



# Embodied carbon, biogenic carbon, reduction strategies and policy

## AIA COTE

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# Agenda

## **Embodied carbon basics**

Biogenic carbon

Embodied carbon reduction strategies

Carbon Leadership Forum (CLF) policy efforts



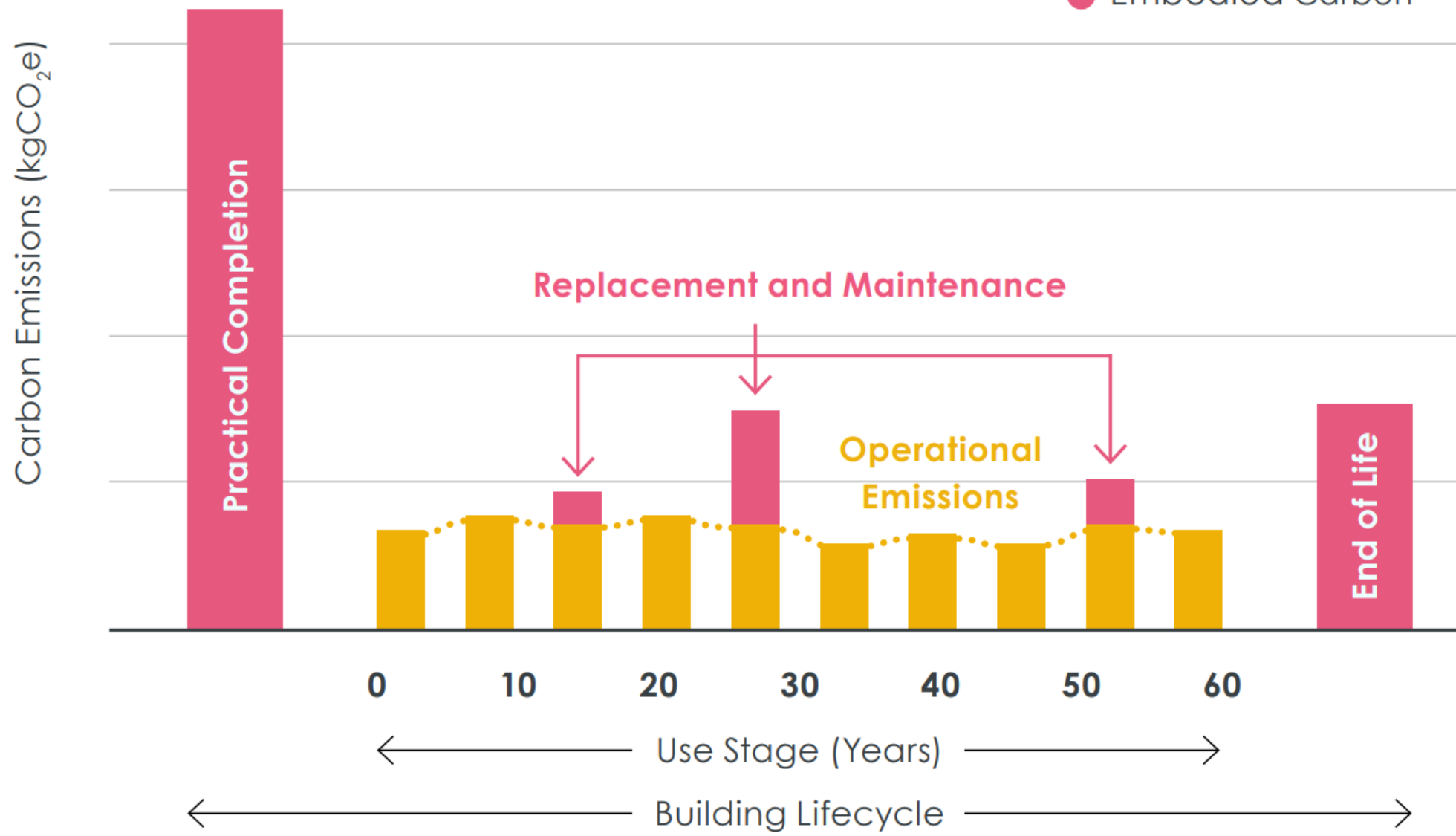
‘Upfront’ Embodied Carbon  
Manufacture, transport and  
installation of construction materials

Operational Carbon  
Building energy consumption

Source: SKANSKA

Source: LETI Embodied Carbon Primer (Jan 2020 edition)

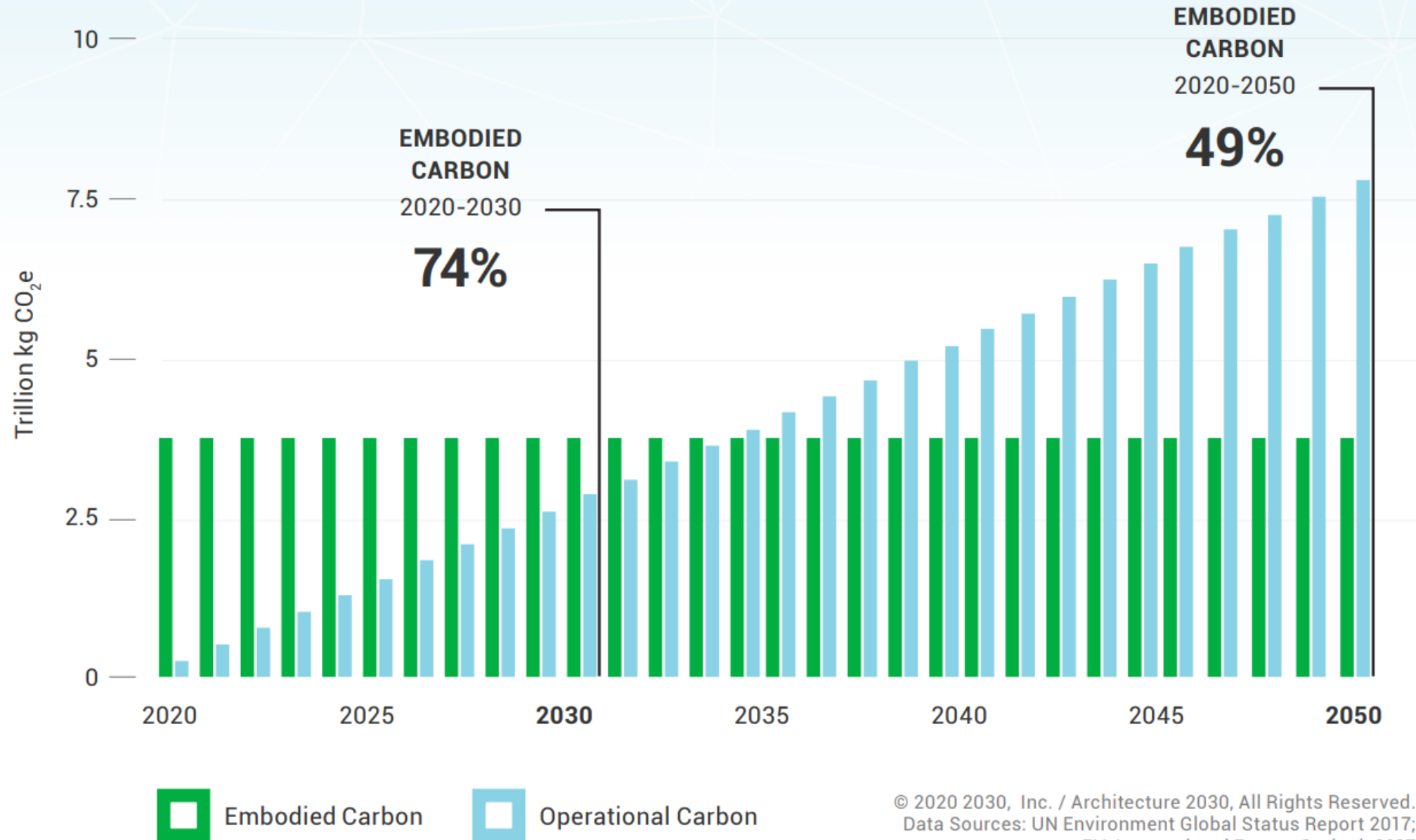
● Operational Carbon  
● Embodied Carbon



**Figure A.9.3** – Graph showing interaction between operation and embodied carbon throughout the lifetime of a building

# Total carbon emissions of global new construction from 2020-2050

Business as usual projection



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Data Sources: UN Environment Global Status Report 2017;  
EIA International Energy Outlook 2017

# Environmental Impact Categories

Global Warming Potential (kg CO<sub>2</sub> eq)



Non-renewable Energy Demand (MJ)



Eutrophication Potential (kg N eq)



Acidification Potential (kg SO<sub>2</sub> eq)



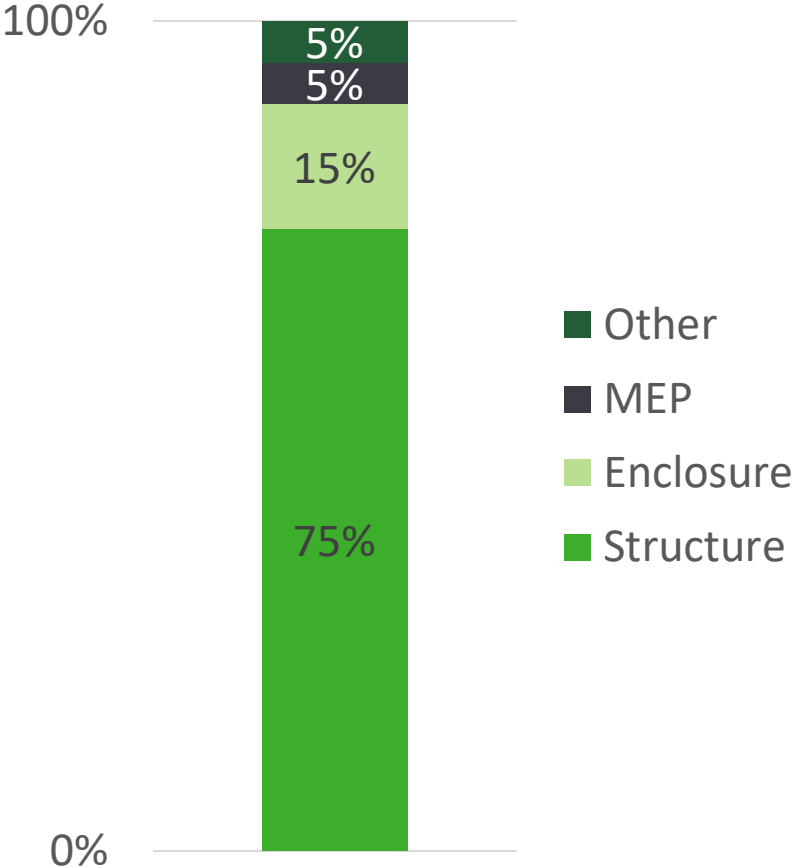
Smog Formation Potential (kg O<sub>3</sub> eq)



Ozone Depletion Potential (kg CFC-11 eq)



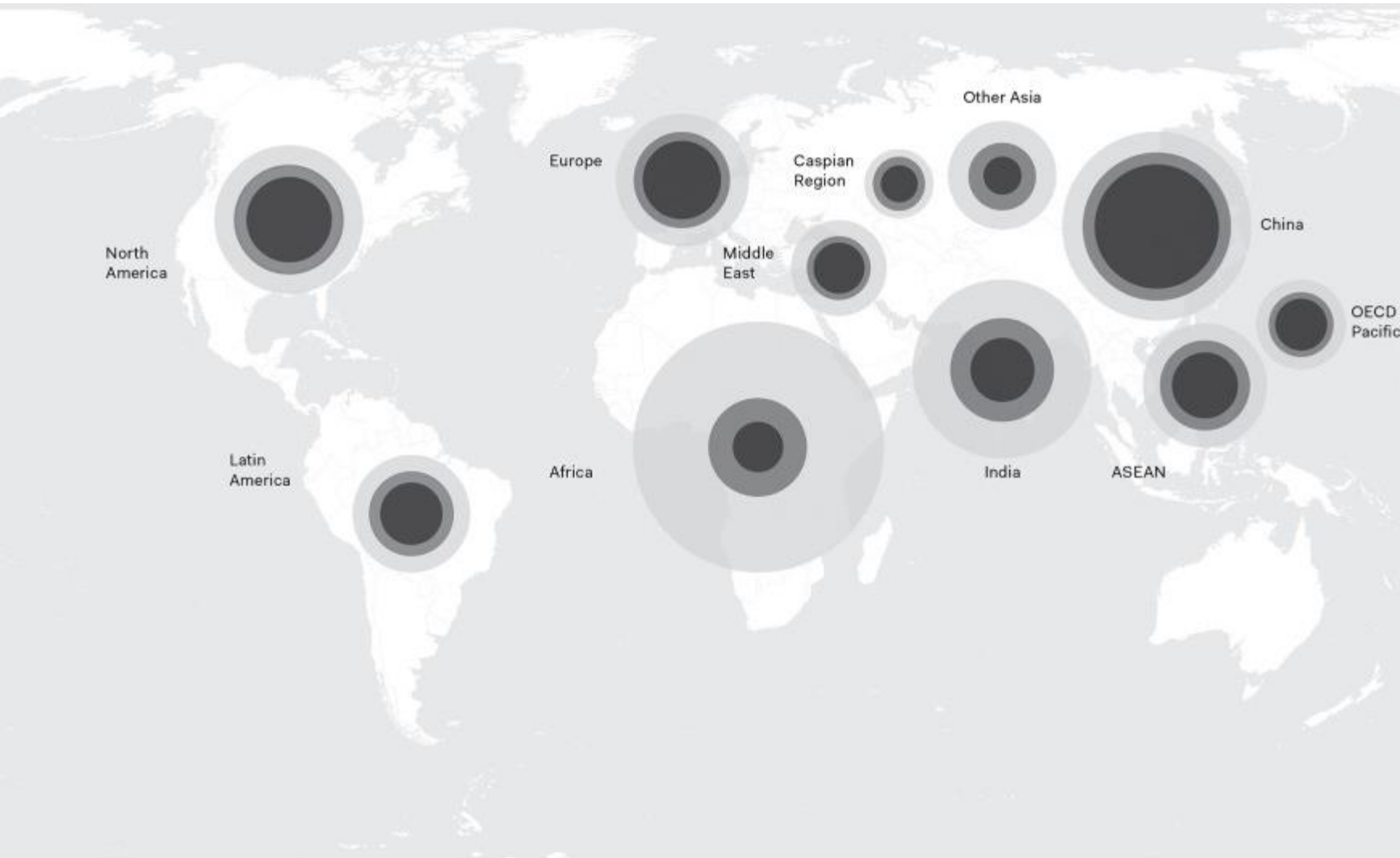
# Embodied impacts for commercial construction



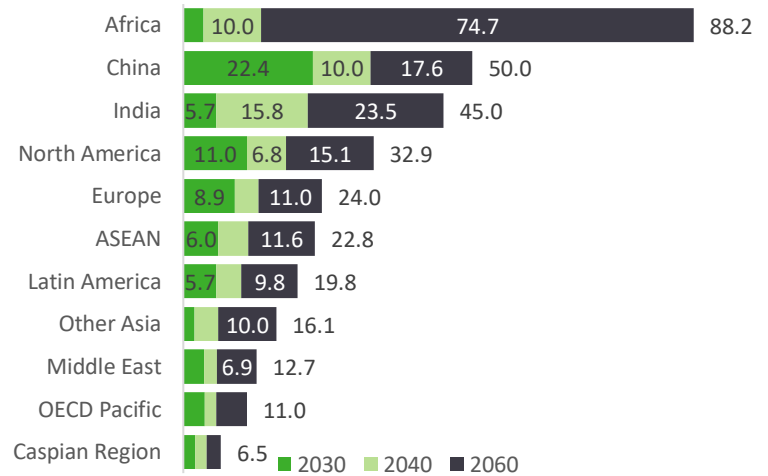
Most emissions are from the structure

Structure is mostly concrete and/or steel

Concrete impact is mostly from cement.  
Cement ≠ Concrete



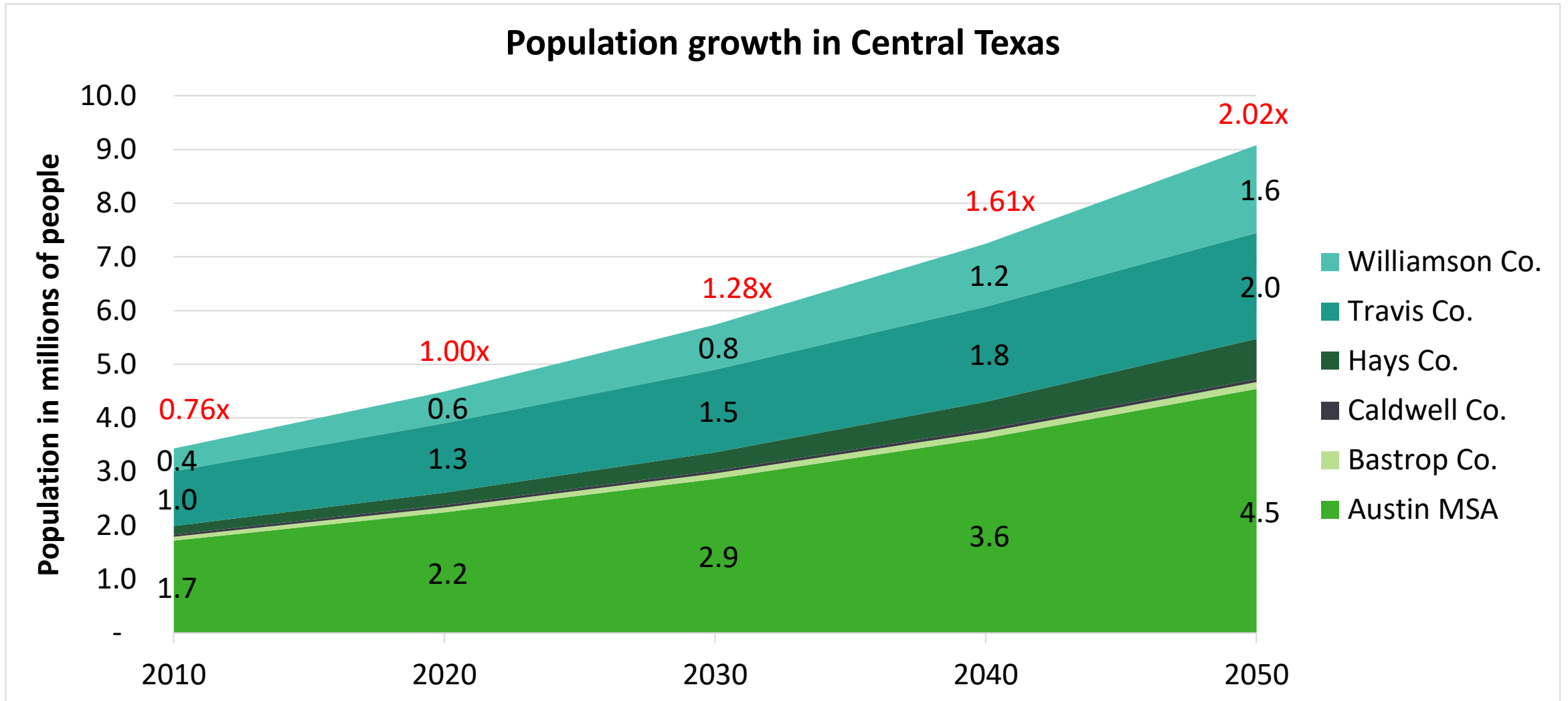
Building floor additions from 2020  
(billions m<sup>2</sup>)



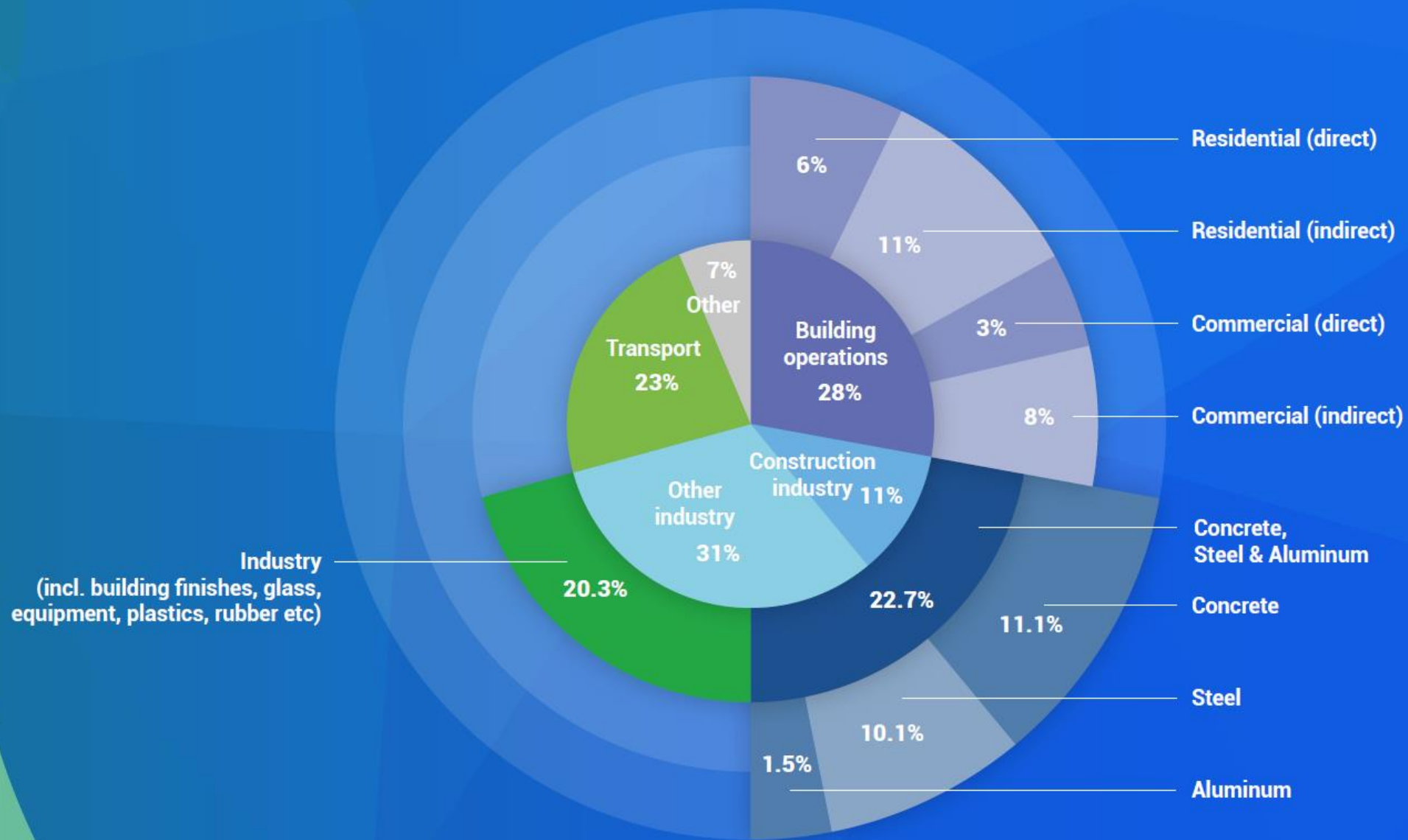
Source: Architecture 2030: Global ABC, Global Status Report 2017  
(areas are approximate)



## Population growth in Central Texas



Source: Texas State Data Center, 2018 Population Projections



# Big Neglected Solvable

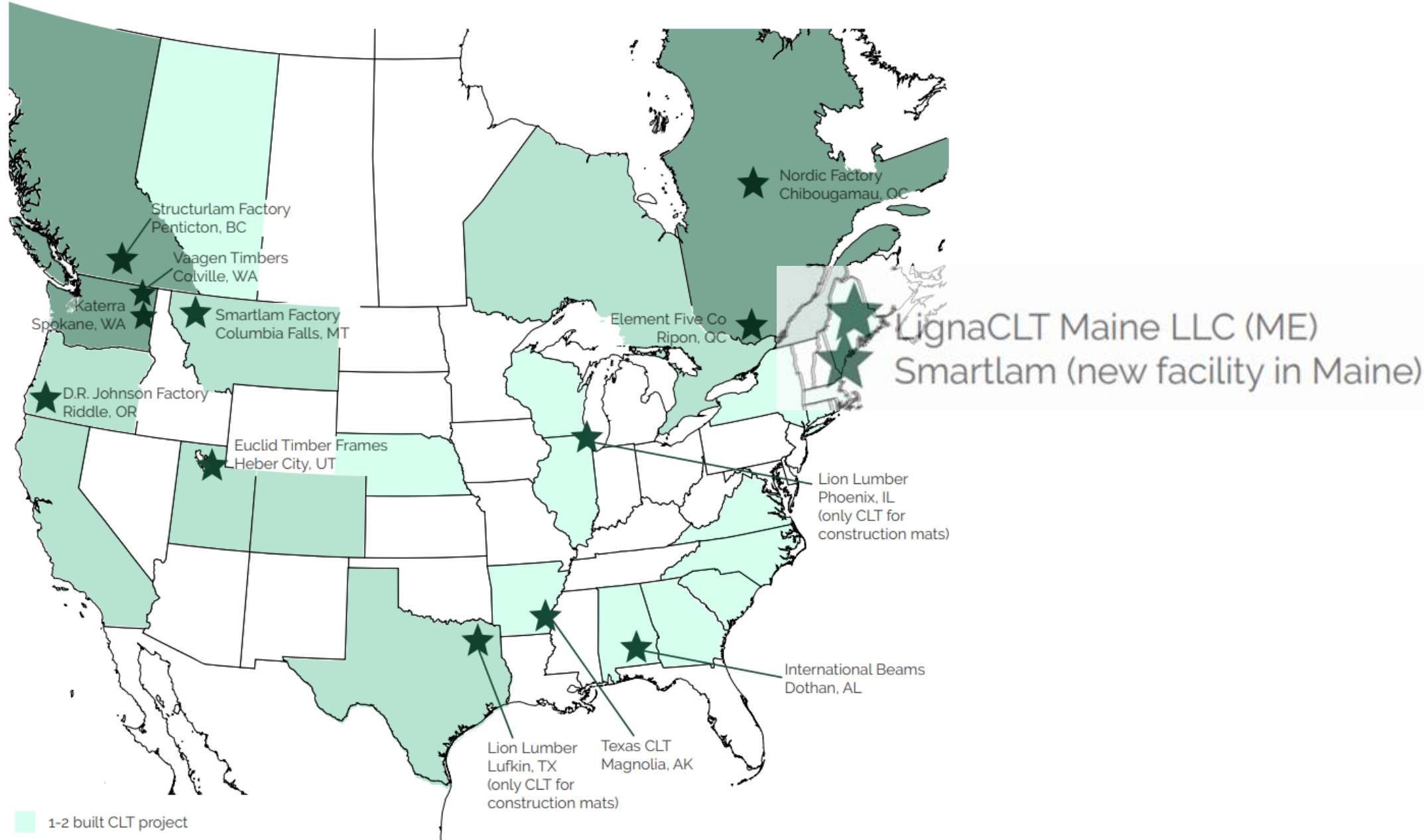
# Agenda

Embodied carbon basics

**Biogenic carbon**

Embodied carbon reduction strategies

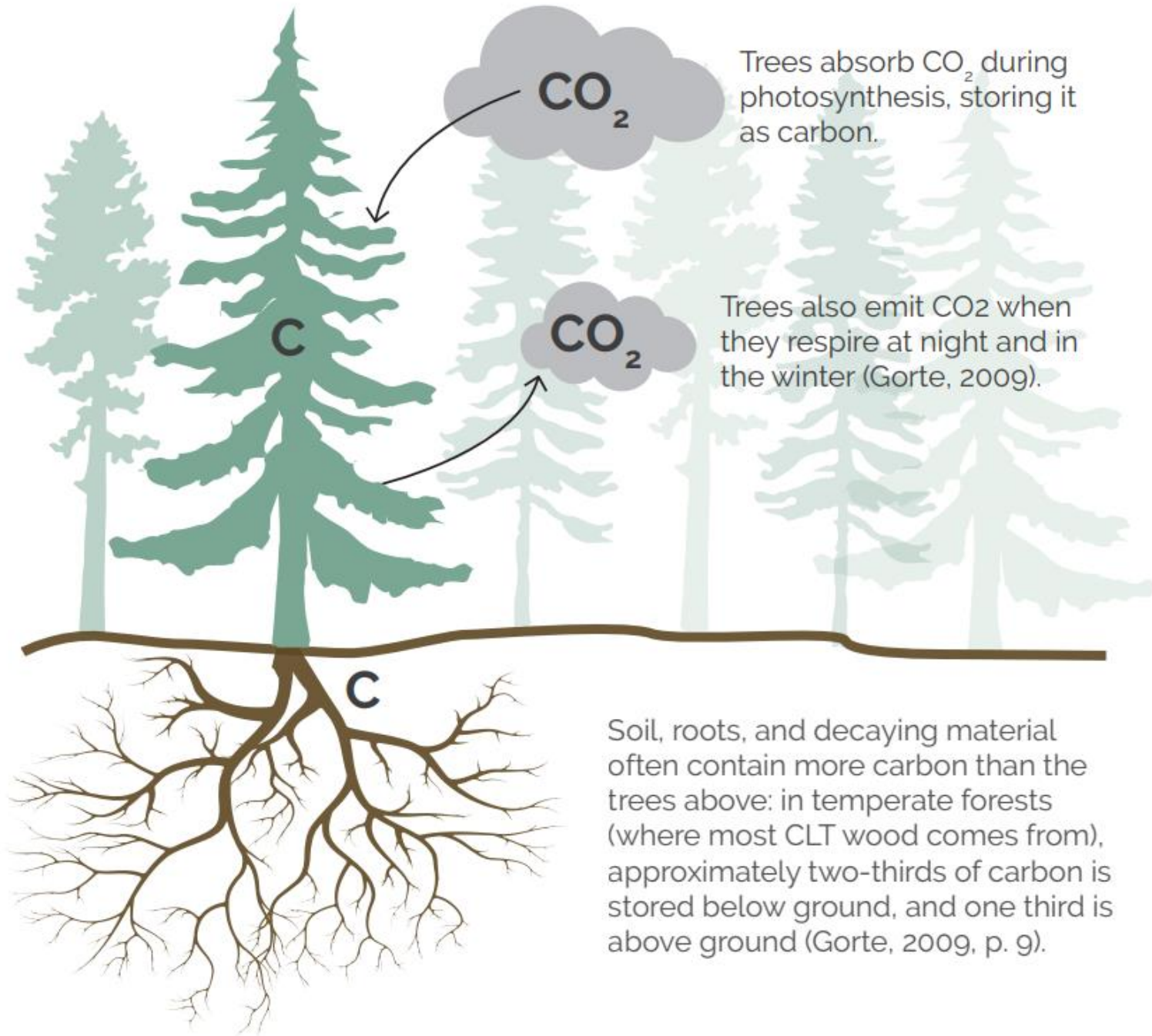
Carbon Leadership Forum (CLF) policy efforts



- 1-2 built CLT project
- 3-10 built CLT projects
- 10-20 built CLT projects
- CLT manufacturing locations

### Distribution of CLT Projects (built) & Manufacturers

\*Note: map is not exhaustive and does not include unpublished or uncompleted projects  
 \*sources for CLT project information include manufacturer, industry, and news websites



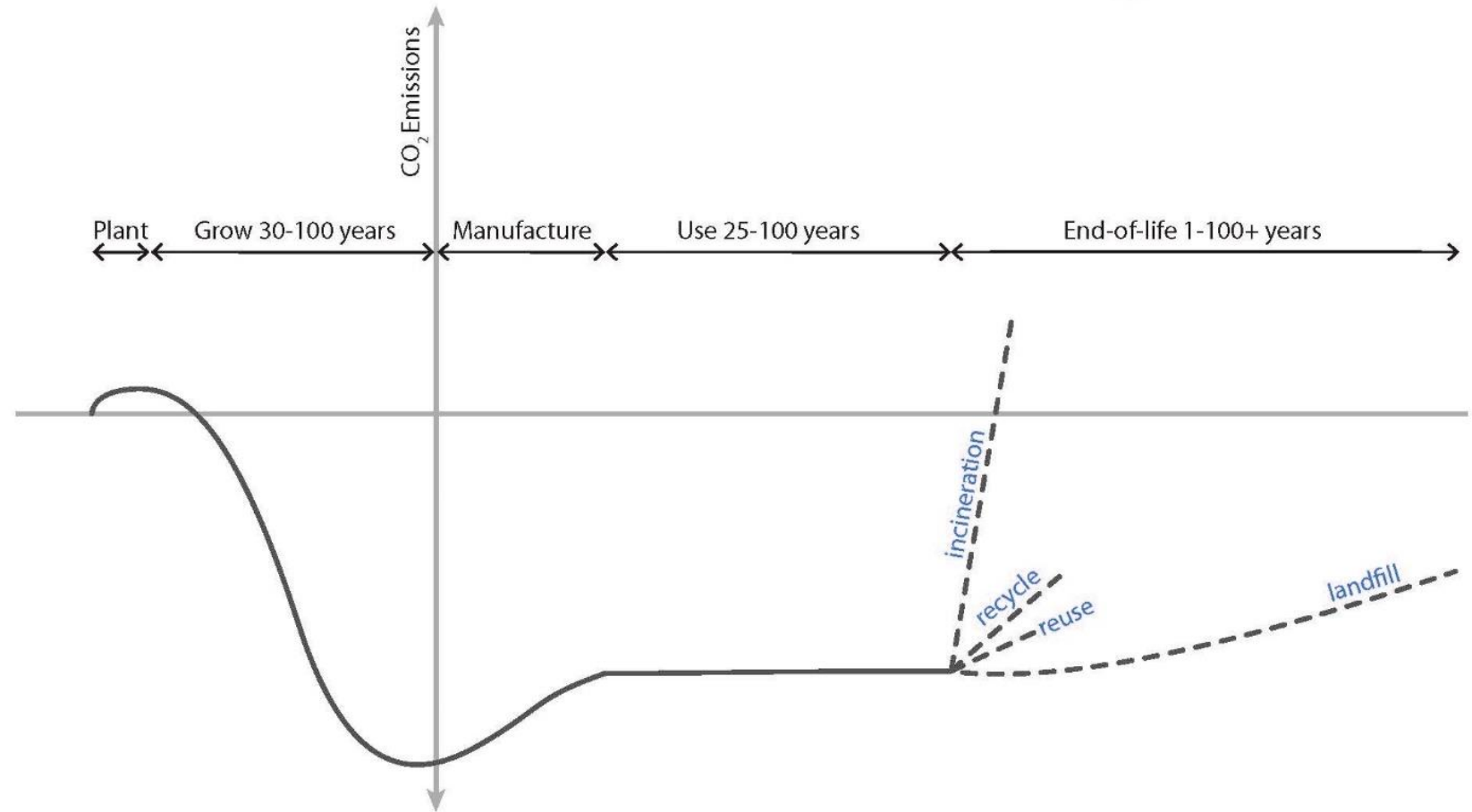
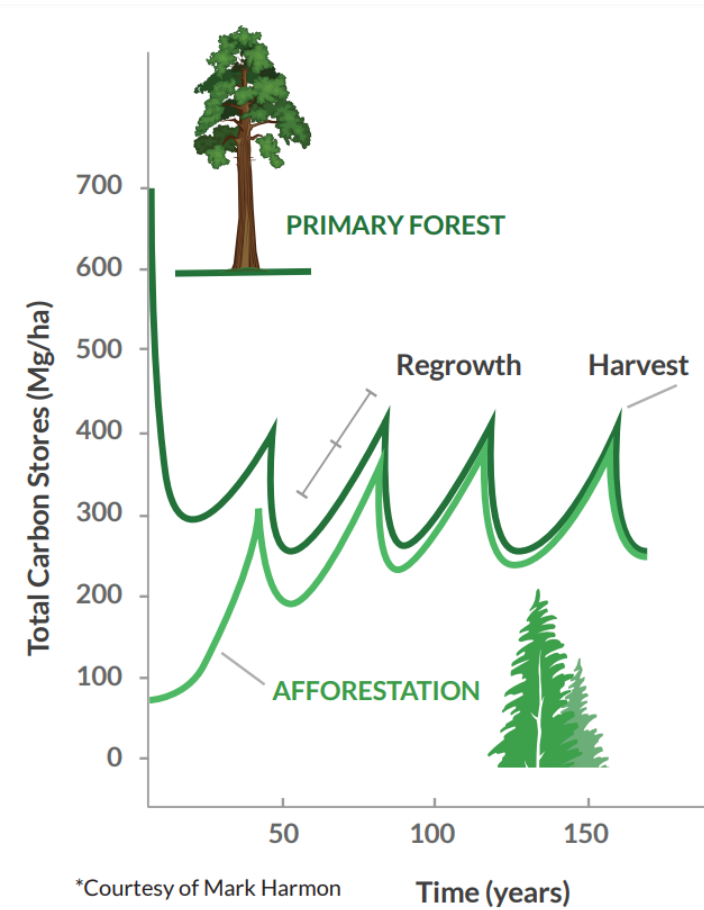
Trees absorb  $\text{CO}_2$  during photosynthesis, storing it as carbon.

Trees also emit  $\text{CO}_2$  when they respire at night and in the winter (Gorte, 2009).

Soil, roots, and decaying material often contain more carbon than the trees above: in temperate forests (where most CLT wood comes from), approximately two-thirds of carbon is stored below ground, and one third is above ground (Gorte, 2009, p. 9).

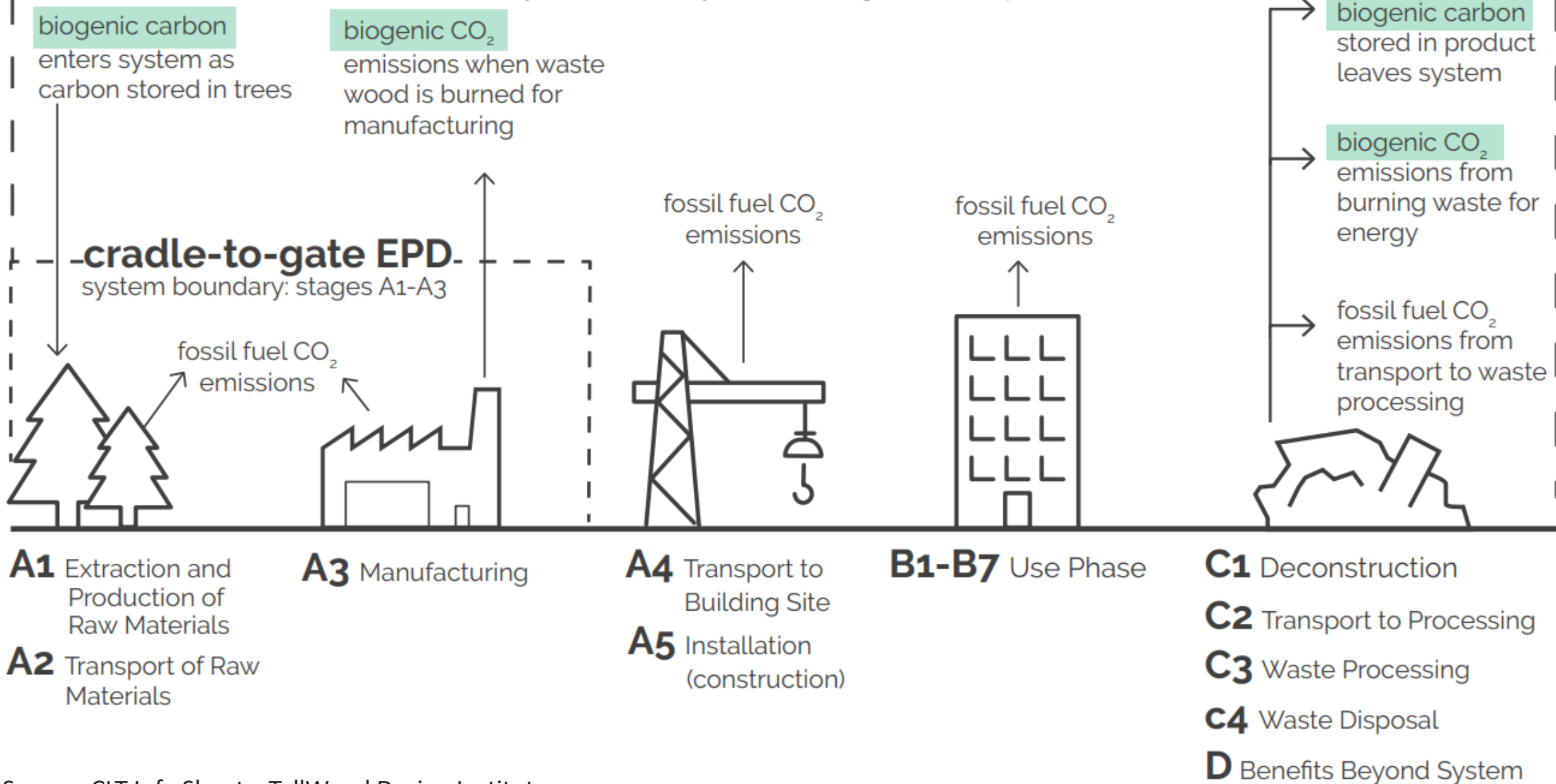
Source: CLT Info Sheets,  
TallWood Design Institute

# Carbon over Life of Wood Product



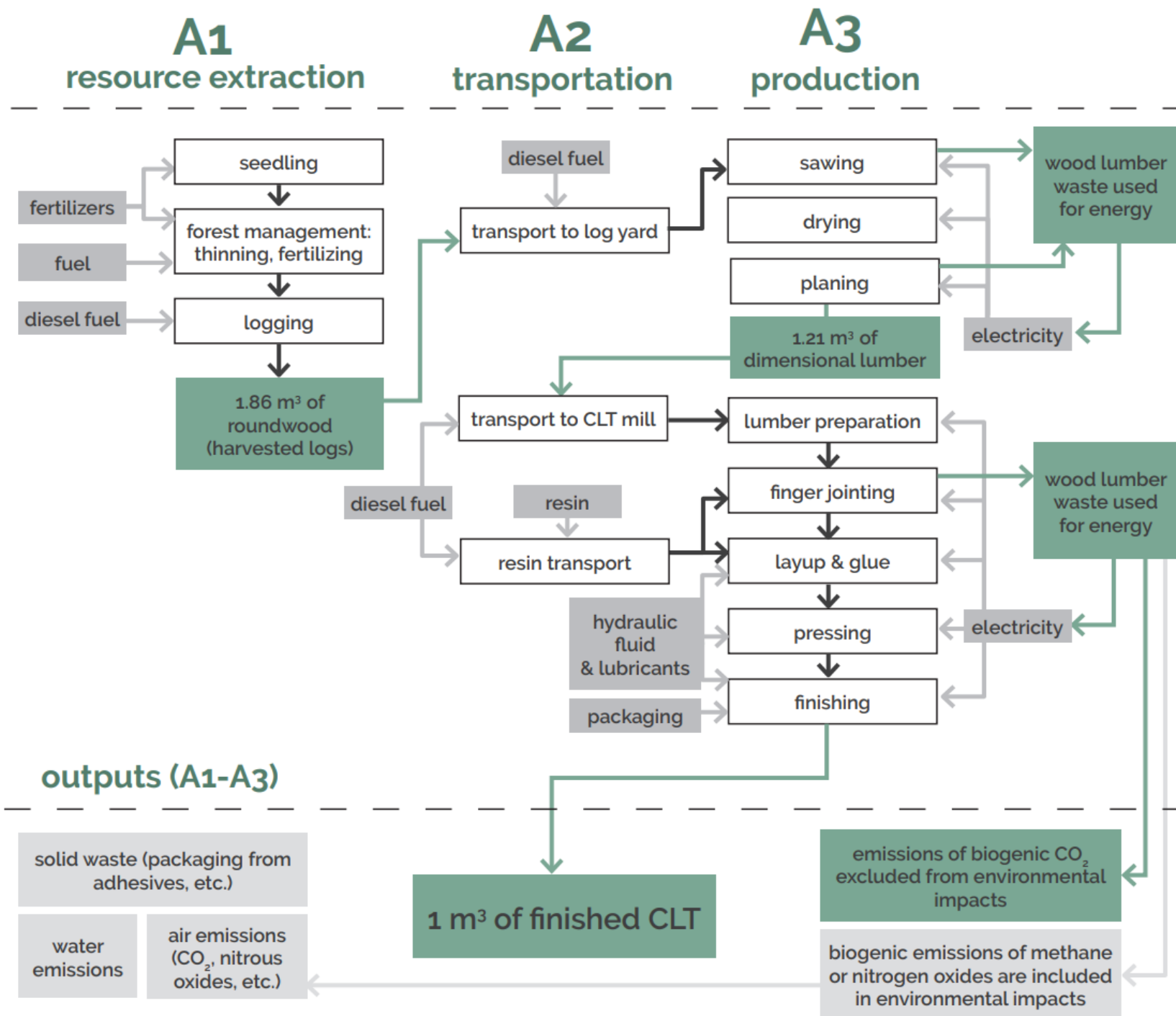
# — cradle-to-grave EPD —

system boundary includes stages A1-C4 (optional module D)

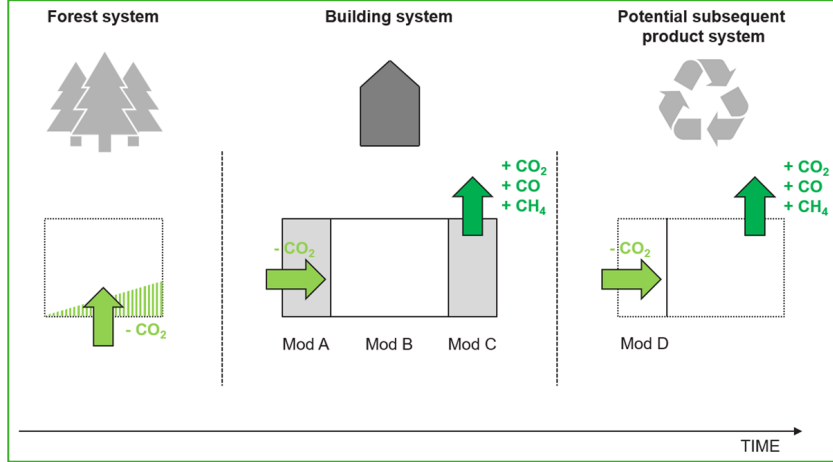
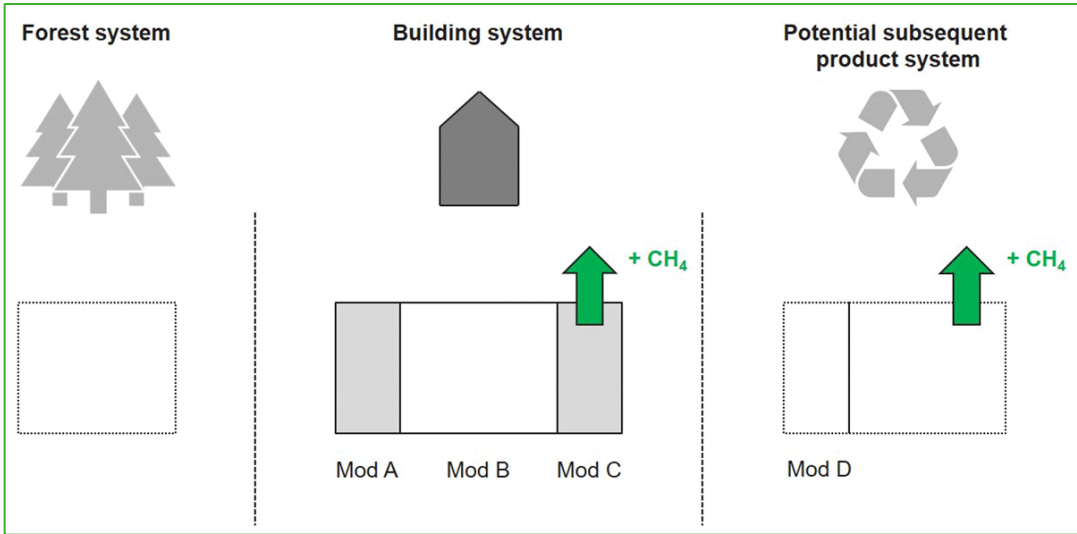


Source: CLT Info Sheets, TallWood Design Institute



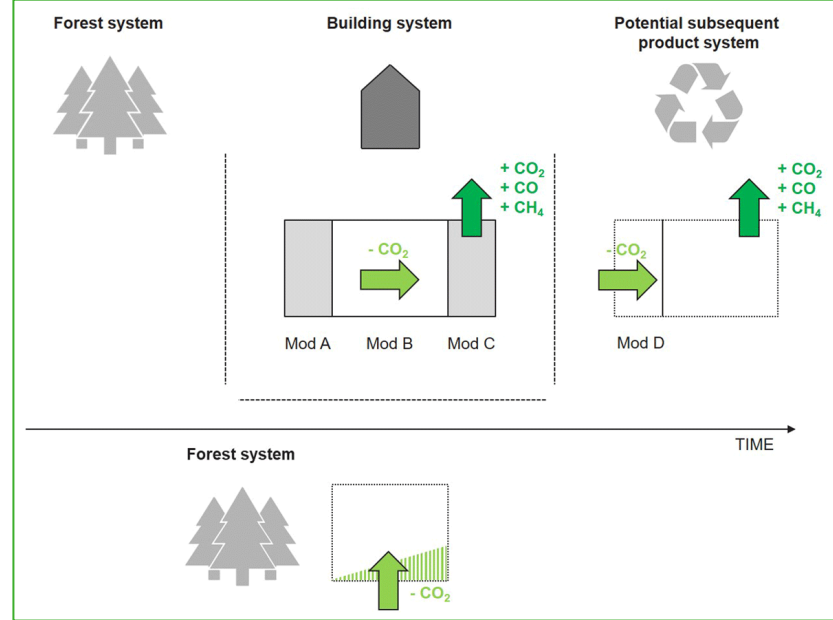
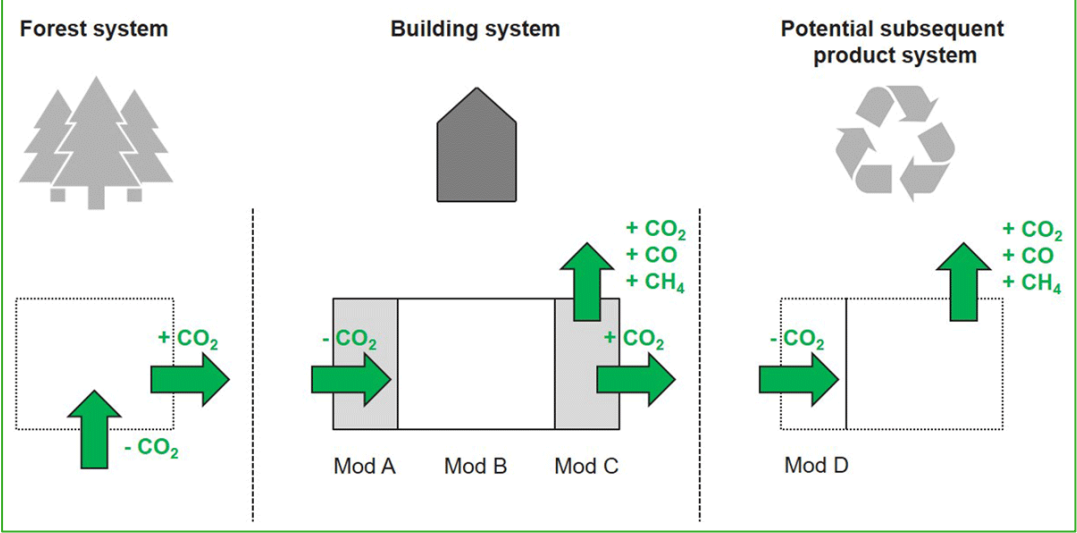


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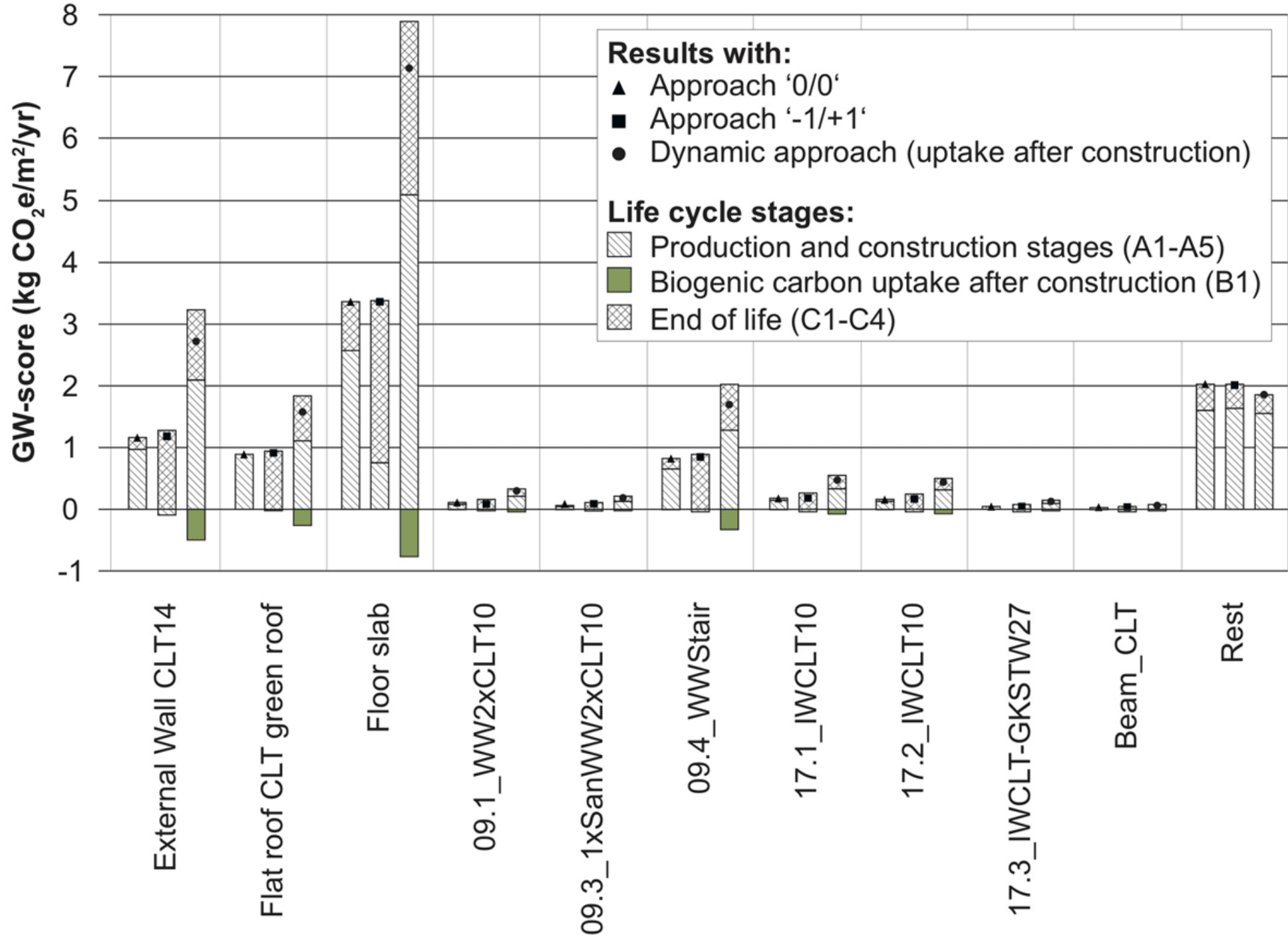


Dynamic LCA

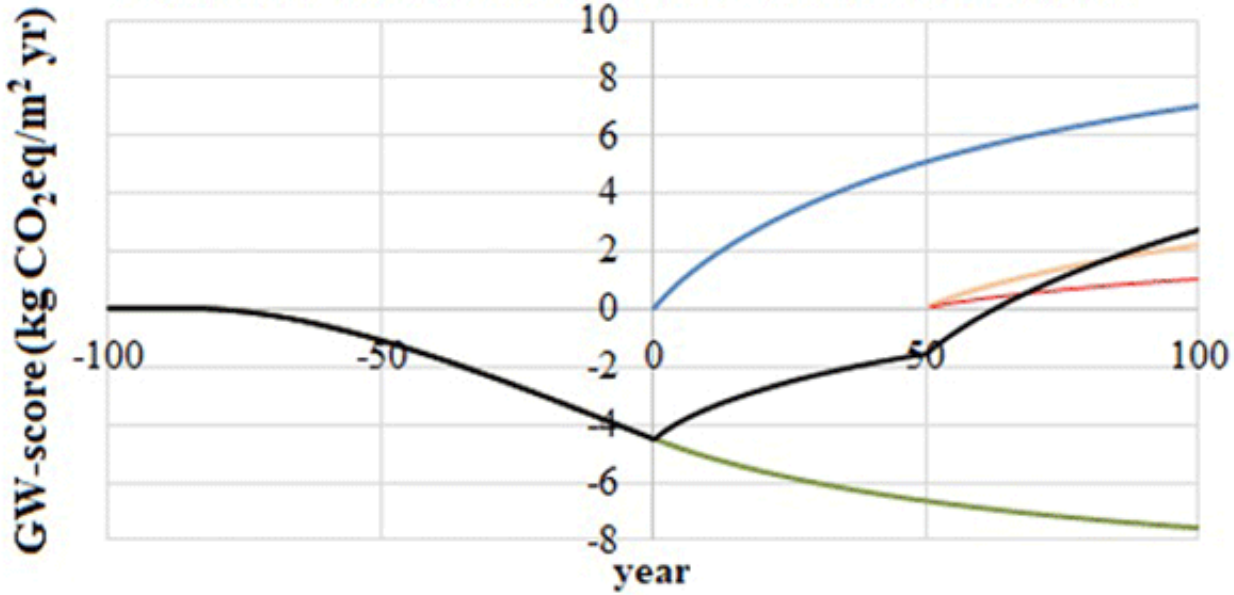
-1/+1



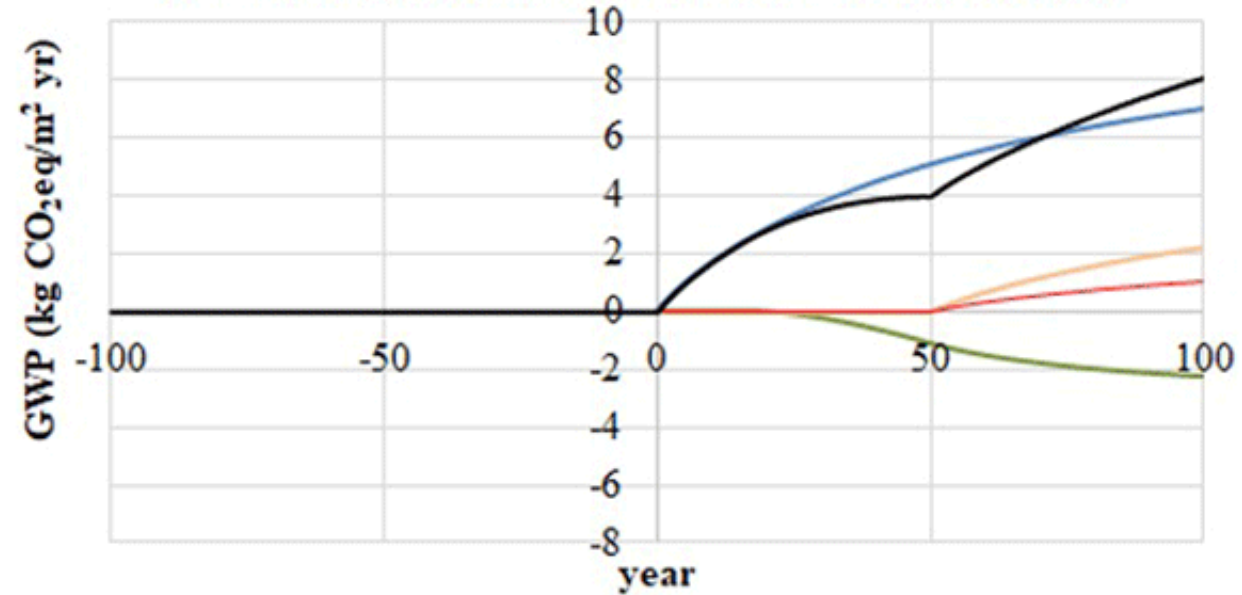
Dynamic LCA  
GWP<sub>bio</sub>



**Dynamic approach (uptake before construction)**

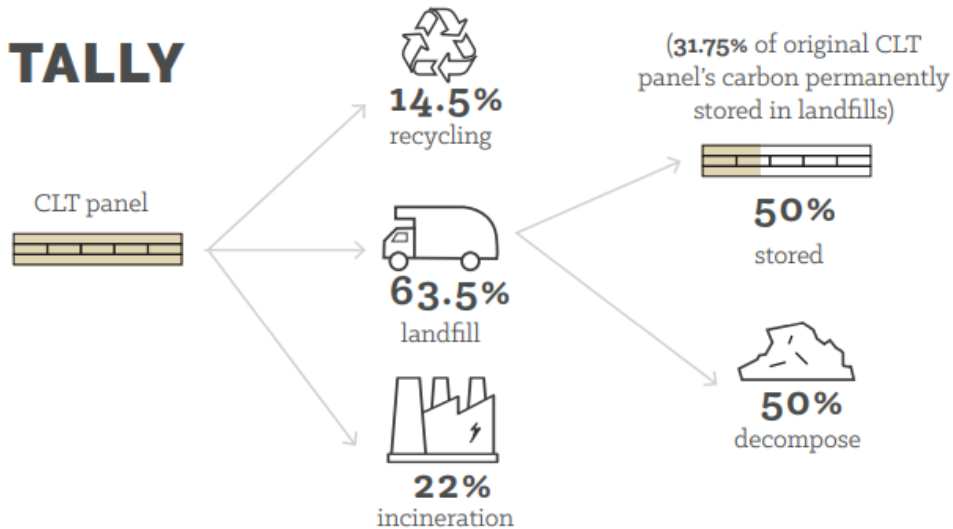
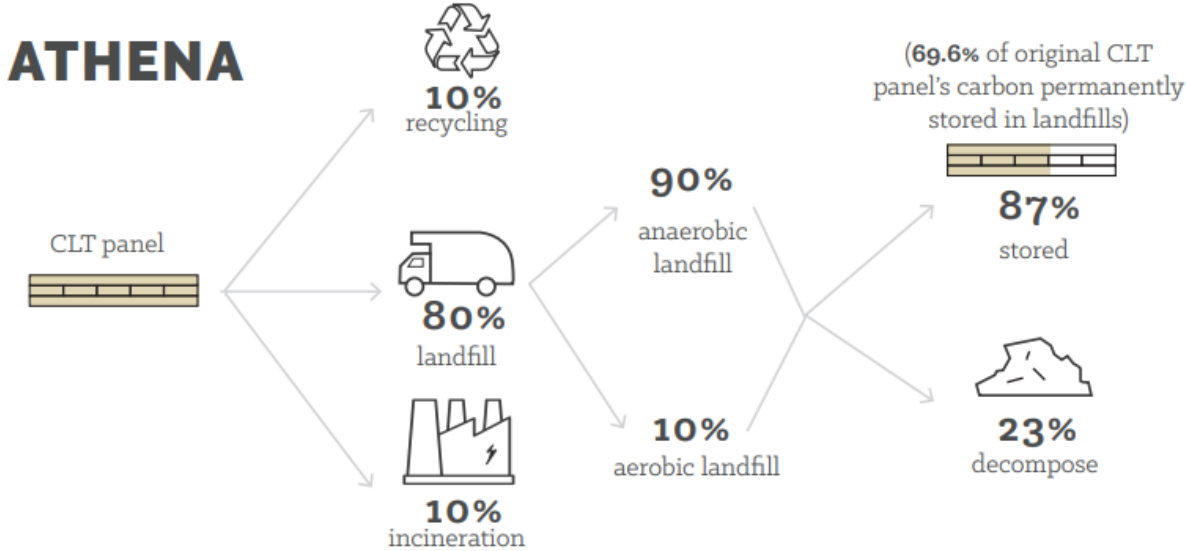


**Dynamic approach (uptake after construction)**



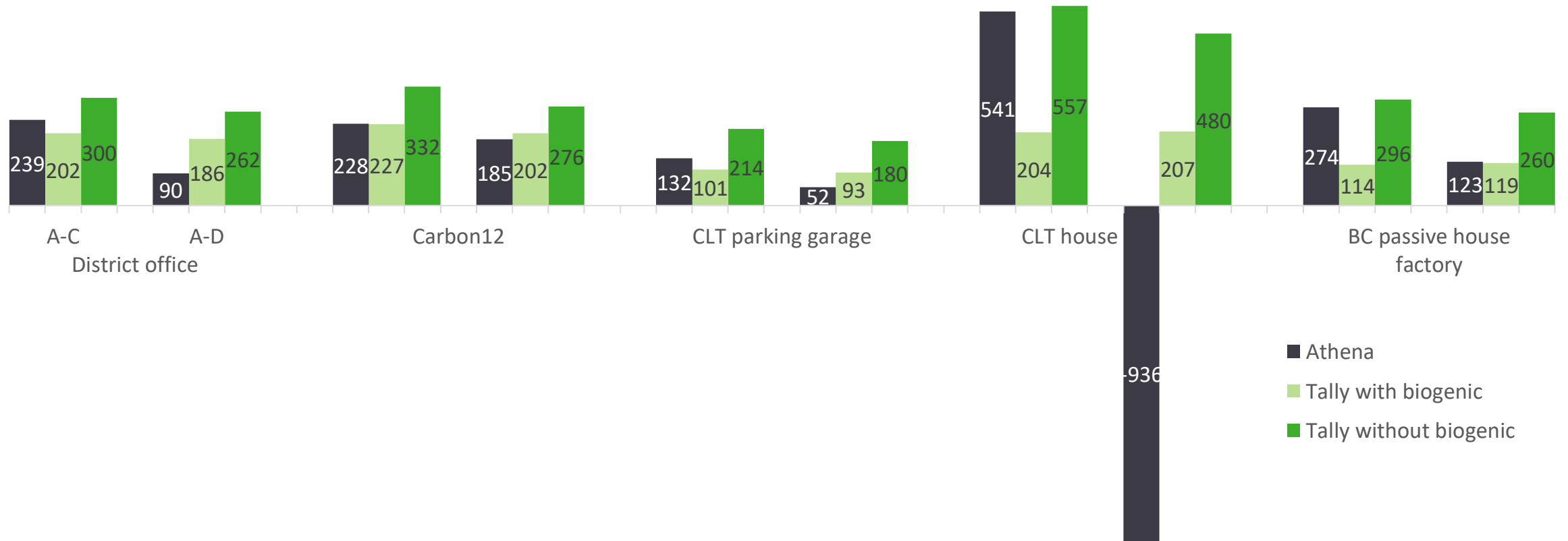
- A1-A5 (building components)
 ■ A1-A5 (biogenic carbon uptake before construction)
■ Total
- B1 (biogenic carbon uptake after construction)
 ■ C1-C4 (building components)
■ C1-C4 (biogenic carbon release)

# END-OF-LIFE CLT ASSUMPTIONS



Source: CLT Buildings: a WBLCA case study series, TallWood Design Institute

# CLT case studies in Tally and Athena (kg CO<sub>2</sub>e/m<sup>2</sup>)



# Knowledge gaps

Transparency and impacts of pesticides and fertilizer use

Linking complex carbon models to CLT and wood product use

Stored carbon content

Timing of biogenic and fossil fuel emissions

CLT carbon storage in landfills

Life cycle data for all stages

Lack of LCAs

Impacts of CLT sealants, finishes, and metal connections

WBLCA and CLT data

# What can we do now?

1. Select CLT from sustainably managed forests (FSC certified)
2. Reuse or recycle CLT panels at end of life
3. Design with specific manufacturer size to avoid waste
4. Use interlocking CLT that doesn't require adhesives
5. Expose CLT wood to avoid additional materials like gypsum
6. Choose regional manufacturer
7. Air dry lumber
8. Upgrade drying kilns and power



# Agenda

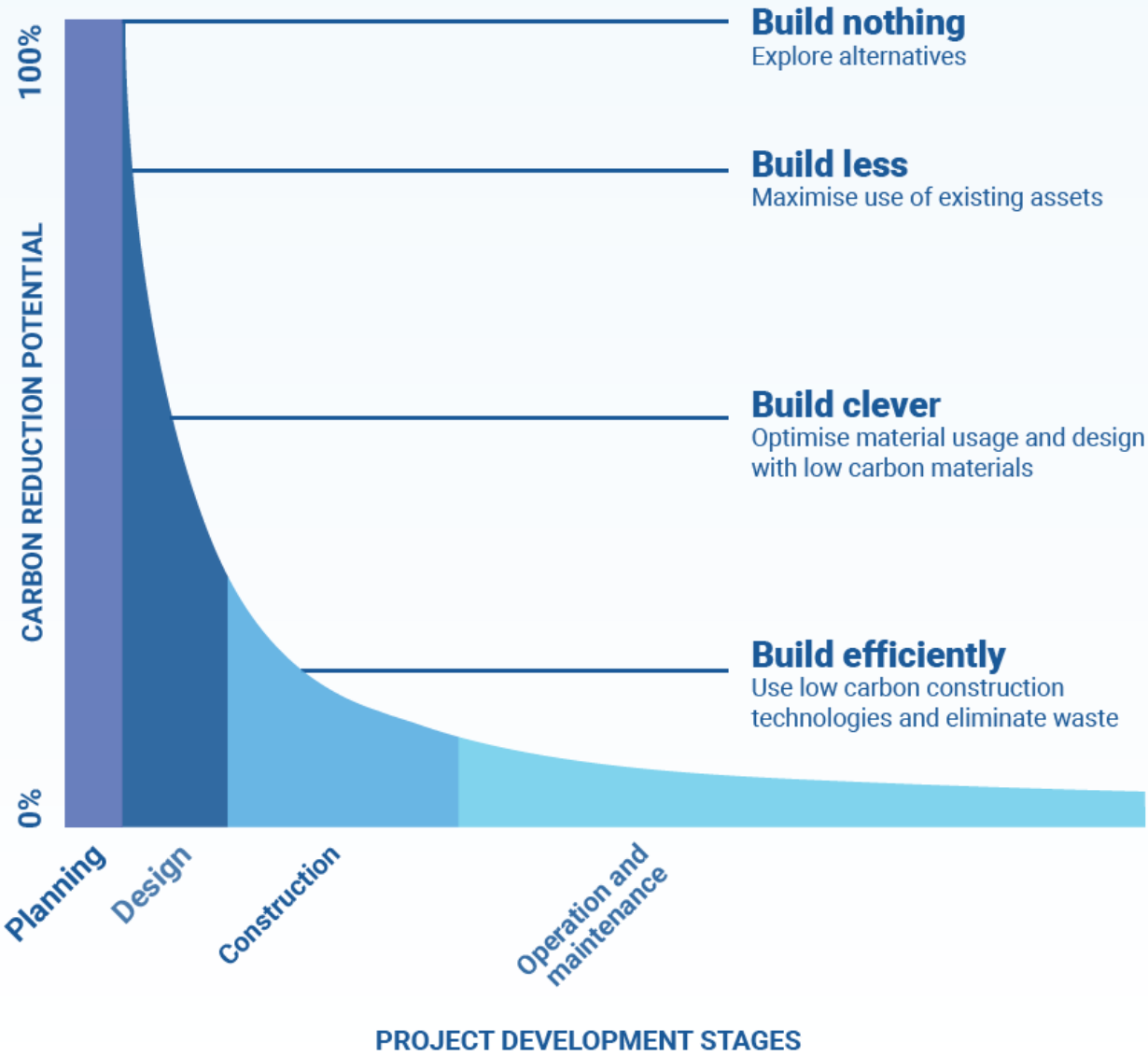
Embodied carbon basics

Biogenic carbon

**Embodied carbon reduction strategies**

Carbon Leadership Forum (CLF) policy efforts

# Carbon reduction potential



**REDEFINE**  
the solution

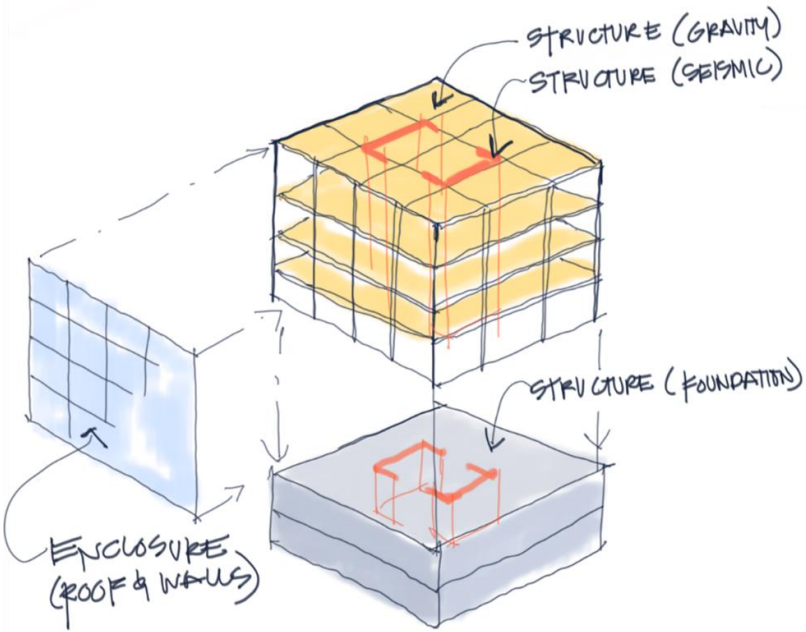
**REFURBISH**  
existing assets

**REDUCE & REPLACE**  
materials and structure

**REUSE**  
products and materials

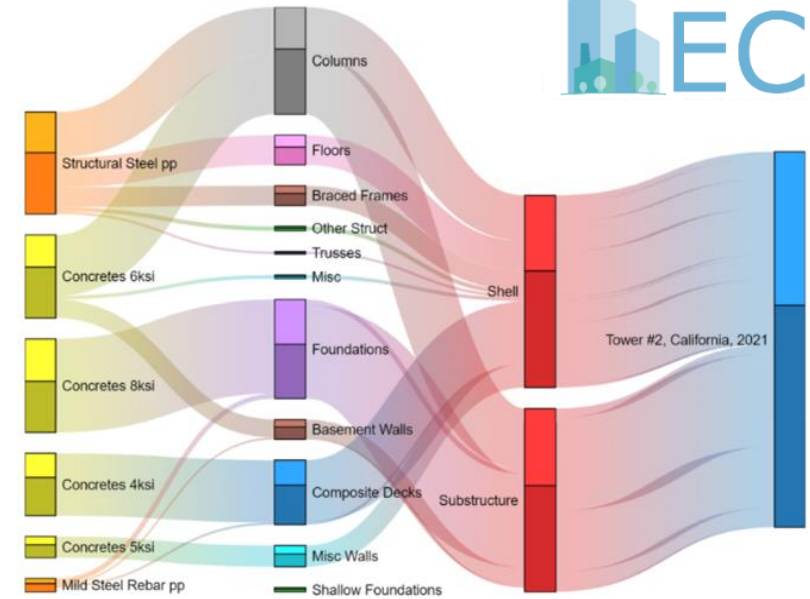
**REQUIRE**  
low carbon products

Figure 4: Opportunities to reduce embodied carbon from stage of design process. Source: HM Treasury: Infrastructure Carbon Review, 2013



**Life Cycle Impact Results (per m<sup>3</sup>)**  
 Declared Unit: 1 m<sup>3</sup> of 10,000 psi concrete at 28 days

OPERATIONAL IMPACTS	PerformX™ PECC10K
Plant Operating Energy (MJ)	38.6
On-Site Plant Fuel Consumption (MJ)	11.1
Concrete Batch Water (m <sup>3</sup> )	1.68E-01
Concrete Wash Water (m <sup>3</sup> )	1.91E-02
On-Site Waste Disposal (kg)	0.0
<b>ENVIRONMENTAL IMPACTS</b>	
Total Primary Energy (MJ)	3,017
Climate Change (kg CO <sub>2</sub> eq)	445
Ozone Depletion (kg CFC 11 eq)	1.31E-08
Acidification Air (kg SO <sub>2</sub> eq)	2.96
Eutrophication (kg N eq)	0.09
Photochemical Ozone Creation (kg O <sub>3</sub> eq)	0.61



MATERIAL  
QUANTITY  
ESTIMATE



IMPACT  
PER MATERIAL  
EPDS



BUILDING  
IMPACT  
ESTIMATE

# LCA Overview

1

Initiate Assessment

What is the goal and scope?

2

Define the Building

Size, scale, construction, use, and end-of-life scenarios

3

Determine Environmental Impacts

Which LCA tool do you use?

4

Interpret Results

Is the analysis sufficient to meet project goals?

5

Prepare Reports

Document analysis and findings

# Primary high impact materials

**Concrete** - It's about total cement content, not (just) fly ash replacement

**Steel** - Electric arc furnace (wide flange, recycled) over basic oxygen furnace (HSS, virgin ore)

**Wood** - Is it coming from a sustainably managed forest?

# Secondary high impact materials

**Insulation** - Stay away from high intensity HFC blowing agents

**Gypsum** - Specify lightweight gypsum and eliminate waste material

**Envelope** - Lower WWRs, reduce aluminum use, prioritize recycled aluminum

**Carpet** - Specify low-carbon carpet tile products

# Agenda

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**Carbon Leadership Forum (CLF) policy efforts**



## Research

We investigate the pathways for maximizing carbon reductions and lead collaborative research with material experts, NGOs, industry partners and policymakers.



## Resources

We accelerate learning by crowdsourcing and disseminating knowledge that empowers our members.



## Network

We bring together architects, engineers, contractors, material suppliers, building owners, policymakers and associations, through environments designed to connect inspired advocates and spark unprecedented collaboration.



## Initiatives

We accelerate market transformation by inspiring, supporting and empowering our members to advance new ideas through impactful initiatives.



**PLAN**

**IMPLEMENT**

**SHARE**

1

**Embodied carbon action plan**

Office action plan including supporting staff education efforts and internal SMQ and GWP tracking



2

**Implementation and accountability**

Engage in sustainable goals of projects, specify low carbon impact materials and understand the GWP of each project using the LCA methods



3

**Data sharing and tracking**

Share GWP and SMQ data of structural systems for benchmark establishment and development of annual reduction targets

**SE 2050 Commitment Program**

Asks structural engineers and structural engineering firms to accelerate the embodied carbon reduction in structural systems and materials through three main activities.



# CLF Austin

## Future initiatives

LCA Workshop: Thursday, April 29<sup>th</sup>

SE 2050 overview

Outreach/coordination/mentorship

Climate Equity Plan implementation

Buy Clean ATX - EPD support

Continue to host information sessions and discussions

## Past events

EC3 demonstration with Stacy Smedley

Material presentation (concrete, steel, timber)

Climate Equity Plan overview

Climate Equity Plan comments and discussion

Local embodied carbon needs (discussion)

CarbonCure

# Buy Clean Policies

EPD requirement for certain materials

Set GWP maximums for procurement

Drive maximums down over time

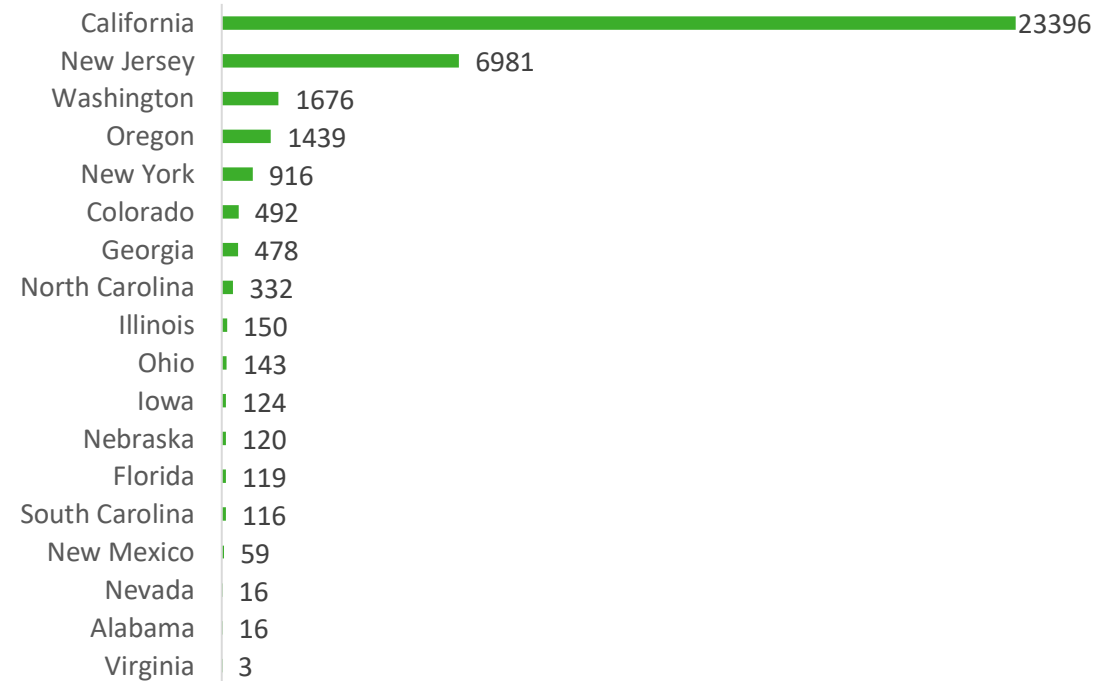
You can't reduce what you don't measure!

**Disclose impact data**

**Set performance-based standards**

**Use incentives**

Concrete EPDs in EC3



# Recap

Embodied carbon (and other stuff) vs. operational carbon

We're building a lot

Big, neglected, solvable

Wood is complicated. More data, more research, put it to use

All biogenic carbon models are wrong. Some are useful

More sustainably harvested forests

Use less material then use better material

Proportion efforts to outcome

Art imitates life imitates art

Talk about embodied carbon

More LCA + EPDs

Here are the resources I linked at the end of the presentation:

- Join the CLF (global) - <https://network.carbonleadershipforum.org/>
- Sign up for CLF Austin updates - <https://forms.gle/7pFFmzbXzkxukDZ66>
- CLF Austin Youtube - [https://www.youtube.com/channel/UCR008w9yMCvEGyzmY\\_r9Y5w](https://www.youtube.com/channel/UCR008w9yMCvEGyzmY_r9Y5w)
- Biogenic carbon accounting of wood products in WBLCA - <https://youtu.be/7XTzKESNGEU>
- TallWood Design Institute CLT reports - <http://tallwoodinstitute.org/projects/carbon-impacts-clt>
- LETI embodied carbon primer - <http://tallwoodinstitute.org/projects/carbon-impacts-clt>
- World GBC Advancing Net Zero Status Report 2020 - <https://www.worldgbc.org/advancing-net-zero-status-report-2020>
- Sierra Club: forests, wood, and climate  
- [https://contentdev.sierraclub.org/sites/www.sierraclub.org/files/program/documents/Forests,%20Wood%20&%20Climate%20Report\\_Sierra%20Club\\_July%202019.pdf](https://contentdev.sierraclub.org/sites/www.sierraclub.org/files/program/documents/Forests,%20Wood%20&%20Climate%20Report_Sierra%20Club_July%202019.pdf)
- Biogenic carbon in buildings: a critical overview of LCA methods - <https://journal-buildingscities.org/articles/10.5334/bc.46/>
- Embodied carbon policy framework - <https://carbonneutralcities.org/embodied-carbon-policy-framework/>
- Carbon smart materials palette - <https://materialspalette.org/>
- WWF dynamic LCA biogenic carbon excel tool - <https://www.worldwildlife.org/projects/biogenic-carbon-footprint-calculator-for-harvested-wood-products>
- Embodied carbon in construction calculator (EC3 – EPD database) - <https://buildingtransparency.org/>

Cheers,  
Martin

**Martin Torres** | Green Building, CES | Austin Energy