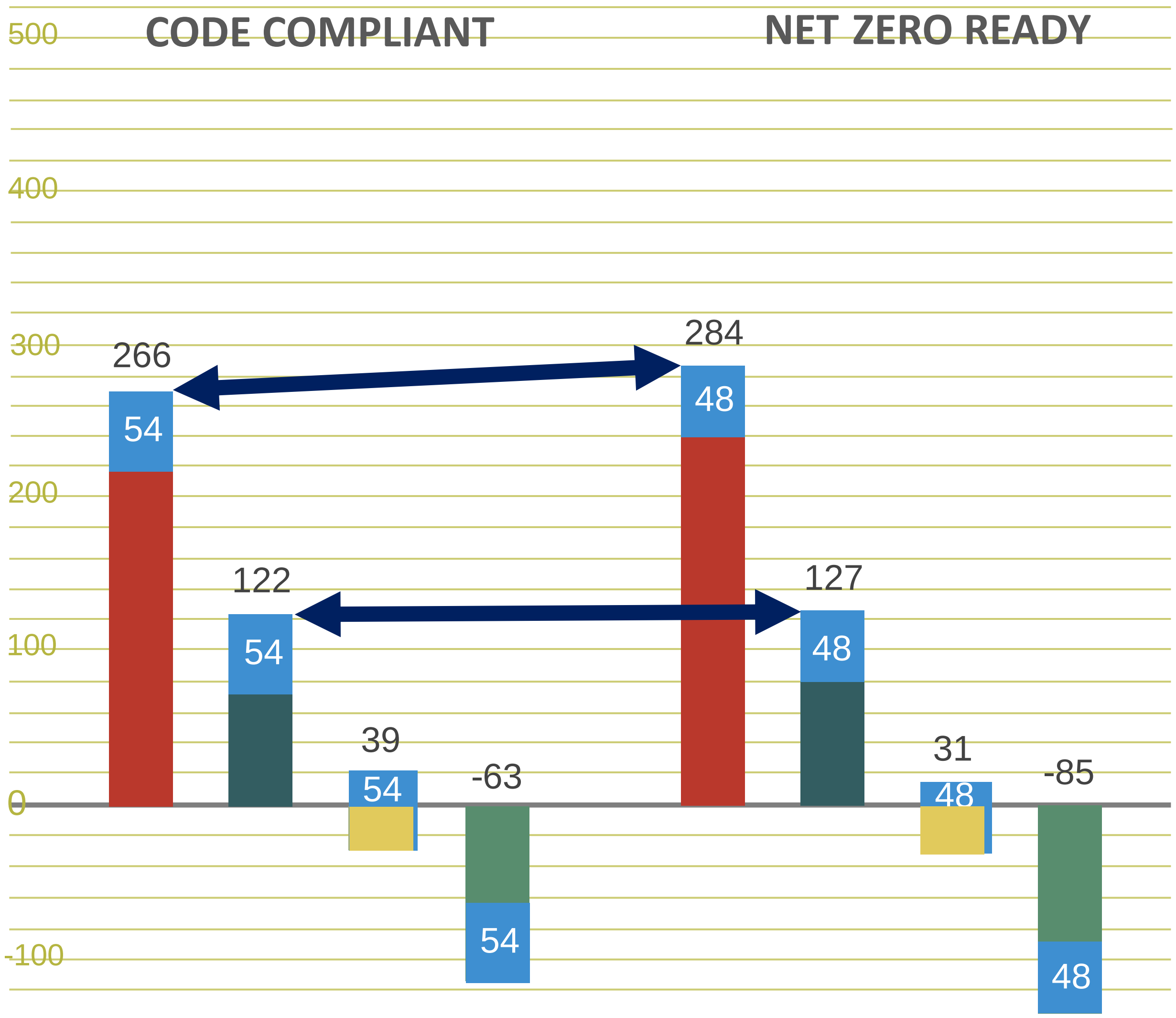


Air source heat pump,

Toronto, 2020-2050

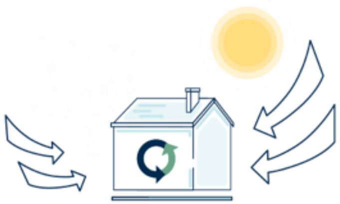
Operational carbon comparison

Code minimum outperforms "net zero"



New way to DEFINE
BUILDING PERFORMANCE

Operational Carbon Emissions



ENERGY
USE INTENSITY

×

ENERGY SOURCE
EMISSIONS

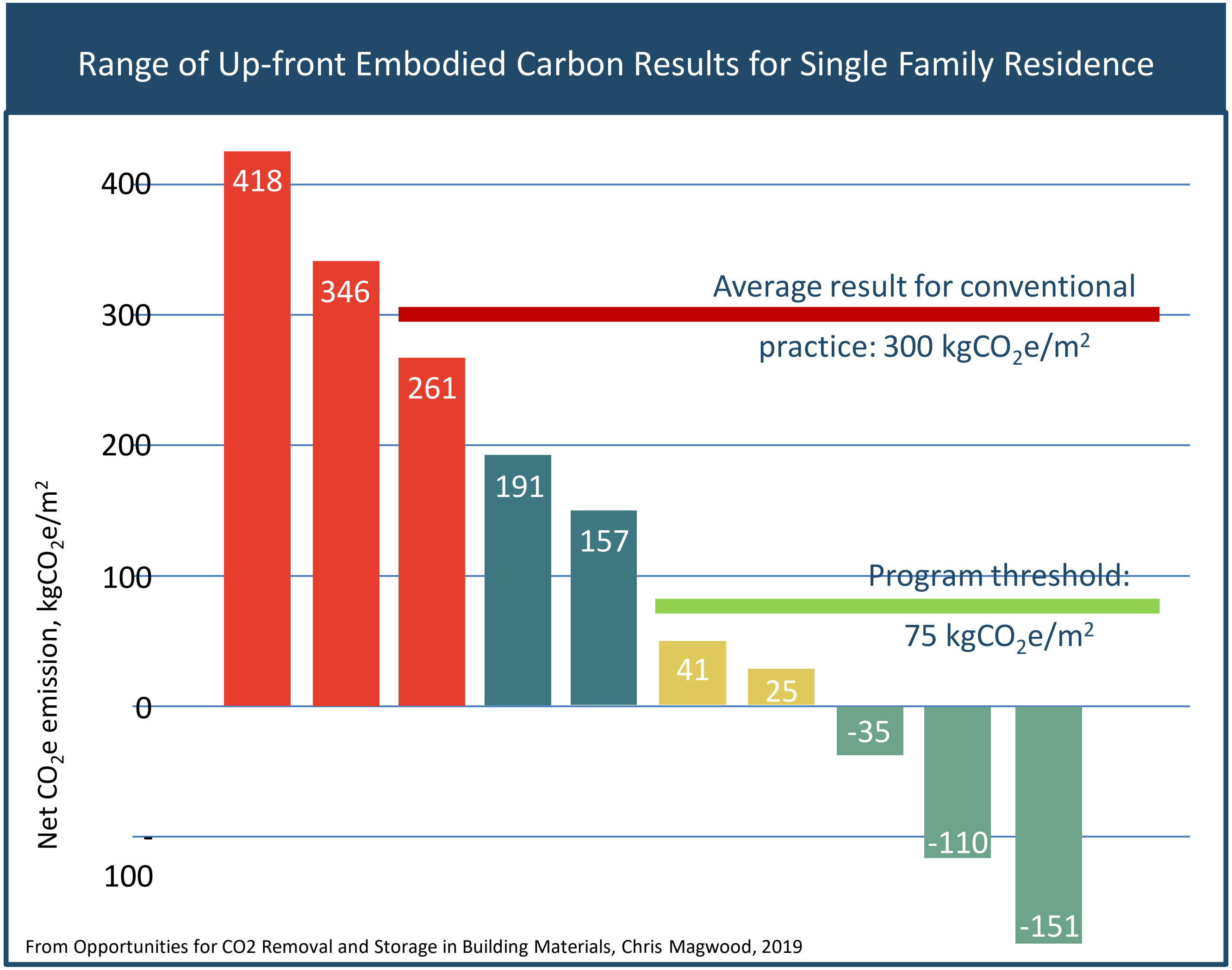
+

Up-Front Embodied Carbon Emissions

=

CARBON USE INTENSITY

Builders for Climate Action and Douro-Dummer Township incentive program.

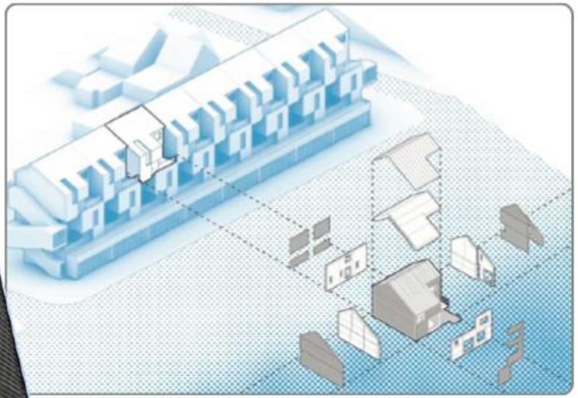


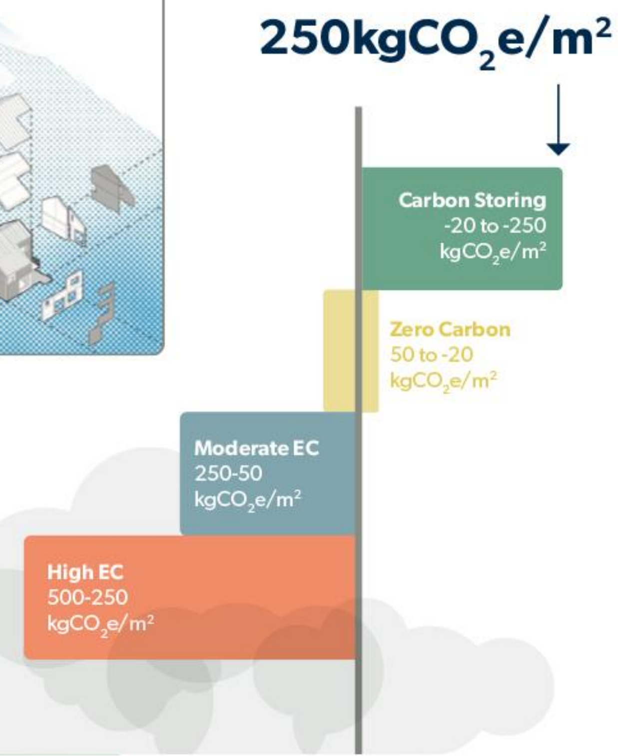
$10,000 rebate to reduce 225kg/m^2 or 50 tonnes per 2,000 square foot house!

Zero House
Prefab, modular, net zero design

Design: Ryerson University & Endeavour Centre
100m² single unit two-bedroom
Designed to be one unit in a 16-unit development

25 tonnes net carbon storage in a single unit
400 tonnes storage potential in 16-unit development

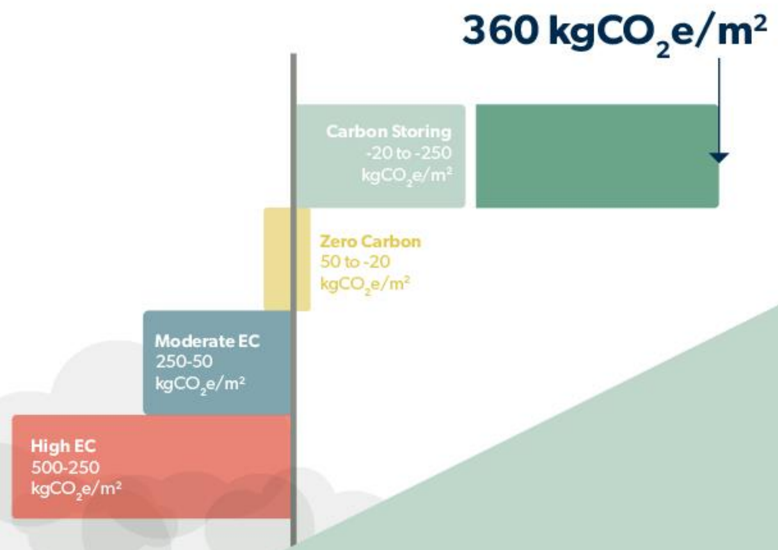




Offices & Meeting Hall
Urban infill, net-positive design

Design: Endeavour Centre
225m^2 three offices, large meeting room, staff room

81 tonnes net carbon storage



Energy: 105% on site generation of solar electricity
0.6 ACH/50 air tightness

There is a straightforward path to achieve real zero carbon buildings

There are reasonable policy tools to achieve set targets

We just need the will to do this

New Frameworks

www.newframeworks.com

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THE SUSTAINABLE BUILDING SCHOOL

www.buildersforclimateaction.org

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