Carbon Footprint of Wood Products & Buildings

March 2022 | Kate Carrigg | Technical Director, WoodWorks

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

AIA Approved Continuing Education

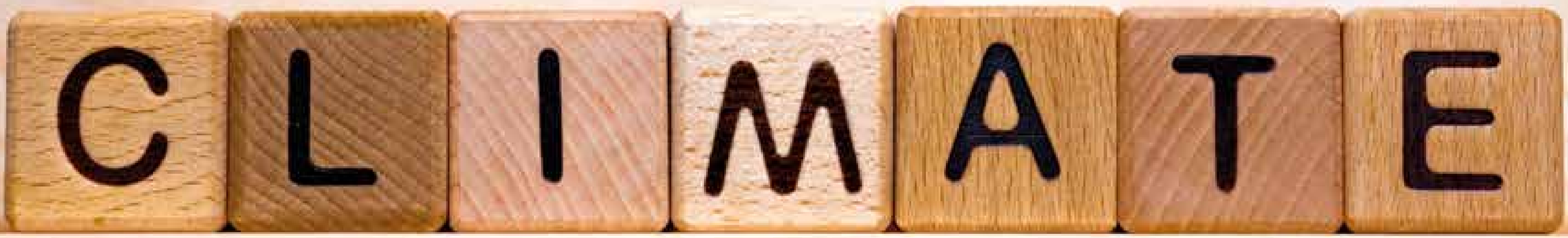
Course Description

Issues surrounding carbon are in the forefront of many building designers' minds. As a result, questions can arise as to what building products should be specified to help achieve a more sustainable structure. This course takes a brief look at the use of wood in construction and highlights some of the positive environmental benefits that it can bring to the building. Basic terminology surrounding carbon will be reviewed along with information on carbon sequestration in wood. Case studies showing the benefits of wood will be presented along with a short survey of carbon policy around the U.S.

Learning Objectives

1. Review carbon basics and how material choice is related to sustainability.
2. Learn how wood products can be beneficial for the environment.
3. Understand carbon storage in wood products.
4. Evaluate case studies highlighting the benefits of wood construction.

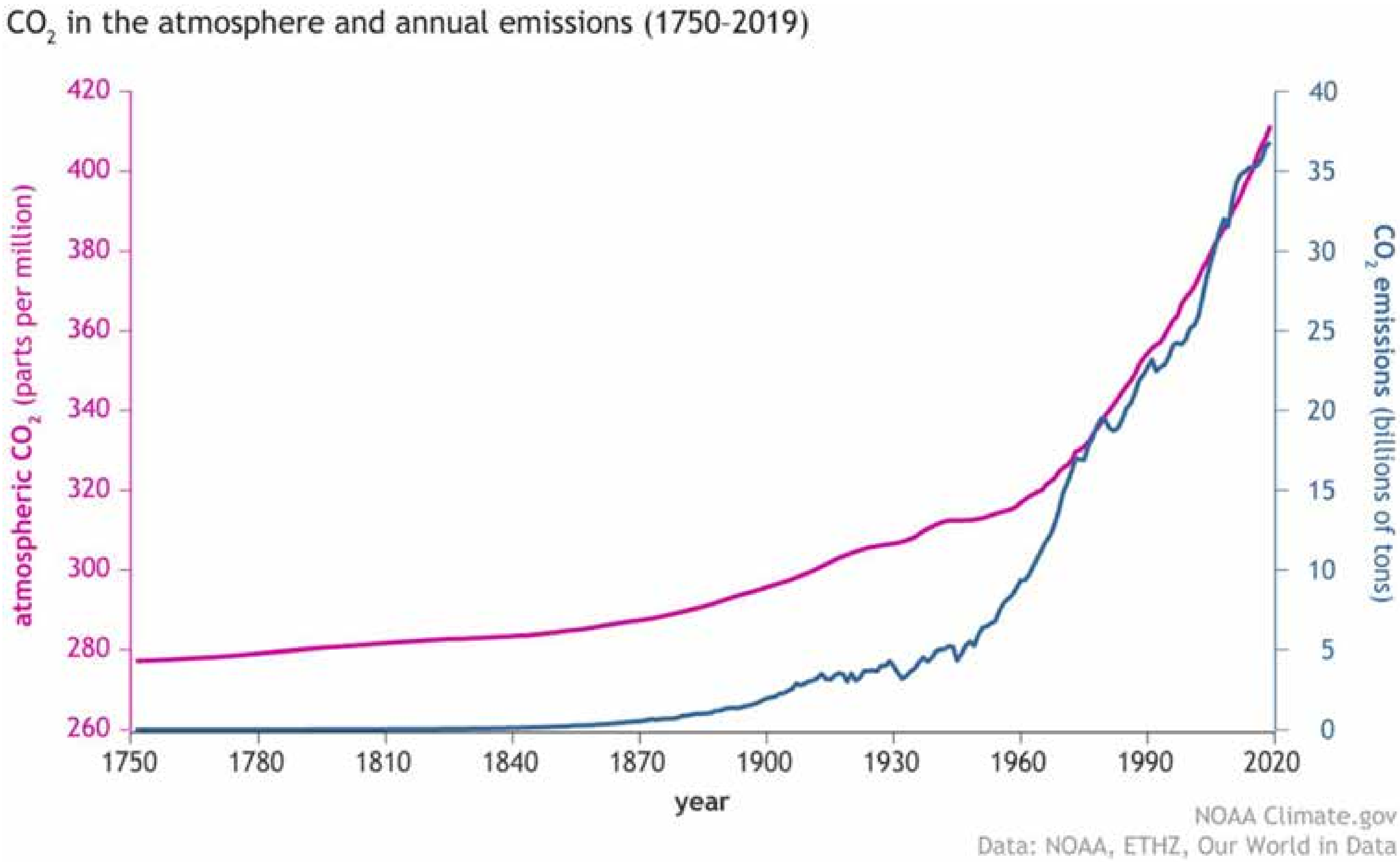
Climate Change Background



Rising Temperatures and Melting Glaciers

From Rising Waters to Catastrophic Wildfires

Carbon & Greenhouse Gas Emissions



Measuring Greenhouse Gases

Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO_2). The time period usually used for GWP's is 100 years. (EPA)

	GWP
Carbon Dioxide (CO_2)	1
Methane (CH_4)	28-36
Nitrous Oxide (N_2O)	265-298
Fluorinated Gases	Thousands to Tens of Thousands

Carbon Dioxide Equivalents (CO_{2eq}) = International standard practice is to express greenhouse gases in terms of CO_2 equivalents

US Climate Policy

In the absence of strong Federal Policy, states and municipalities have adopted their own regulations

- Buy Clean California – first US law to address embodied carbon in construction materials
  - GWP must not exceed set limits
  - Currently targets structural steel, steel rebar, glass, and mineral wool

Federal Policy is advancing under the Biden Administration:

- Rejoining the Paris Agreement
- Several first-week executive actions aimed at advancing zero-carbon technologies, increasing reforestation and carbon sequestration

Global Population Increase

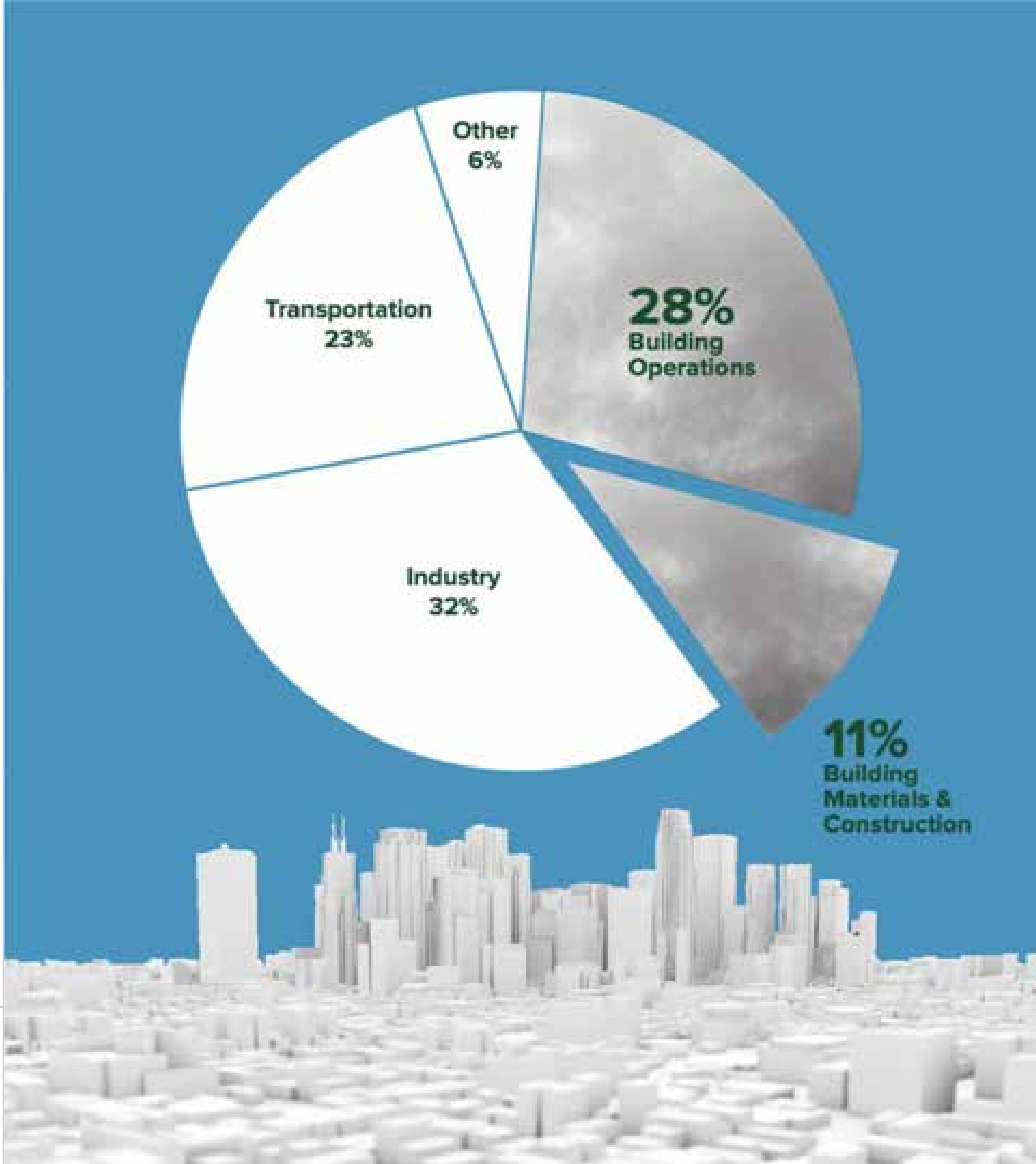
2050 = 9.9
billion people

2020 = 7.8
billion people

Source: www.prb.org

To stay within 1.5°C warming, greenhouse gas emissions need to **decline 45% below 2010 levels by 2030** and reach net zero emissions by 2050.

The built environment accounts for **40% of GHG emissions.** Our sector has a critical role to play.



Sources: How to Calculate the Wood Carbon Footprint of a Building, p. 145; Architecture 2030; and Global Alliance for Buildings and Construction 2018 Global Status Report

Carbon Terms

- **Embodied Carbon**: Carbon emissions associated with the entire life cycle of the building including harvesting, mining, manufacturing, transporting, installing, maintaining, decommissioning, and disposing/reuse of a material or product
- **Operational Carbon**: Carbon emissions associated with operating a building including power, heat, and cooling

Image: Boston Society for Architecture

Embodied Carbon

- Primarily related to **manufacturing of materials**
- More significant than many people realize, has been **historically overlooked**
- Big upfront GHG “cost” - which makes it a **good near-term target** for climate change mitigation

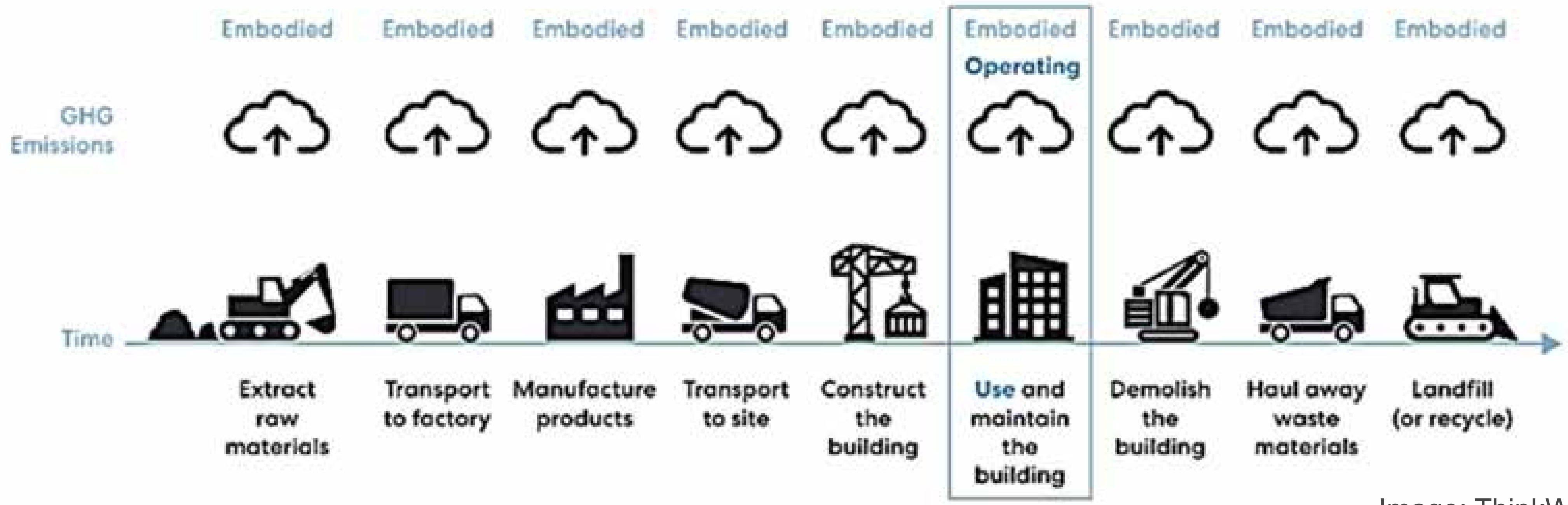


Image: ThinkWood

Embodied vs. Operational Energy

Traditional Non-Wood Building

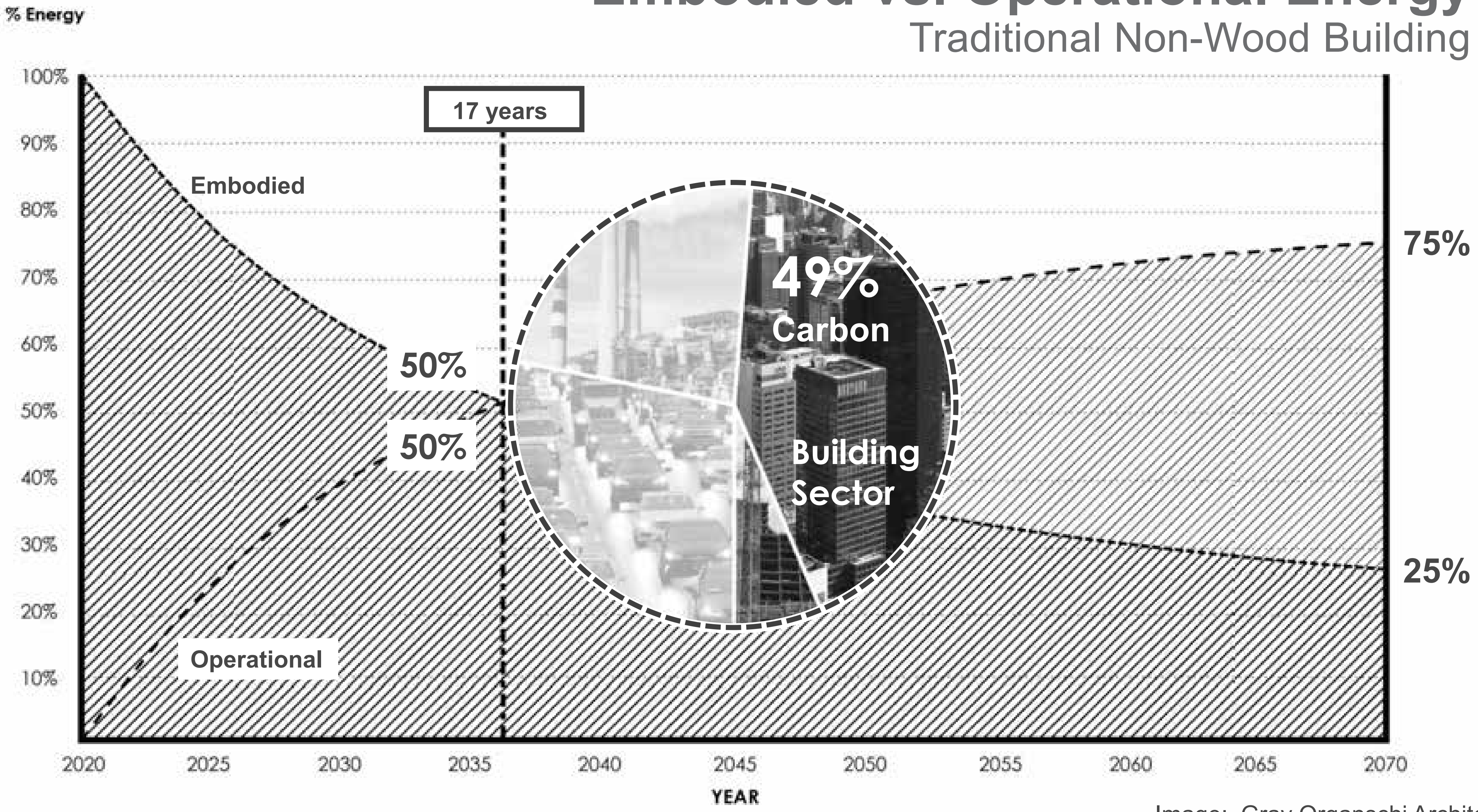
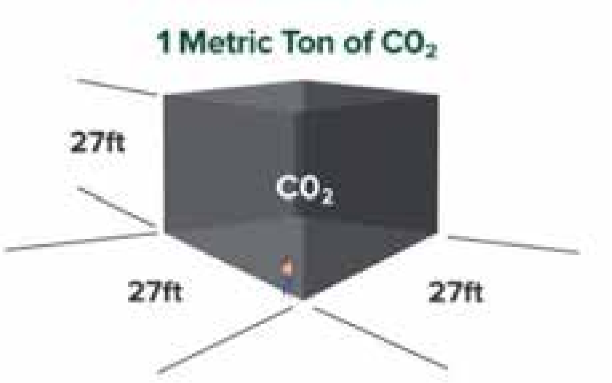


Image: Gray Organschi Architecture

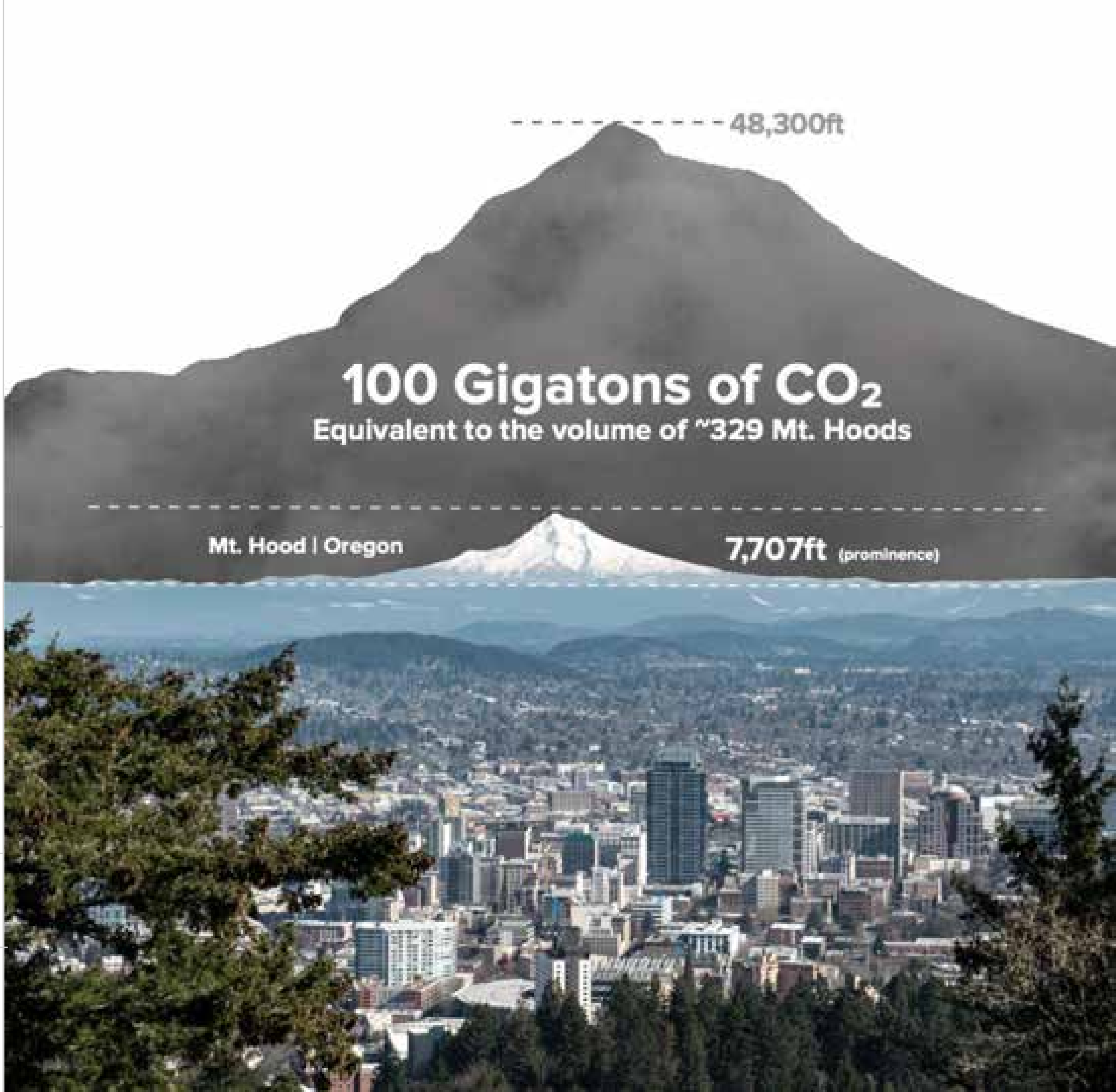
How Does Wood Fit in?

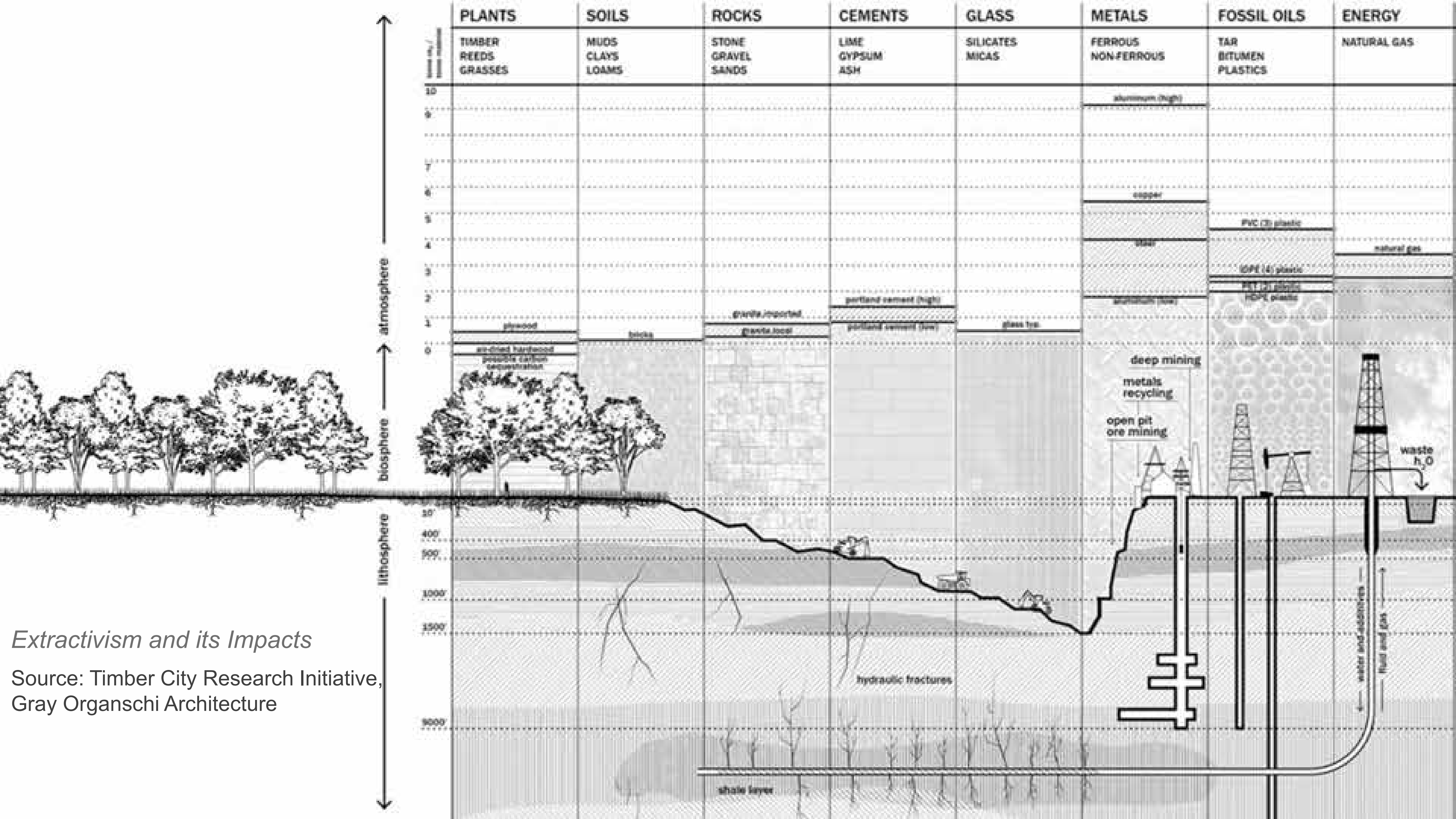
Without decisive action, building materials used in new construction in cities across the globe will generate **100 gigatons** of embodied carbon by 2050.



1 Billion Metric Tons = 1 Gigaton

Source: [Carbon Neutral Cities Alliance](), [How much is a ton of carbon dioxide?]()





Extractivism and its Impacts

Source: Timber City Research Initiative, Gray Organschi Architecture

Harvested Wood Products

- **Solid sawn** wood products have the lowest level of embodied energy.

- Wood products requiring more processing steps (for example, plywood, engineered wood products, flake-based products) require more energy to produce but still require **significantly less energy** than their non-wood counterparts.

Image: Weyerhaeuser

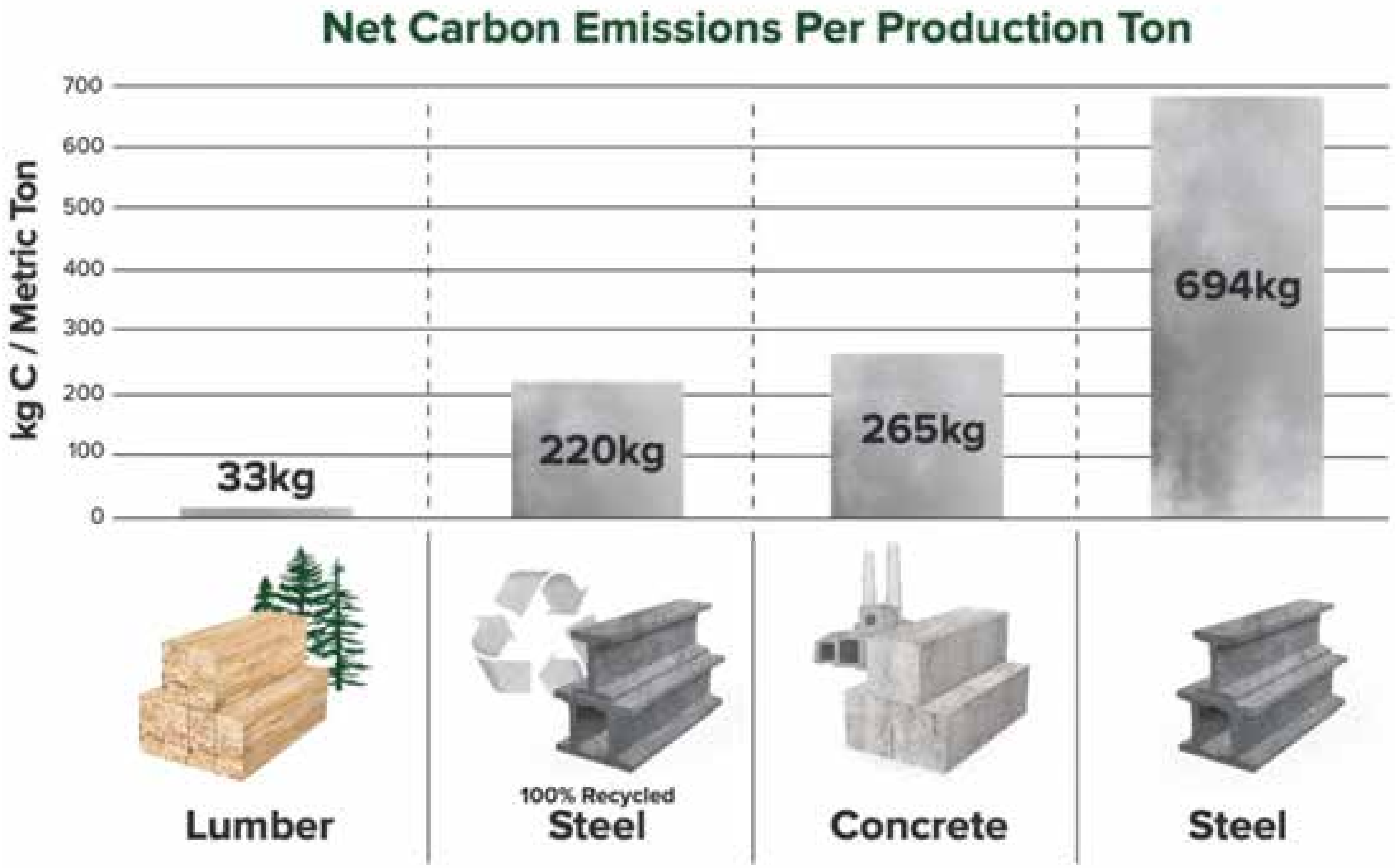
Image: LP Building Solutions

Image: Structurecraft

Image: Georgia-Pacific

Source: USFPL Wood Handbook; Wood as a Sustainable Building Material

Of the three primary structural materials used in construction, manufacturing lumber is the least energy intensive, followed by 100% recycled steel, concrete, and virgin steel. This accounts for wood's low embodied carbon.



Source: Jim Bower, [Portland Cement as a Construction Material: How Does It Compare to Wood, Steel?](), Dovetail, Inc., page 4.

More Carbon Terms

Carbon Sequestration: The process by which CO_2 is **removed** from the atmosphere and deposited in solid or liquid form in oceans, living organisms, or land.

Carbon Storage: Carbon is **stored as a solid** in the form of plant material: roots, trunks, branches, stems, and leaves. It can continue to be stored in **wood building materials**.

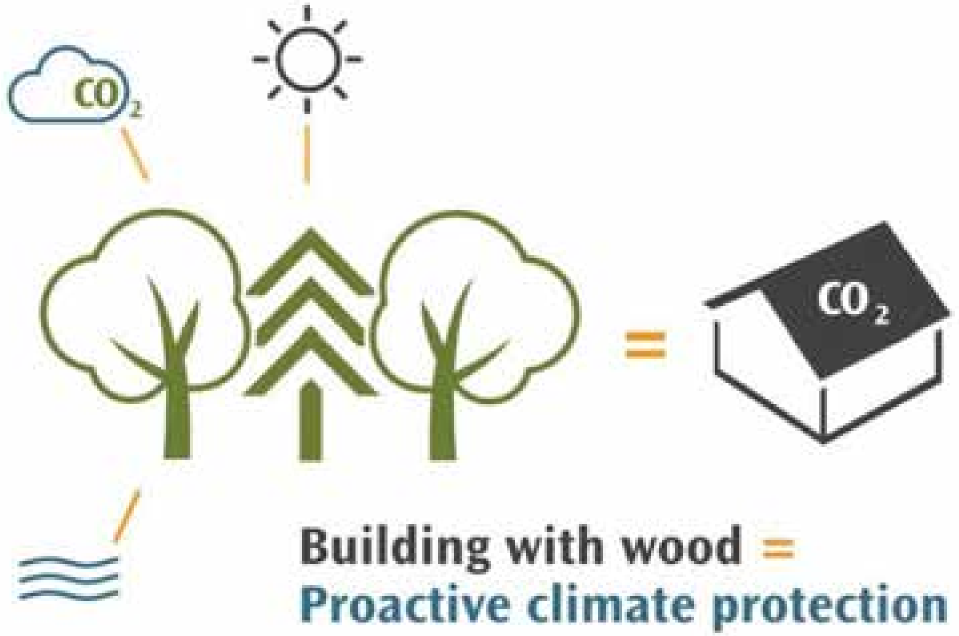


Image: Dovetail Partners, Inc.

Carbon Benefits of Wood

- **Less energy intensive** to manufacture than steel or concrete
- **Less fossil fuel consumed** during manufacture
- Reduce process emissions
- Carbon **storage in forests** and **promote forest health**
- Extended carbon **storage in products**

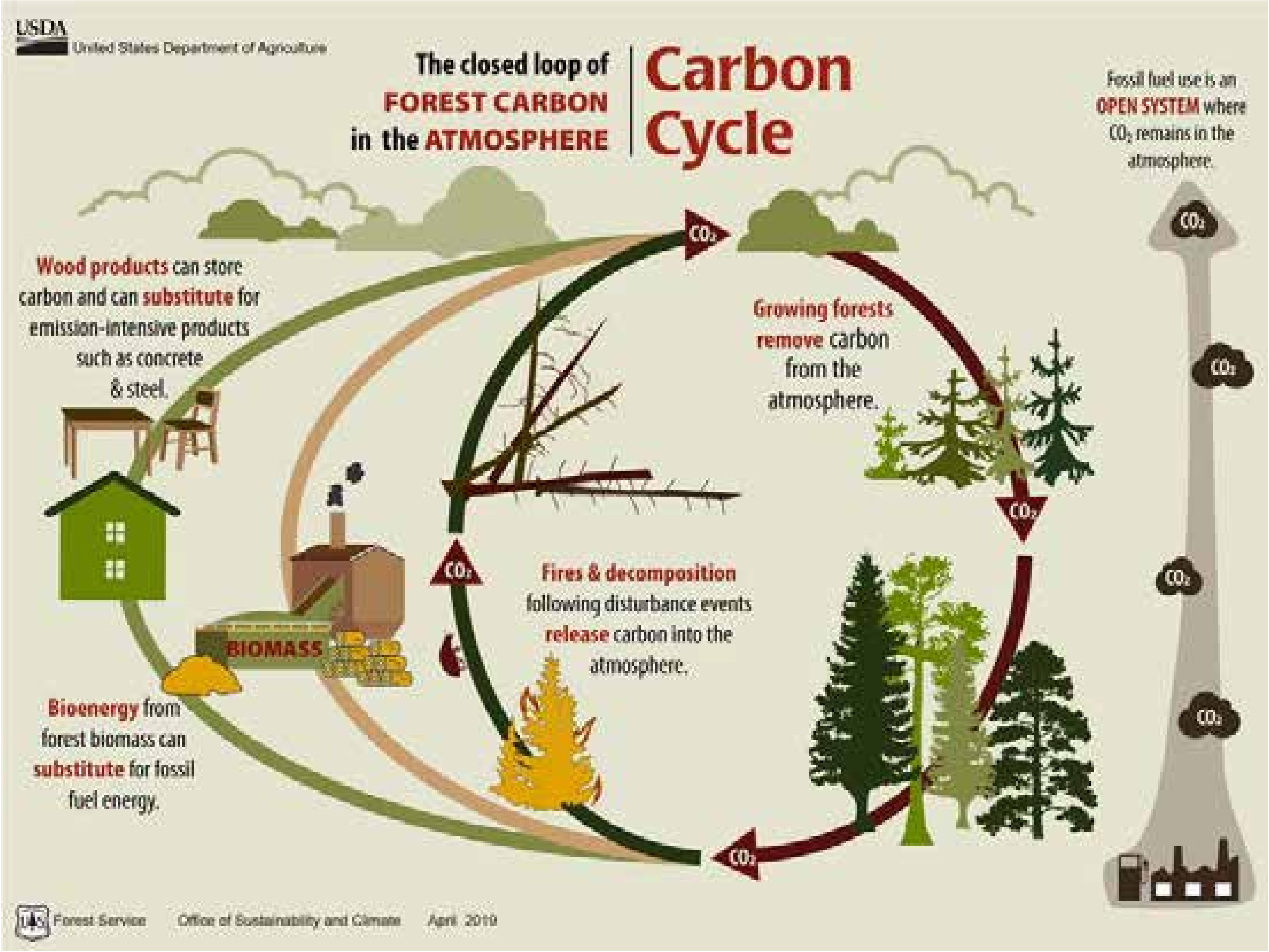
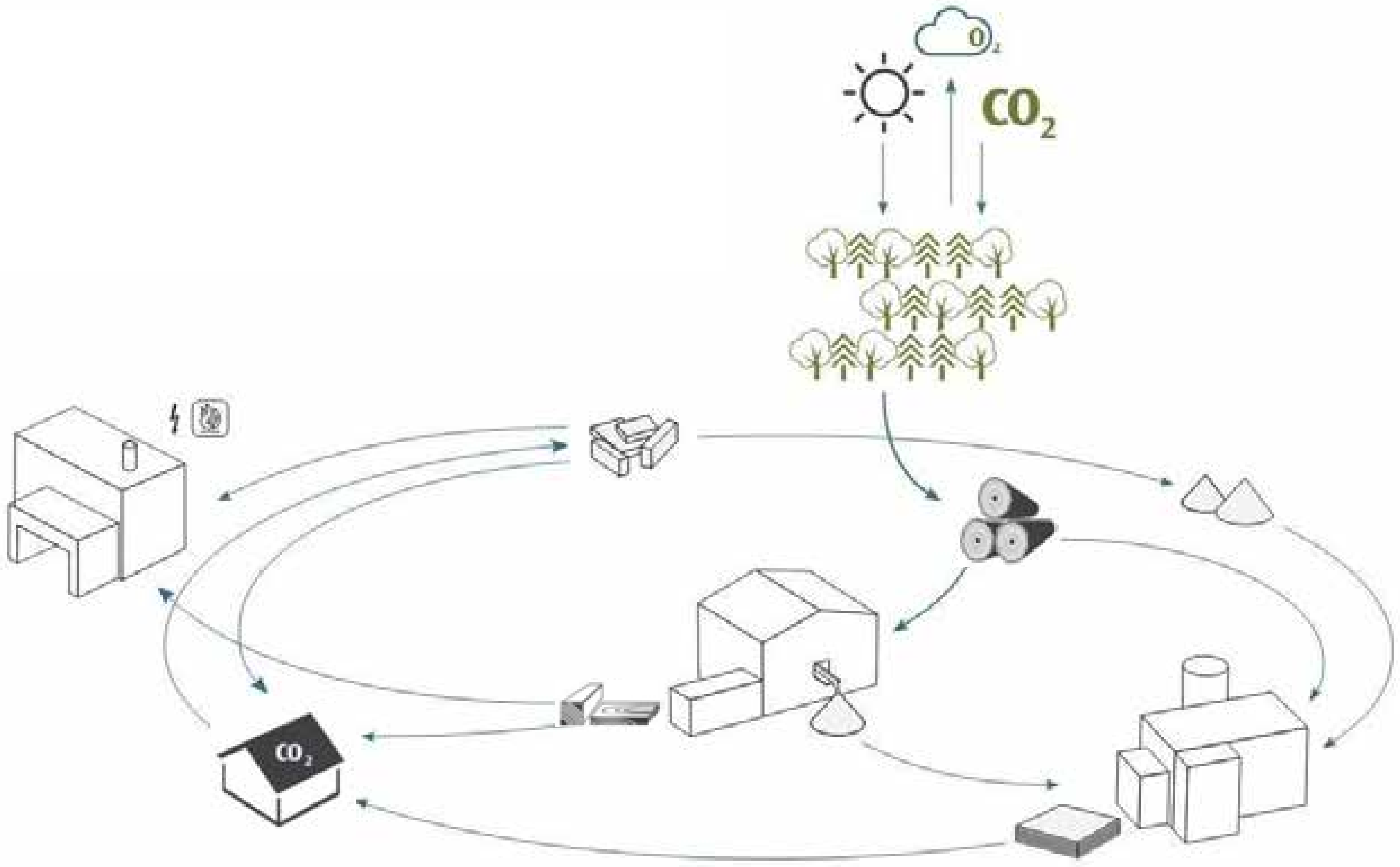


Image: USDA US Forest Service

Carbon Cycle

Renewable Resource | Carbon Sequestration



Source: Building with Wood – Proactive Climate Protection, Dovetail Partners, Inc.

Where is Carbon Stored?

Harvested Wood Pools

- Wood Products
- Solid Waste Disposal Sites

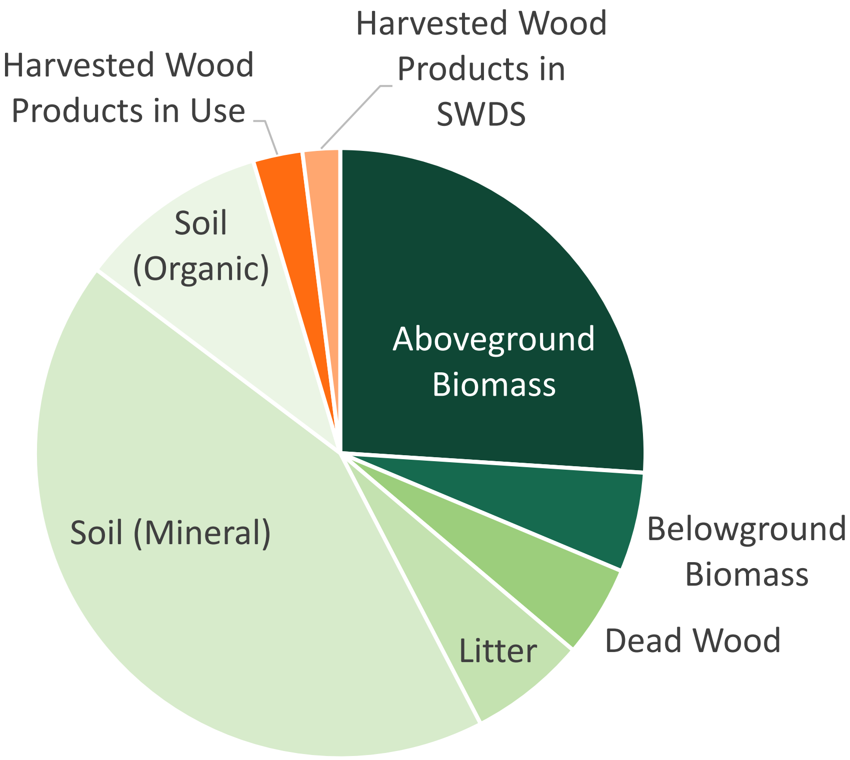
Forest Pools

- Aboveground Biomass
- Belowground Biomass
- Dead Wood
- Litter or Forest Floor
- Soil Organic Carbon

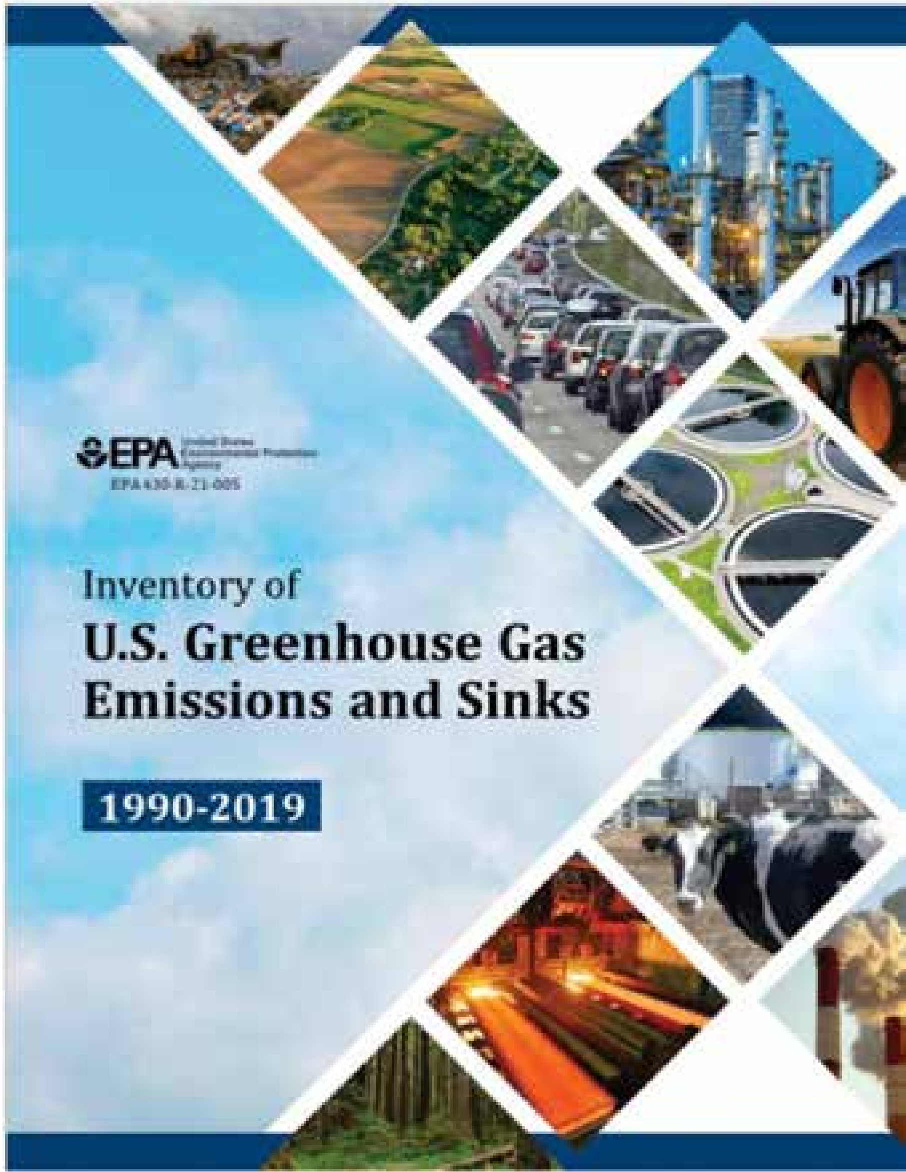
Source: https://usaforests.org/

Carbon Storage in Harvested Wood Products

As of 2020, the carbon stock for Harvested **Wood Products in Use** in the conterminous 48 states and Alaska is estimated at **1,532 Million Metric Tons**.



Carbon Stocks in Forest Land and Harvest Wood Pools, 2020



https://www.epa.gov/sites/production/files/2021-04/documents/us-ghg-inventory-2021-main-text.pdf

Carbon Storage

Wood ≈ 50% Carbon (dry weight)

Image: Kaiser + Path

Image: Lever Architecture

Carbon vs CO_2

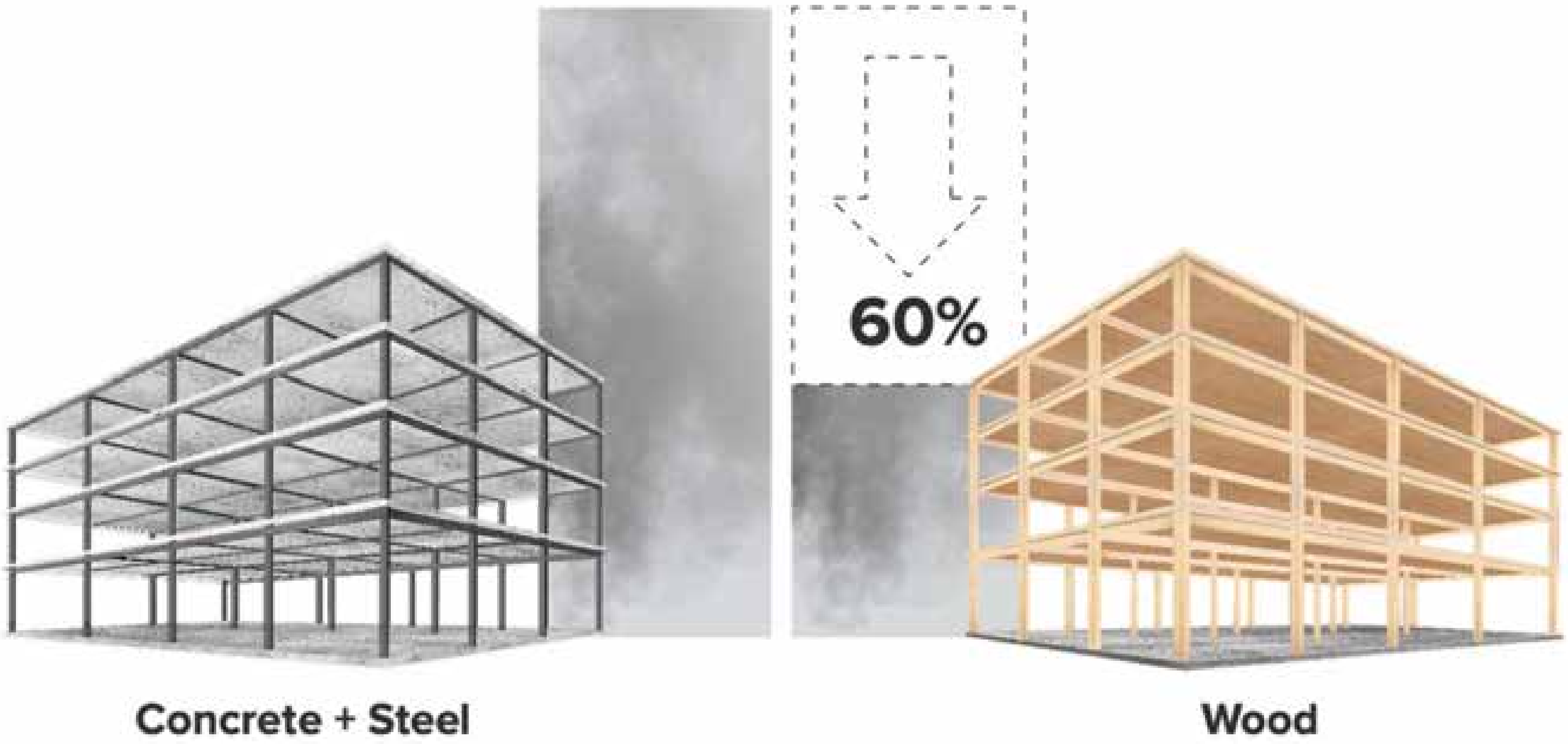
+ 2 *

= 44 CO_2

1 ton Carbon ≠ 1 ton CO_2

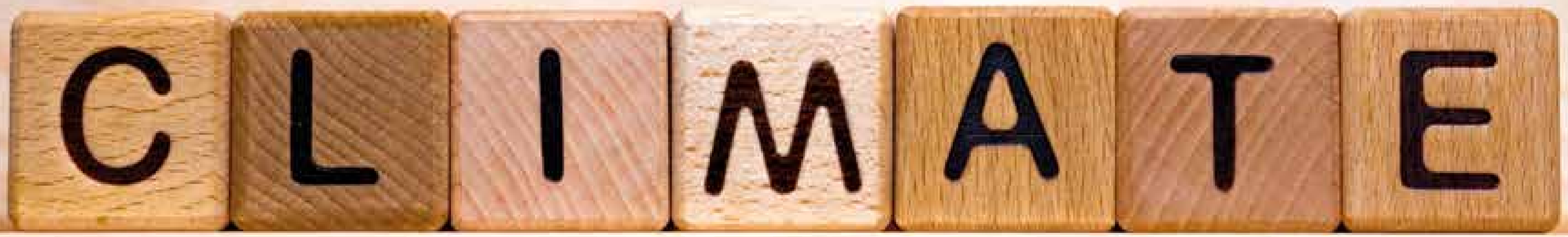
1 ton Carbon = (44/12=) **<u>3.67</u> tons CO_2**

Using life cycle analysis, researchers found that substituting wood for concrete and steel in commercial buildings **cut GHG emissions** by an average of 60%.



Source: Use of structural wood in commercial buildings reduces greenhouse gas emissions, Oregon State University, 2017.

Tools to Evaluate Carbon Impact



Whole Building Life Cycle Assessment (WBLCA)

“Evaluation of the inputs, outputs, and potential environmental impacts… throughout its life cycle”

- WBLCA covers all stages in the life cycle of a building and its components
- Several tools available; various methodologies
- https://www.thinkwood.com/education/calculate-wood-carbon-footprint
- https://www.thinkwood.com/blog/understanding-the-role-of-embodied-carbon-in-climate-smart-buildings

Photo: DPR Office, SmithGroup, photo Chad Davies

Resources from WoodWorks

Whole Building Life Cycle Assessment (WBLCA)

- Introduction to Whole Building Life Cycle Assessment: The Basics

Biogenic Carbon and Carbon Storage

- When to Include Biogenic Carbon in an LCA
- How to Include Biogenic Carbon in an LCA
- Biogenic Carbon Accounting in WBLCA Tools
- Long-Term Biogenic Carbon Storage
- Calculating the Carbon Stored in Wood Products

Environmental Product Declarations (EPDs)

- Current EPDs for Wood Products
- How to Use Environmental Product Declarations

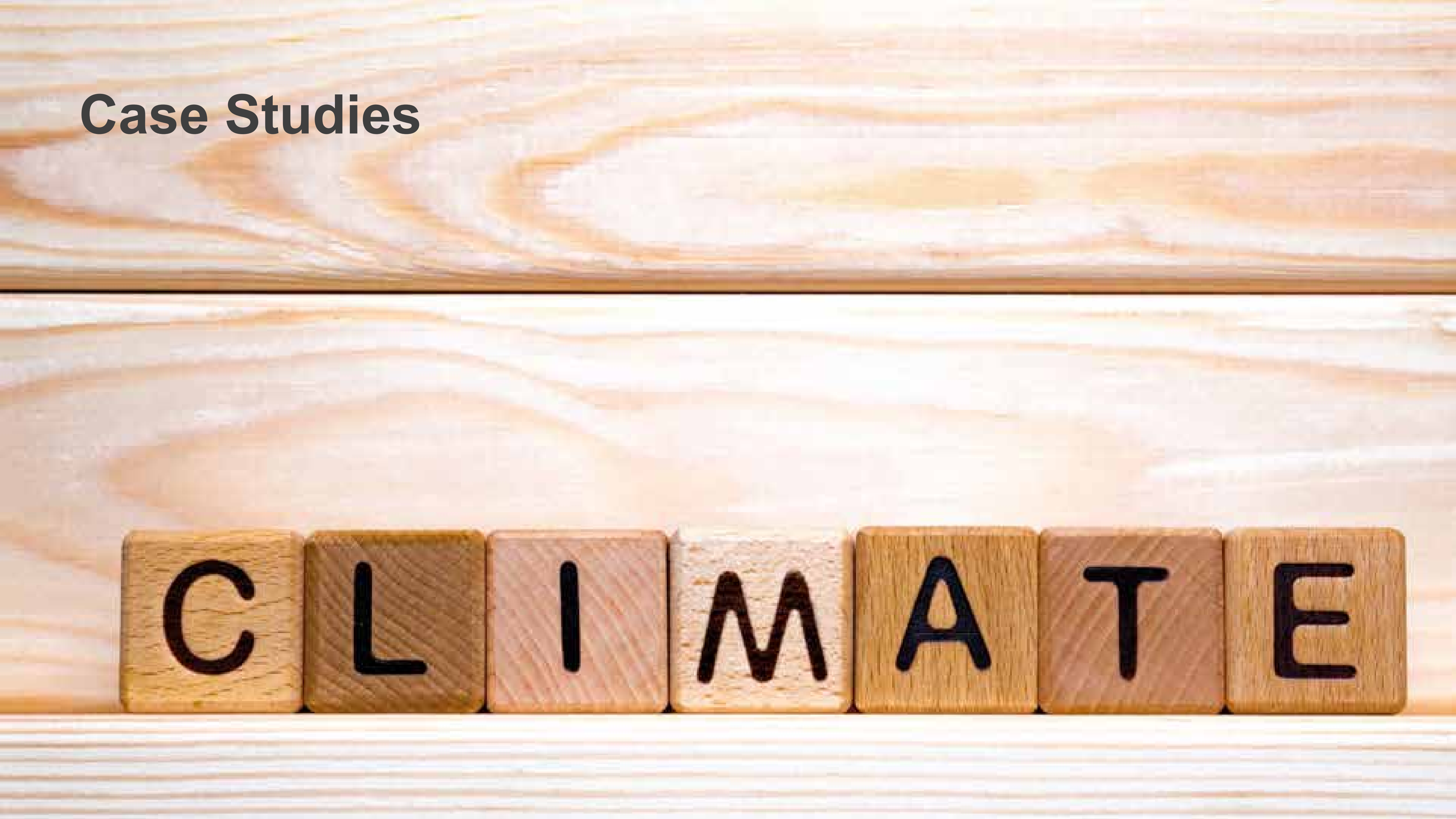
Scan to view

WoodWorks Carbon Calculator

- Available at **woodworks.org**
- Estimates total wood mass in a building
- Provides **estimated** carbon impacts:
    - Amount of **carbon stored** in wood
    - Amount of **greenhouse gas emissions avoided** by choosing wood over a non-wood material

http://www.woodworks.org/carbon-calculator-download-form/

Case Studies



Bullitt Center
Seattle, WA

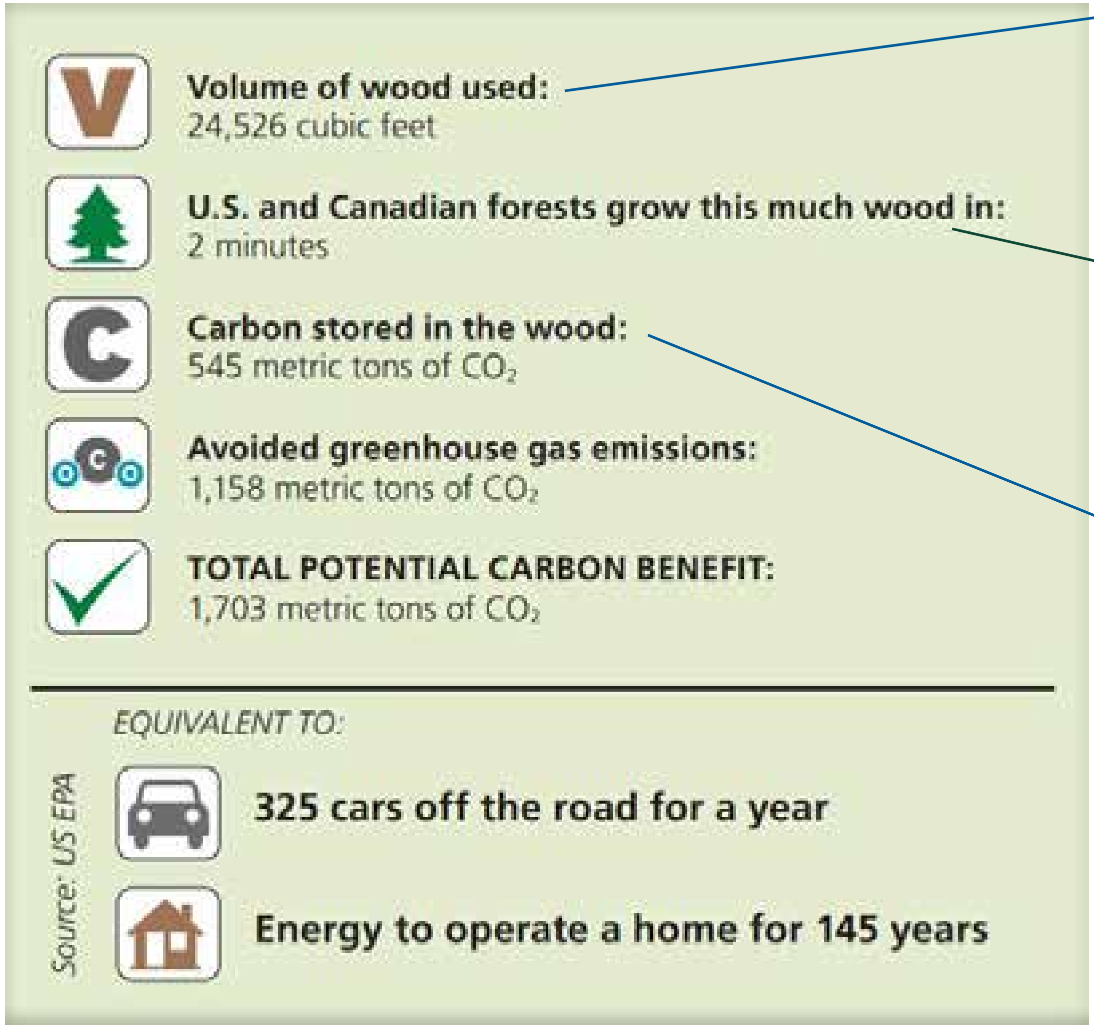

Photo: John Stamets

Architect: The Miller Hull Partnership
Structural Engineer: DCI Engineers

IV (HT)

- Designed for a **250-year** life span
- Met criteria for **Living Building Challenge 2.0**
- Rooftop photovoltaic cells generate electricity for the building; building recycles its own water
- 6 over 2 design; 52,000 sf
- Heavy timber frame: glulam and NLT panels

Bullitt Center
Seattle, WA

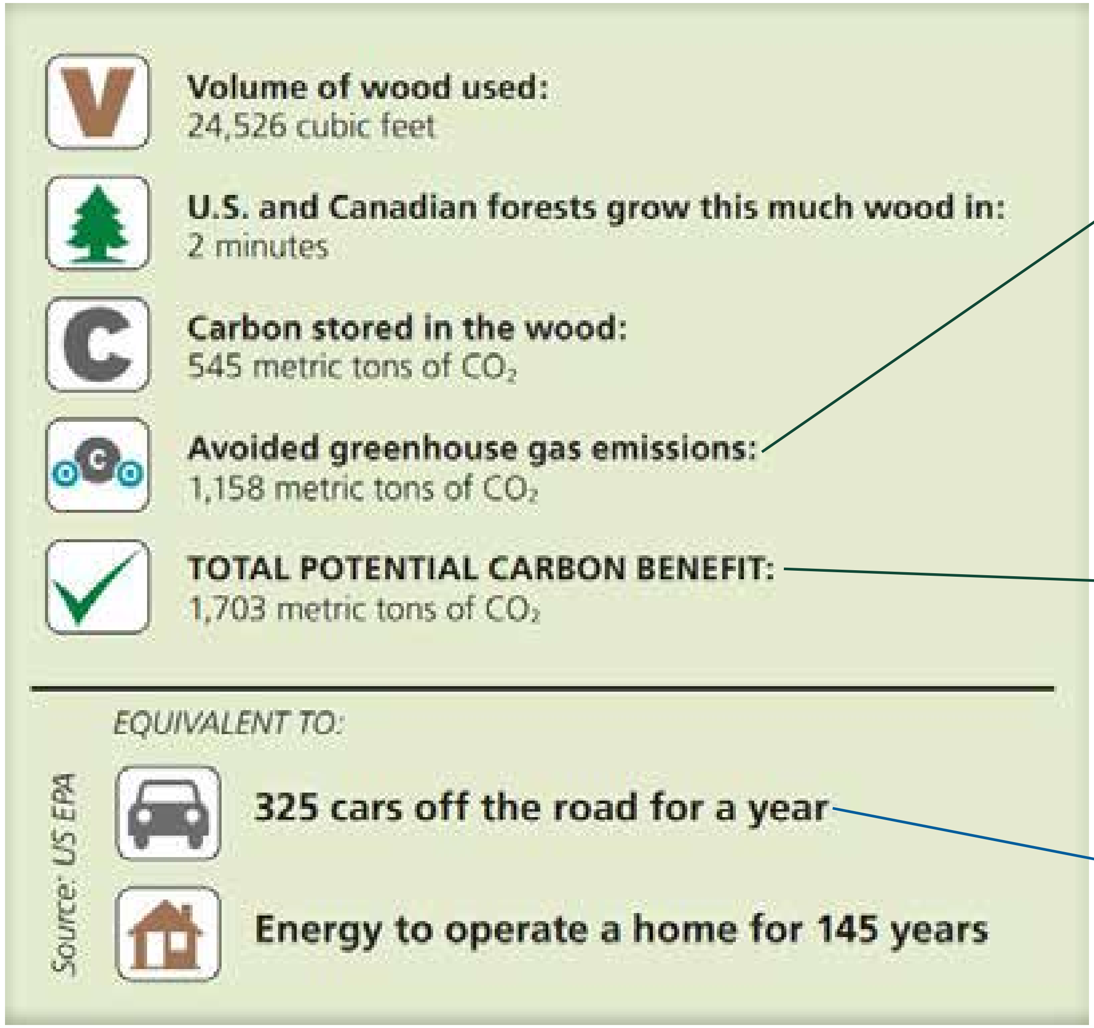


Volume of wood:
Based on user inputs

Volume of Wood → Volume of Logs → Volume of Trees → Tree Growth Rate

Volume of Wood → Mass of Wood → Mass of Carbon (50% of wood) → Mass of CO_2 (3.67 x mass of Carbon)

Bullitt Center
Seattle, WA



Emissions avoided by choosing wood over alternative building material based on building type

Total Potential Carbon Benefit = Carbon Stored + Emissions Avoided

Convert Total Potential Carbon Benefit to laypersons' terms like emissions from operating a car or a home

1430 Q

Sacramento, CA

III-A

- **6 stories of wood + mezzanine** over 2-story concrete podium (IIIA over IA)
- 63,000 square feet
- **First** of its kind in USA
- Needed 6 floors of residential units to make the project viable
- Concrete and steel were too expensive

Architect: HRGA, The HR Group Architects
Structural Engineer: Buehler

1430 Q
Sacramento, CA

Photo: Gary Folkins

1430 Q

Volume of wood products used:
1,708 cubic meters (60,334 cubic feet)

U.S. and Canadian forests grow this much wood in:
5 minutes

Carbon stored in the wood:
1,426 metric tons of CO_2

Avoided greenhouse gas emissions:
3,031 metric tons of CO_2

TOTAL POTENTIAL CARBON BENEFIT:
4,457 *metric tons of* CO_2

EQUIVALENT TO:

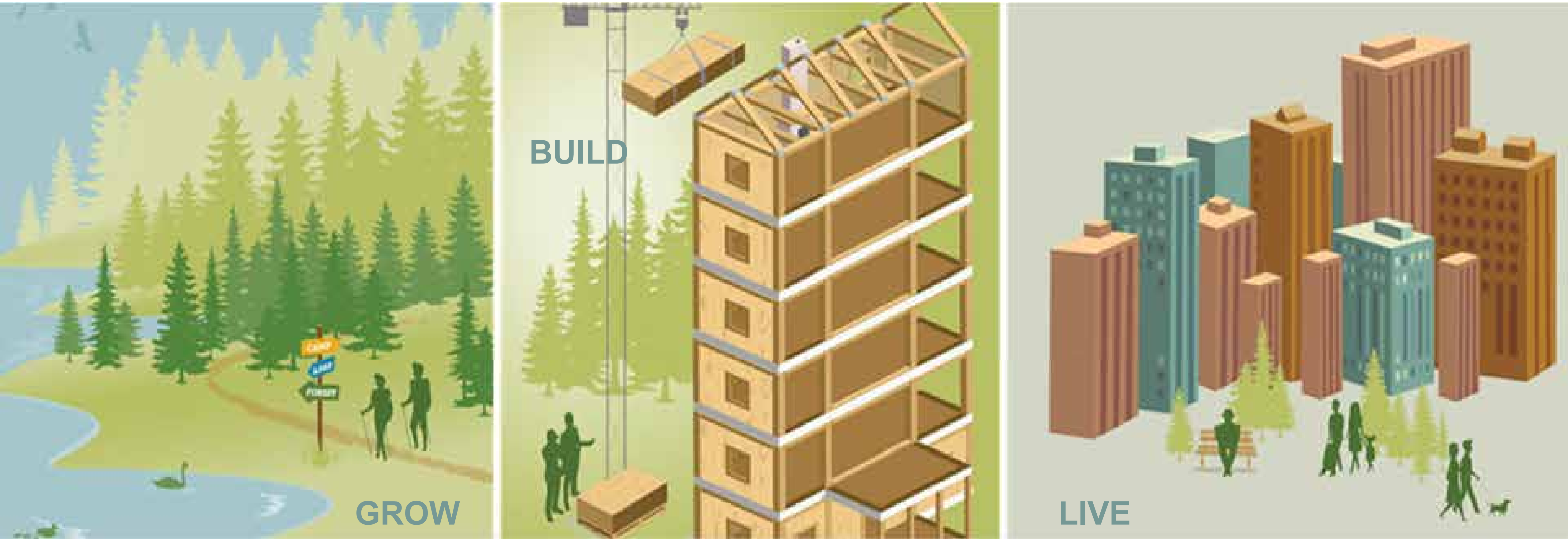
942 cars off the road for a year

Energy to operate 471 homes for a year

Source: US EPA

Estimated by the Wood Carbon Calculator for Buildings, based on research by Sarthre, R. and J. O'Connor, 2010, A Synthesis of Research on Wood Products and Greenhouse Gas Impacts, FPInnovations. Note: CO_2 on this chart refers to CO_2 equivalent.

Forest to Cities
A Systemic Solution in Action



www.ForesttoCities.org

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Questions? Ask us anything.

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901 East Sixth, Thoughtbarn-Delineate Studio, Leap!Structures, photo Casey Dunn