



Realizing Mass Timber's Benefits: Key Design Decisions and Carbon Analysis

September 30, 2026

Presented by:

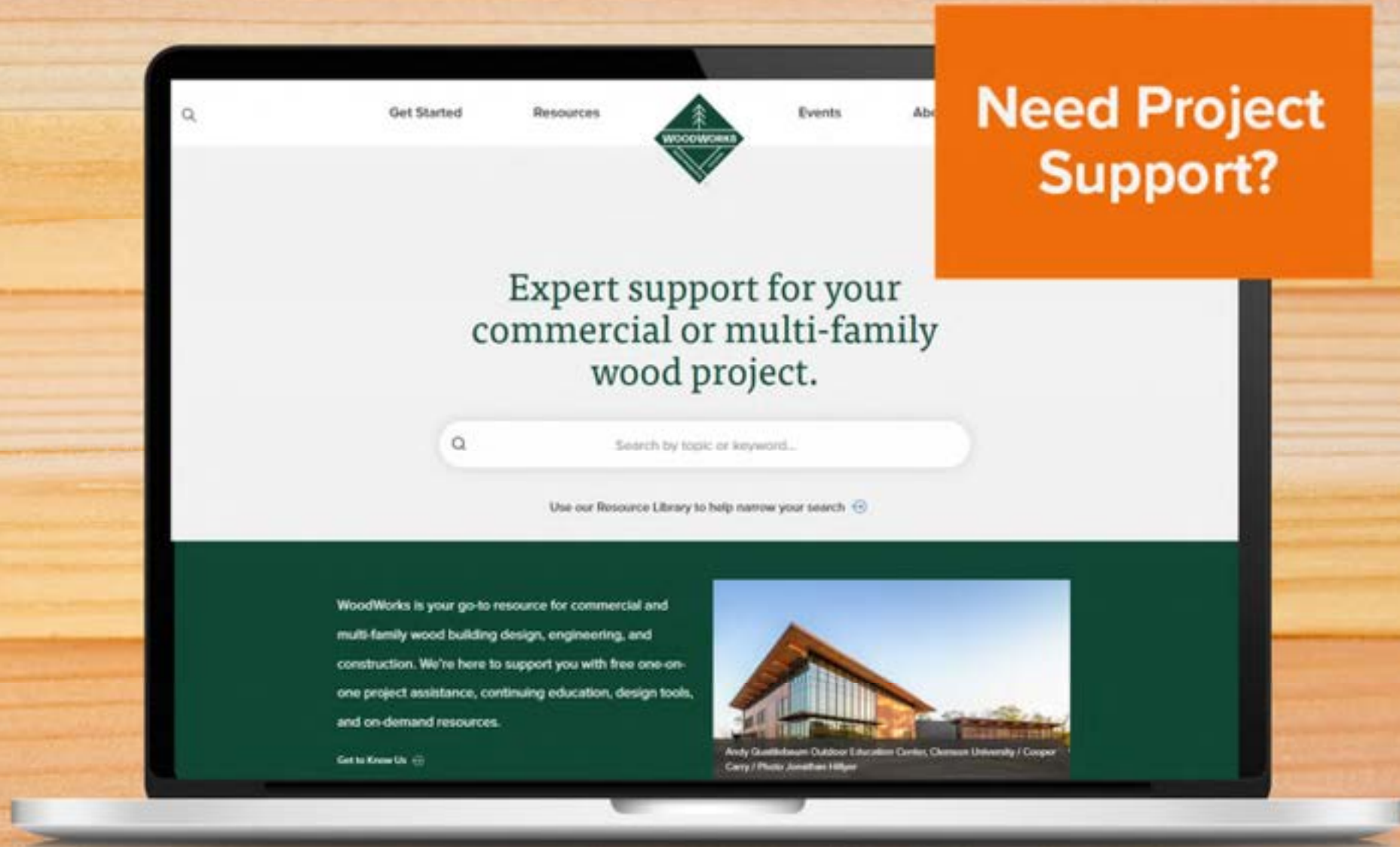
Kate Carrigg, PE
WoodWorks

Image: Shortstack Mississippi, Works Architecture, DCI Engineers, Joshua James Huff Photography

Regional Directors: One-on-One Project Support

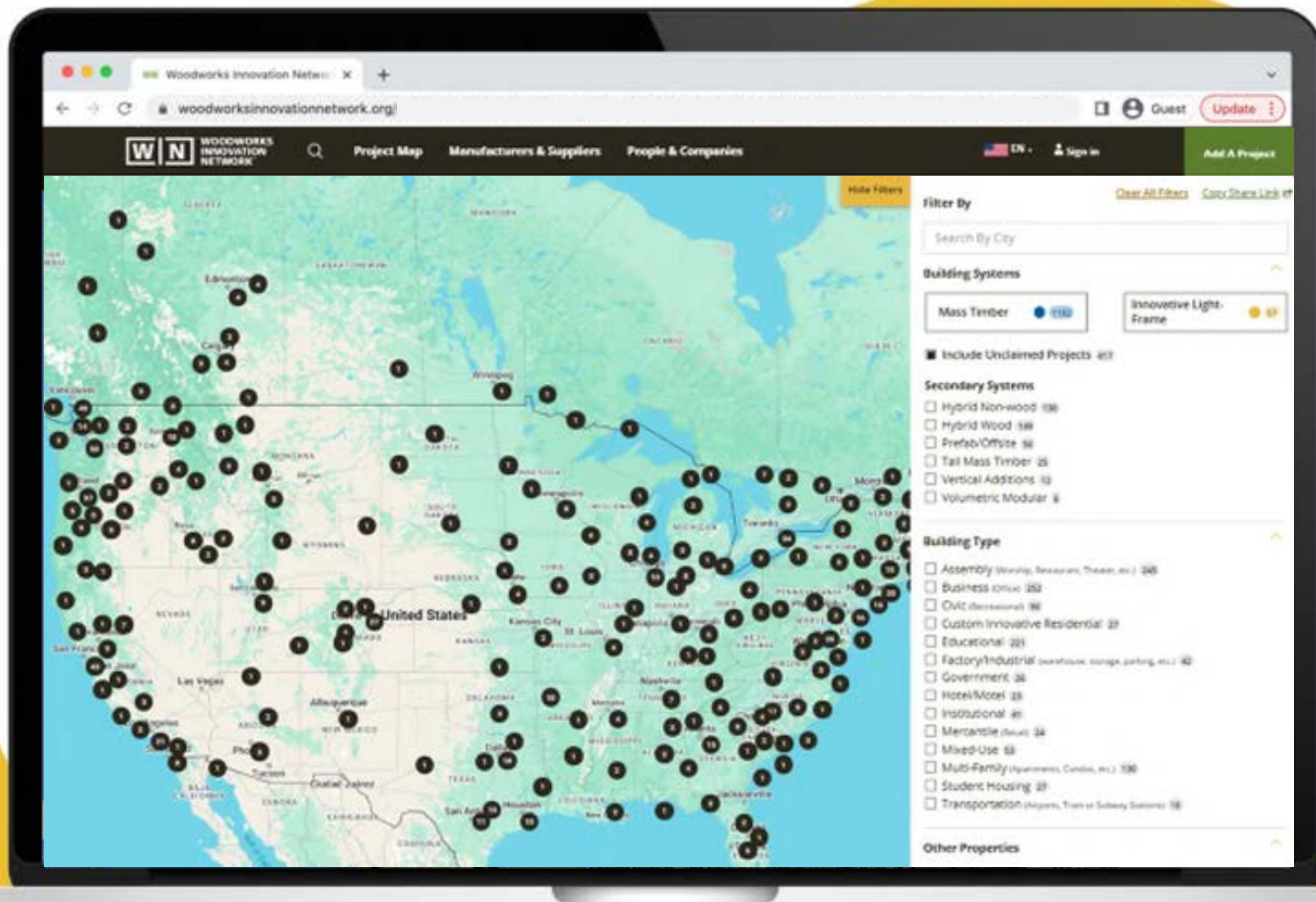


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Attendee Notes

1. To receive a certificate of completion, stay on for the duration of the webinar.
2. Certificates will be sent via email withing a few days.
3. The PDF of today's presentation can be found on WoodWorks.org under the *Events* tab—then *Presentation Archives*.





Agenda

Realizing Mass Timber's Benefits: Key Design Decisions and Carbon Analysis

11:00 am – 11:05 am

Welcome

11:05 am – 12:05 pm

Presentation

12:05 pm – 12:10 pm

Break

12:10 pm – 1:10 pm

Presentation

1:10 pm – 1:30 pm

Q&A (optional)

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



Course Description

Mass timber is a unique, non-commodity building material and, to lay the groundwork for success, certain critical decisions must be made as early as possible. These decisions can have a big impact on cost, and can either increase or limit the opportunities available later in design. This presentation will examine early project decisions and design steps, focusing on how to optimize projects for mass timber to avoid price premiums. Topics will include construction types, fire ratings, column grids and beam/panel spans, acoustics, and MEP integration. Completed mass timber projects will be presented to illustrate the variety of viable options when navigating these key decisions.

Another important topic in mass timber building design is understanding how building material choice contributes to carbon impact. As more building designers utilize life cycle assessment (LCA) to compare the environmental performance of material and design alternatives, questions arise about how wood products and buildings should be analyzed. Most designers recognize the carbon-storing capability of wood but are unsure how to include it in their carbon analysis. This course will provide an in-depth look at biogenic carbon accounting, including when and how it should be counted, as well as a discussion of end-of-life assumptions.

Learning Objectives

1. Discuss the impacts of construction type on required fire-resistance ratings of structural elements, noting the impacts that these ratings have on member spans and resulting grids.
2. Highlight effective methods of integrating MEP services in a mass timber building and discuss the relative impacts of each on cost, aesthetics, occupant comfort, and future tenant renovations.
3. Define biogenic carbon and understand how to calculate the amount of carbon stored in wood products.
4. Explain biogenic carbon removals, emissions, and exports at each stage of a wood product's life cycle, in alignment with ISO standards.

LEED Credits for Use of Wood Products



*Overview plus
in-depth resource for
understanding the
contribution of structural
wood products to LEED
certification*

The LEED Platinum and Living Building Challenge-certified Kendeda Building for Innovative Sustainable Design / The Miller Hull Partnership with Lord Aeck Sargent / photo Jonathan Hillyer

Wood in LEED

VERSION 5



Wood can contribute up to **20 points**

- » More than in previous versions
- » Related to increased focus on decarbonization

Source: *Dovetail Partners*



Oregon Zoo Education Center, Opsis
Architecture, Photo: Christian Columbres

Wood in LEED

VERSION 5



Potential Wood Points:

LEED v5 Credit	Potential Points
MRp2: Qualify and Assess Embodied Carbon	0 (pre-req)
MRc1: Building and Materials Reuse	1-2
MRc2: Reduce Embodied Carbon	1-6
MRc3: Low-Emitting Materials	1-2
MRc4: Building Product Selection and Procurement	1-5
MRc5: Construction and Demolition Waste Diversion	1-2
EQc2: Occupant Experience	1-3

Source: *Dovetail Partners*

Wood in LEED

VERSION 5

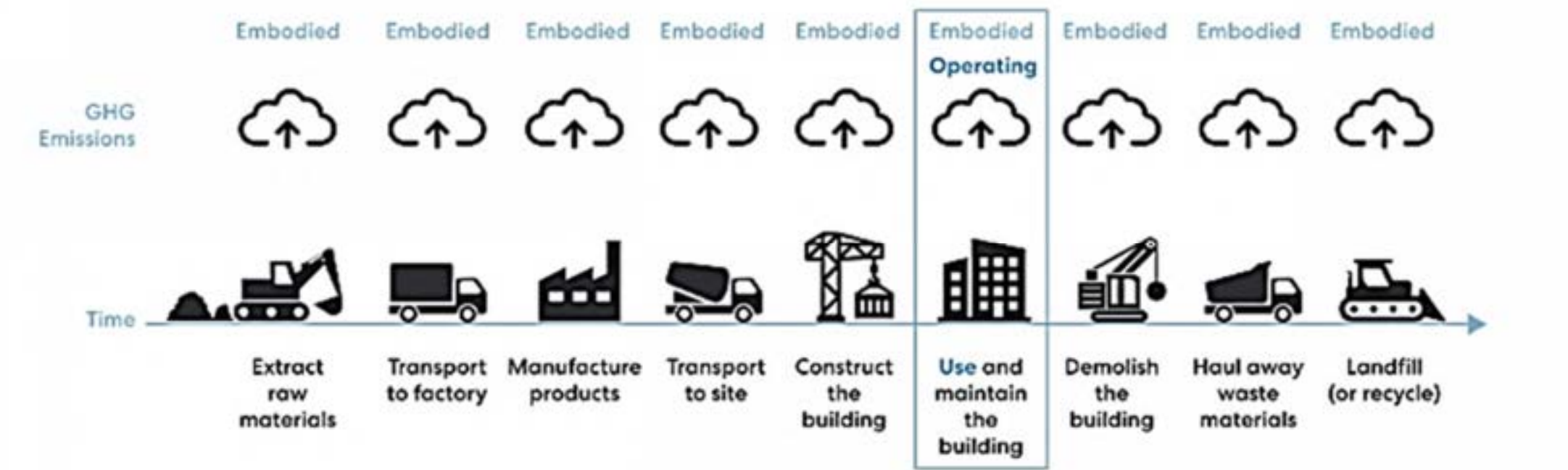


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EQc2: Occupant Experience	1-3

Source: *Dovetail Partners*

Embodied Carbon



Life Cycle Assessment (LCA)

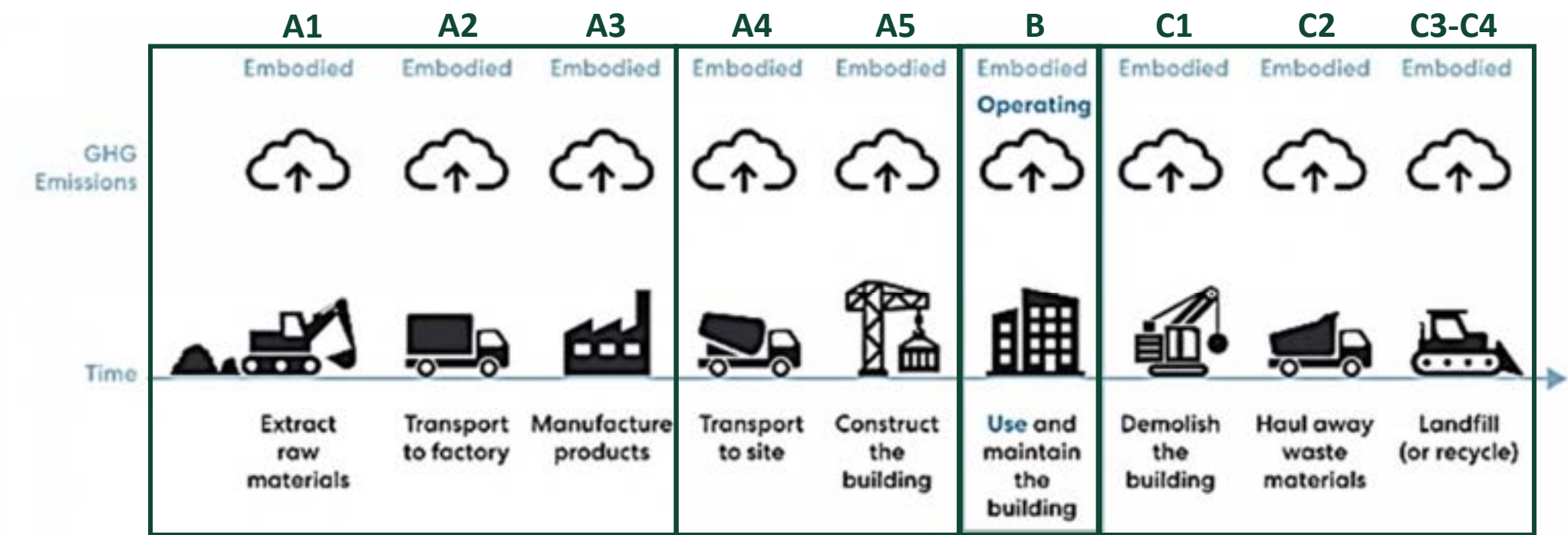
“Evaluation of the inputs, outputs, and potential environmental impacts of a product system throughout its life cycle”

- » Systematic, scientific **quantification**

Used for:

- » Single products or processes: e.g., a wood product
- » Complex, integrated systems: e.g., an entire building (**Whole Building Life Cycle Assessment - WBLCA**)

Life Cycle Assessment (LCA)



Wood in LEED

VERSION 5

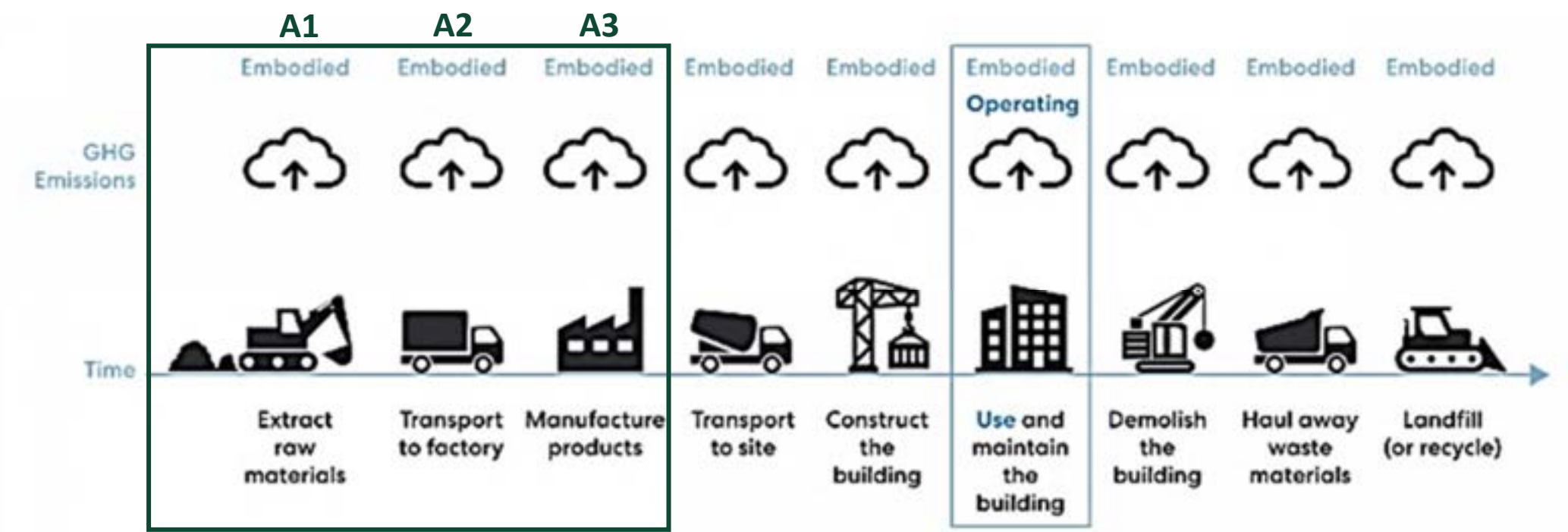


Potential Wood Points:

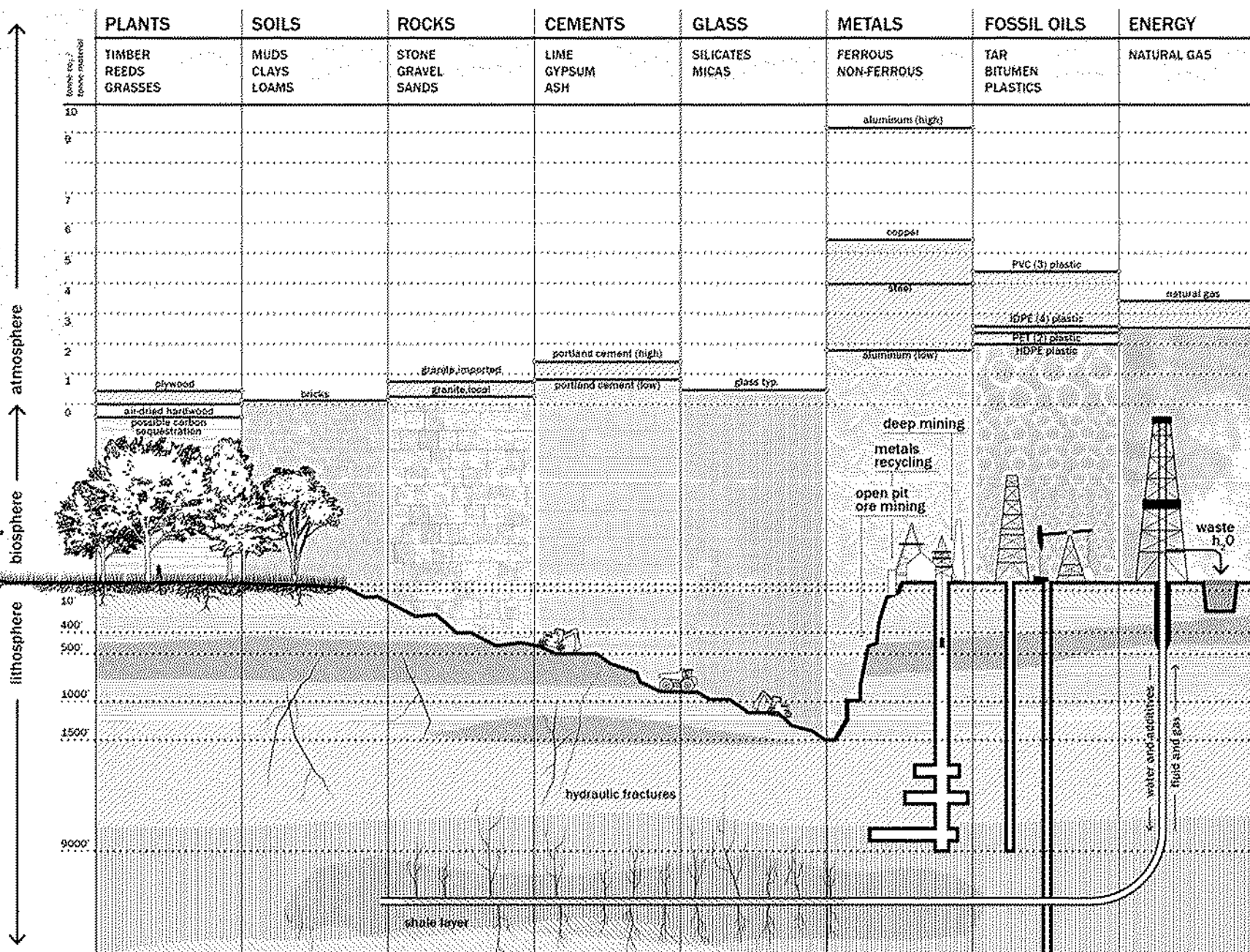
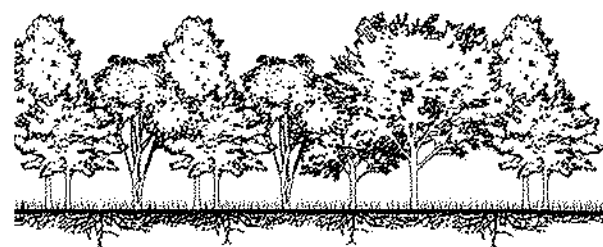
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EQc2: Occupant Experience	1-3

Source: *Dovetail Partners*

Life Cycle Assessment (LCA)



Extractivism and its Impacts



Production Stage: A1-A3

Starts at first point of human intervention

A1: Extraction and upstream production

» Raw material extraction or harvest

A2: Transport to factory

» Transportation of raw materials to the factory or mill

A3: Manufacturing

» Manufacturing of the product itself

Includes:

- Forest road construction
- Fertilization
- Precommercial thinning
- Harvest (felling, skidding)
- Growing seedlings (greenhouse operations)
- Planting seedlings

Production Stage: A1-A3

A1: Extraction and upstream production

» Raw material extraction or harvest

A2: Transport to factory

» Transportation of raw materials to the mill or factory

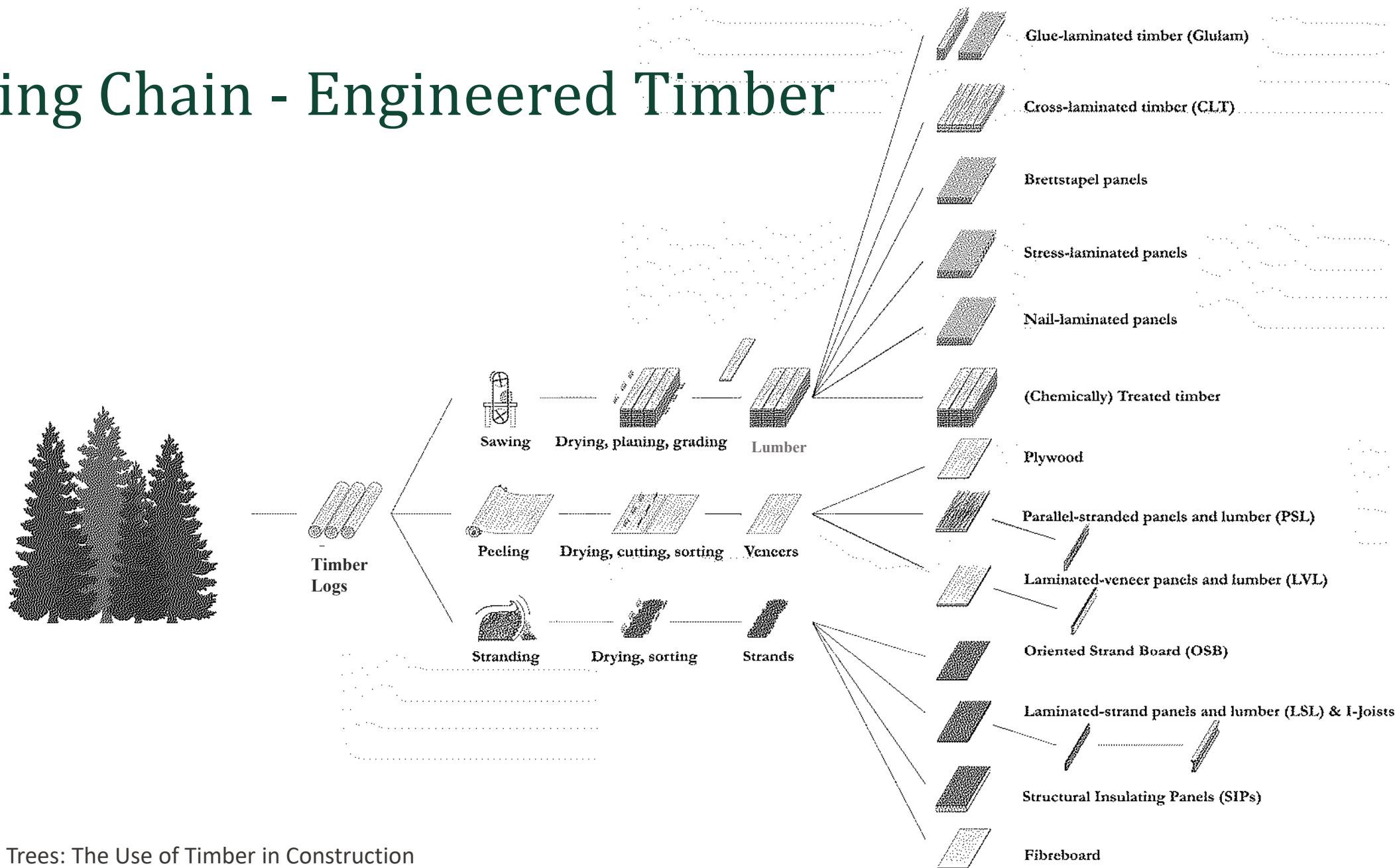
Diesel powered trucks



A3: Manufacturing

» Manufacturing of the product itself

Processing Chain - Engineered Timber



Production Stage: A1-A3

A1: Extraction and upstream production

» Raw material extraction or harvest

A2: Transport to factory

» Transportation of raw materials to the mill or factory

A3: Manufacturing

» Manufacturing of the product itself

Includes:

- Debarking logs
- Sawing logs into rough sawn lumber
- Drying lumber
- Planing to final size
- Additional manufacturing and fabrication as required

Harvested Wood Products

- **Solid sawn** wood product:
 - » **Lowest embodied** carbon
- **Engineered** wood products:
 - » More processing steps (more embodied carbon)
 - » **Significantly less embodied carbon** than non-wood

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



Image: Weyerhaeuser



Image: LP Building Solutions



Image: Structurecraft



Image: Georgia-Pacific

Whole Building Life Cycle Assessment

Mass Timber Building vs **Steel or Concrete Building**

requires

Functional Equivalency

Functional Equivalency



Concrete Slab:

6" Thick

80 PSF



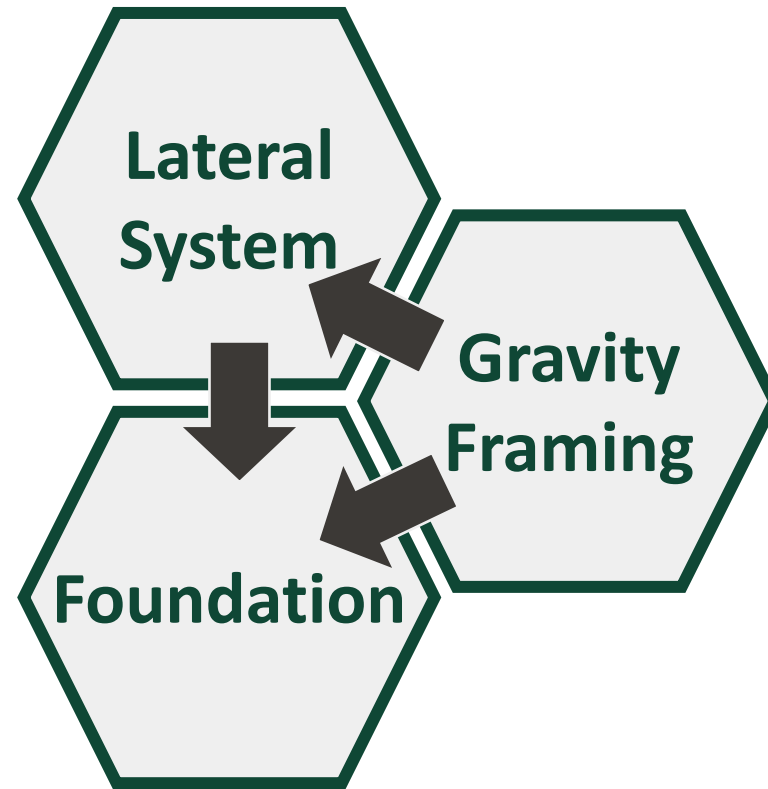
CLT Slab:

6-7/8" Thick

18 PSF

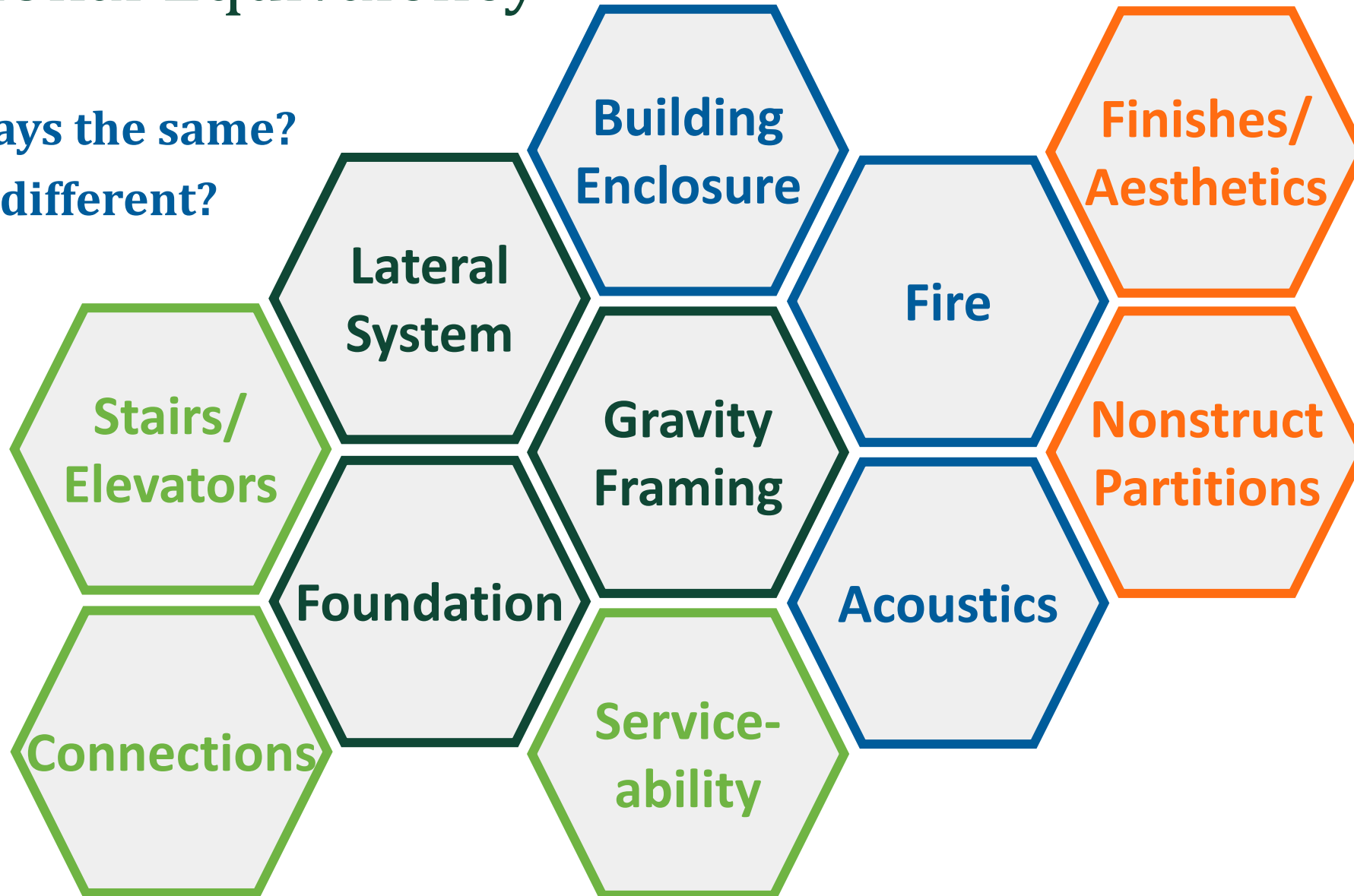


Functional Equivalency



Functional Equivalency

What stays the same?
What is different?



Wood in LEED

VERSION 5



Potential Wood Points:

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MRp2: Qualify and Assess Embodied Carbon	0 (pre-req)
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EQc2: Occupant Experience	1-3

Source: *Dovetail Partners*

Key Early Design Decisions

What is the Single Most Important Early Design Decision on a Mass Timber Project?

Construction Type	MEP Layout
Fire-Resistance Ratings	Acoustics
Member Sizes	Concealed Spaces
Grids & Spans	Connections
Exposed Timber (where & how much)	Penetrations

They All Need to Be Weighed (Plus Others)

Key Early Design Decisions

Early = Efficient

Realize Efficiency in:

- » Cost reduction
- » **Material use (optimize fiber use, minimize waste)**
- » Construction speed
- » Trade coordination
- » Minimize RFIs

Commit to a mass timber design from the start

MASS TIMBER IN THE CODE



Construction Types

When does the code allow mass timber to be used?

Permitted anywhere that ***combustible materials*** and ***heavy timber*** are allowed, plus more...



Construction Types

IBC Section 2304.11:

**TABLE 2304.11
MINIMUM DIMENSIONS OF HEAVY TIMBER STRUCTURAL MEMBERS**

SUPPORTING	HEAVY TIMBER STRUCTURAL ELEMENTS	MINIMUM NOMINAL SOLID SAWN SIZE		MINIMUM GLUED- LAMINATED NET SIZE		MINIMUM STRUCTURAL COMPOSITE LUMBER NET SIZE	
		Width, inch	Depth, inch	Width, inch	Depth, inch	Width, inch	Depth, inch
Floor loads only or combined floor and roof loads	Columns; Framed sawn or glued- laminated timber arches that spring from the floor line; Framed timber trusses	8	8	6 ³ / ₄	8 ¹ / ₄	7	7 ¹ / ₂
	Wood beams and girders	6	10	5	10 ¹ / ₂	5 ¹ / ₄	9 ¹ / ₂
Roof loads only	Columns (roof and ceiling loads); Lower half of: wood-frame or glued- laminated arches that spring from the floor line or from grade	6	8	5	8 ¹ / ₄	5 ¹ / ₄	7 ¹ / ₂
	Upper half of: wood-frame or glued- laminated arches that spring from the floor line or from grade	6	6	5	6	5 ¹ / ₄	5 ¹ / ₂
	Framed timber trusses and other roof framing; ^a Framed or glued- laminated arches that spring from the top of walls or wall abutments	4 ^b	6	3 ^b	6 ⁷ / ₈	3 ¹ / ₂ ^b	5 ¹ / ₂

Construction Types

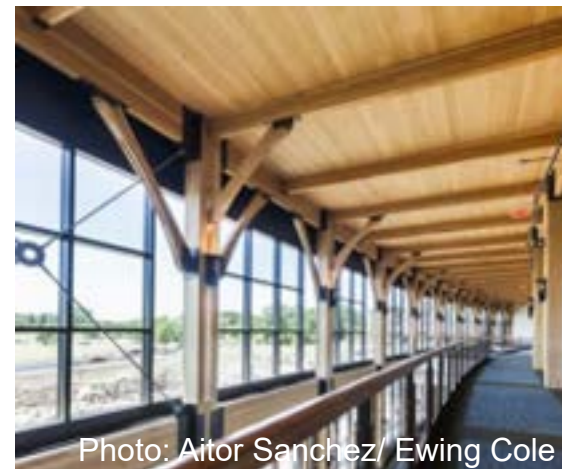
IBC Section 2304.11:

Floor Panels / Decking

- » CLT: 4" thick (actual)
- » NLT/DLT/GLT: 4" thick (nominal) or
Decking: 3" thick (nominal)
 - » Covered with: 1" tongue-and-groove
or 15/32" WSP or 1/2" particleboard

Roof Panels/Decking:

- » 3" thick CLT (actual thickness)
- » 3" NLT/DLT/GLT (nominal thickness)
- » 2" thick (nominal) decking



Construction Types

IBC defines 5 construction types. A building must be classified as one of these:

I, II, III, IV, V

Construction Types I & II:

All elements required to be non-combustible materials

» However, there are exceptions for mass timber

Construction Types I-B, II-A, II-B

Timber Roof Construction

- » **IBC Table 601**, Footnote c:
 - » In all occupancies, heavy timber complying with Section 2304.11 shall be allowed for roof construction, including primary structural frame members, where a 1-hour or less fire-resistance rating is required.

Wellesley College, Wellesley, MA



Wellesley College Science Complex / Skidmore, Owings & Merrill / Le Messurier / Photo Dave Burk © SOM

Control Layer Continuity for Mass Timber Building Enclosure Design

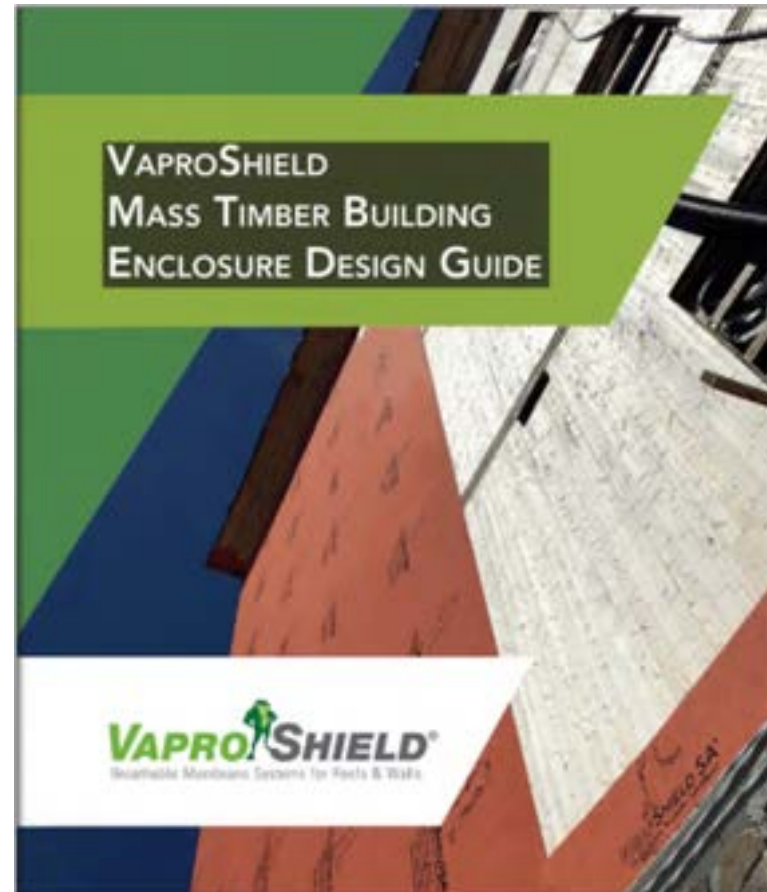


Introductory level design guidance and effective practices for durable mass timber building enclosures

RDH Building Science Inc.

Building Envelope: Mass Timber Detailing Guides

These are two great guides with example building envelope details for mass timber.



Mid-Rise Construction Types

Type V

- » All building elements any allowed by code

Type III

- » Interior elements any allowed by code
- » Exterior walls non-combustible (may be light frame FRTW)

Type IV (A, B, C, HT)

All building elements mass timber or non-combustible

- » For IV-HT, exterior walls may also be FRTW, including light frame
- » For IV-HT, interior elements may also be 1-hour FRR light frame

Construction Types IV-HT

Type IVHT Minimum Dimensions (IBC Section 2304.11)

- » Interior Walls
 - » Laminated construction: 4" thick
 - » Solid wood construction: Min (2) layers of 1" matched boards
 - » Wood stud walls, 1-hour min
 - » Non-combustible, 1-hour min



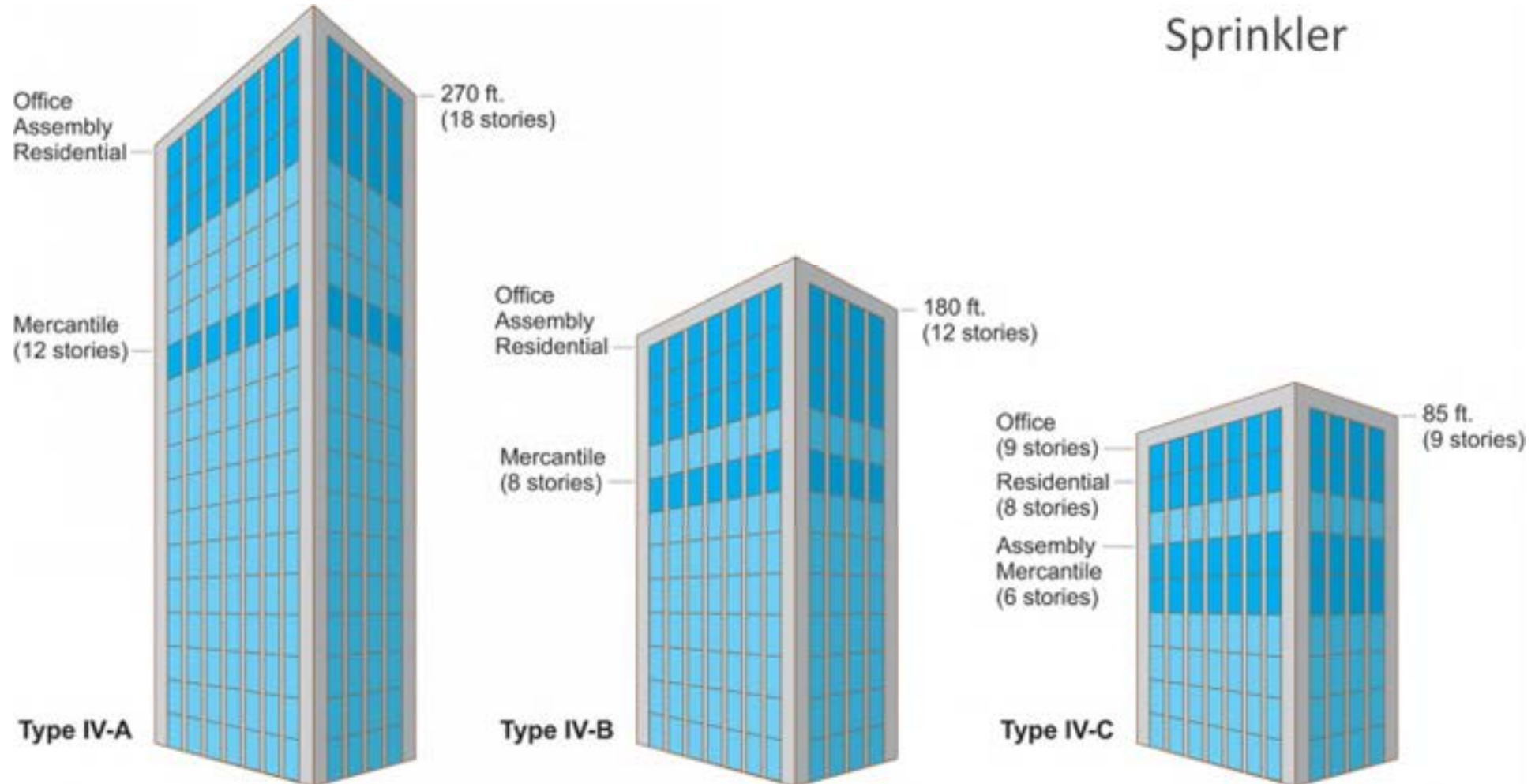
Key Early Design Decisions

Construction Type – Primarily based on building size & occupancy

	Construction Type (All Sprinklered Values)							
	IV-A	IV-B	IV-C	IV-HT	III-A	III-B	V-A	V-B
Occupancies	Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)							
A, B, R	270	180	85	85	85	75	70	60
	Allowable Number of Stories above Grade Plane (IBC Table 505.4)							
A-2, A-3, A-4	18	12	6	4	4	3	3	2
B	18	12	9	6	6	4	4	3
R-2	18	12	8	5	5	5	4	3
	Allowable Area Factor (At) for SM, Feet ² (IBC Table 506.2)							
A-2, A-3, A-4	135,000	90,000	56,250	45,000	42,000	28,500	34,500	18,000
B	324,000	216,000	135,000	108,000	85,500	57,000	54,000	27,000
R-2	184,500	123,000	76,875	61,500	72,000	48,000	36,000	21,000

Construction Types IV-A,B,C

New Options in 2021 IBC
Allowable mass timber building size for
group B occupancy with NFPA 13
Sprinkler



Noncombustible Protection (NC)

IV-C



All timber surfaces
may be exposed

IV-B



Some* timber surfaces
may be exposed

IV-A



No timber surfaces
may be exposed

Structural Warmth



TMBR (unbuilt) Minneapolis, MN | Images: D/O Architects

Wood in LEED

VERSION 5



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Source: *Dovetail Partners*

MASS TIMBER FIRE RESISTANCE



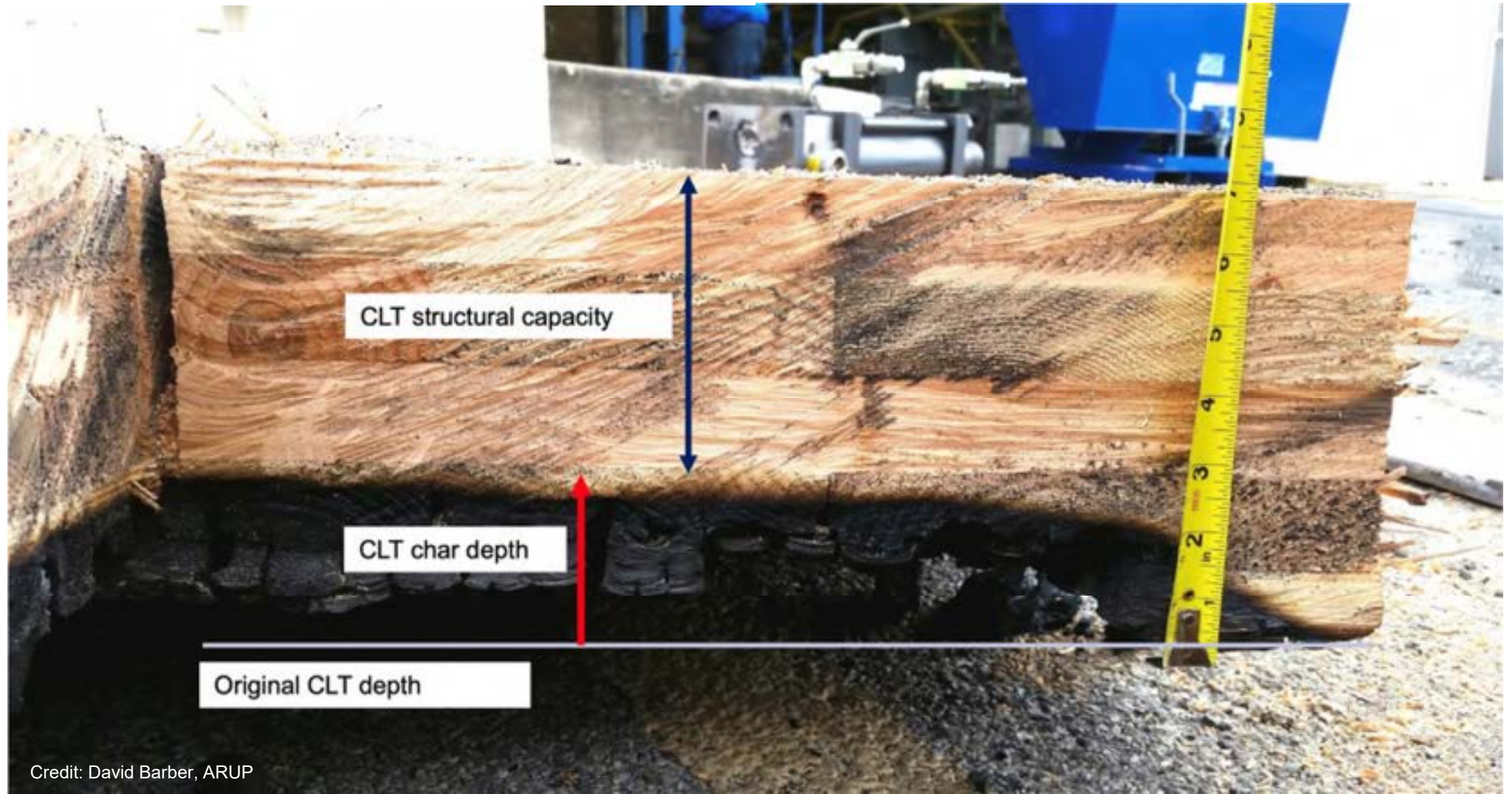
Key Early Design Decisions

Construction type influences Fire Resistance Rating

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame ^f (see Section 202)	3 ^{a, b}	2 ^{a, b, c}	1 ^{b, c}	0 ^c	1 ^{b, c}	0	3 ^a	2 ^a	2 ^a	HT	1 ^{b, c}	0
Bearing walls												
Exterior ^{e, f}	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3 ^a	2 ^a	1	0	1	0	3	2	2	1/HT ^g	1	0
Nonbearing walls and partitions Exterior	See Table 705.5											
Nonbearing walls and partitions Interior ^d	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1 ^{1/2} ^b	1 ^{b, c}	1 ^{b, c}	0 ^c	1 ^{b, c}	0	1 ^{1/2}	1	1	HT	1 ^{b, c}	0

Fire Design of Mass Timber

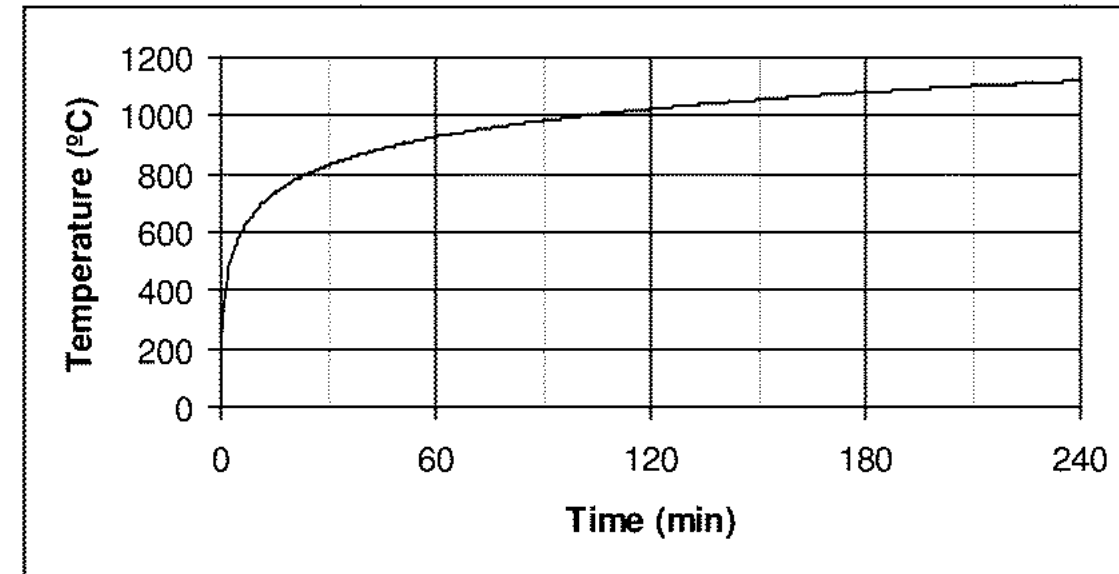


Fire Design of Mass Timber

Tested Fire Resistance Rating of Exposed Mass Timber:

IBC 703.2 notes the acceptance of Fire Resistance Rating demonstration via testing in accordance with ASTM E119

703.2 Fire-resistance ratings. The *fire-resistance rating* of building elements, components or assemblies shall be determined in accordance with the test procedures set forth in ASTM E119 or UL 263 or in accordance with Section 703.3. The *fire-resistance rating* of penetrations and *fire-resistant joint systems* shall be determined in accordance Sections 714 and 715, respectively.

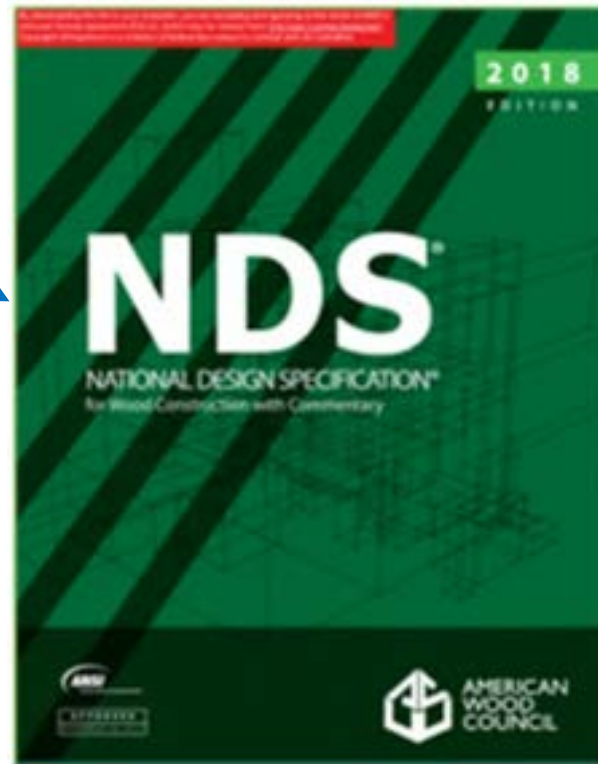


Standard ASTM E119 test time-temperature curve

Fire Design of Mass Timber

Calculated FRR of Exposed MT:

» IBC to NDS code compliance path



Code Path for Exposed Wood Fire-Resistance Calculations

IBC 703.2.2

Methods for determining fire resistance

- Prescriptive designs per IBC 721.1
- **Calculations in accordance with IBC 722**
- Fire-resistance designs documented in sources
- Engineering analysis based on a comparison
- Alternate protection methods as allowed by 104.11



IBC 722

Calculated Fire Resistance

"The calculated *fire resistance* of exposed wood members and wood decking shall be permitted in accordance with **Chapter 16 of ANSI/AWC National Design Specification for Wood Construction (NDS)**



NDS Chapter 16

Fire Design of Wood Members

- Limited to calculating fire resistance up to 2 hours
- Char depth varies based on exposure time (i.e., fire-resistance rating), product type and lamination thickness. Equations and tables are provided.
- TR 10 and NDS commentary are helpful in implementing permitted calculations.

Fire Design of Mass Timber (NDS Chapter 16)

$$a_{char} = \beta_t t^{0.813}$$

Solid Sawn, Glulam, SCL

$$a_{char} = n_{lam} h_{lam} + \beta_t \left(t - (n_{lam} t_{gl}) \right)^{0.813}$$

CLT

$$a_{eff} = 1.2a_{char}$$

Effective Char Depth

Nominal char rate of 1.5"/HR is recognized in NDS. Effective char depth calculated to account for duration, structural reduction in heat-affected zone

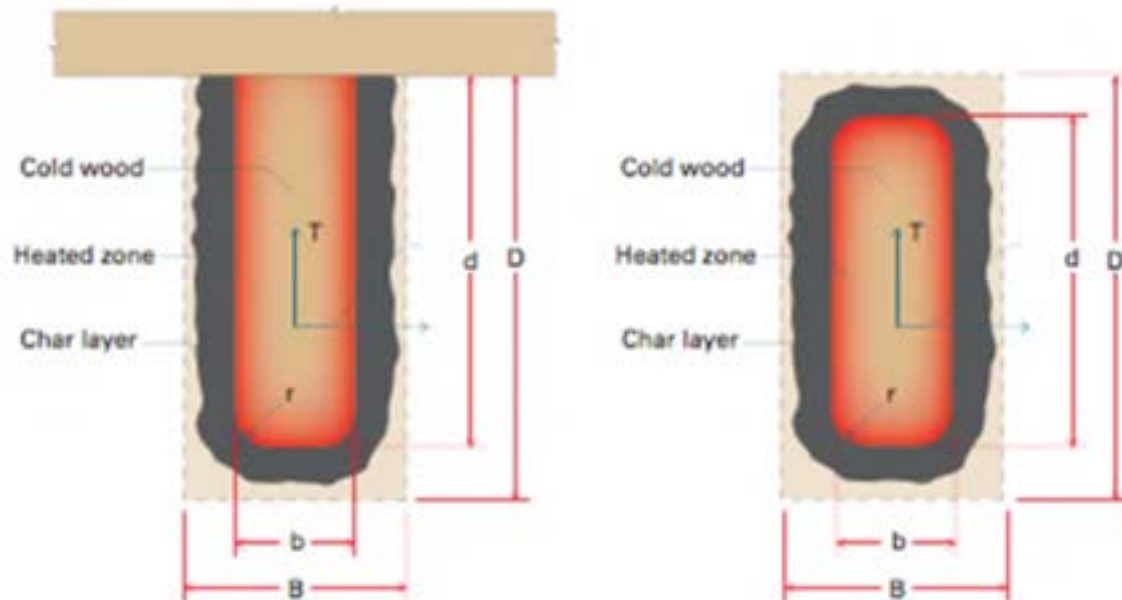
Table 16.2.1A Char Depth and Effective Char Depth (for $\beta_n = 1.5$ in./hr.)		
Required Fire Resistance (hr.)	Char Depth, a_{char} (in.)	Effective Char Depth, a_{eff} (in.)
1-Hour	1.5	1.8
1½-Hour	2.1	2.5
2-Hour	2.6	3.2

Table 16.2.1B Effective Char Depths (for CLT with $\beta_n=1.5$ in./hr.)									
Required Fire Endurance (hr.)	Effective Char Depths, a_{char} (in.)								
	lamination thicknesses, h_{lam} (in.)								
	5/8	3/4	7/8	1	1-1/4	1-3/8	1-1/2	1-3/4	2
1-Hour	2.2	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.8
1½-Hour	3.4	3.2	3.1	3.0	2.9	2.8	2.8	2.8	2.6
2-Hour	4.4	4.3	4.1	4.0	3.9	3.8	3.6	3.6	3.6

Fire Design of Mass Timber

Two structural capacity checks performed:

1. On entire cross section neglecting fire effects
2. On post-fire remaining section, with stress increases



Source: AWC's TR 10

Fire Design of Mass Timber

NDS Table 16.2.2 Design stress adjustment factors applied to adjust to average ultimate strength under fire design conditions

Table 16.2.2 Adjustment Factors for Fire Design¹

			ASD					
			Design Stress to Member Strength Factor	Size Factor ²	Volume Factor ²	Flat Use Factor ²	Beam Stability Factor ³	Column Stability Factor ³
Bending Strength	F _b	x	2.85	C _F	C _V	C _{fu}	C _L	-
Beam Buckling Strength	F _{bE}	x	2.03	-	-	-	-	-
Tensile Strength	F _t	x	2.85	C _F	-	-	-	-
Compressive Strength	F _c	x	2.58	C _F	-	-	-	C _P
Column Buckling Strength	F _{cE}	x	2.03	-	-	-	-	-

1. See 4.3, 5.3, 8.3, and 10.3 for applicability of adjustment factors for specific products.

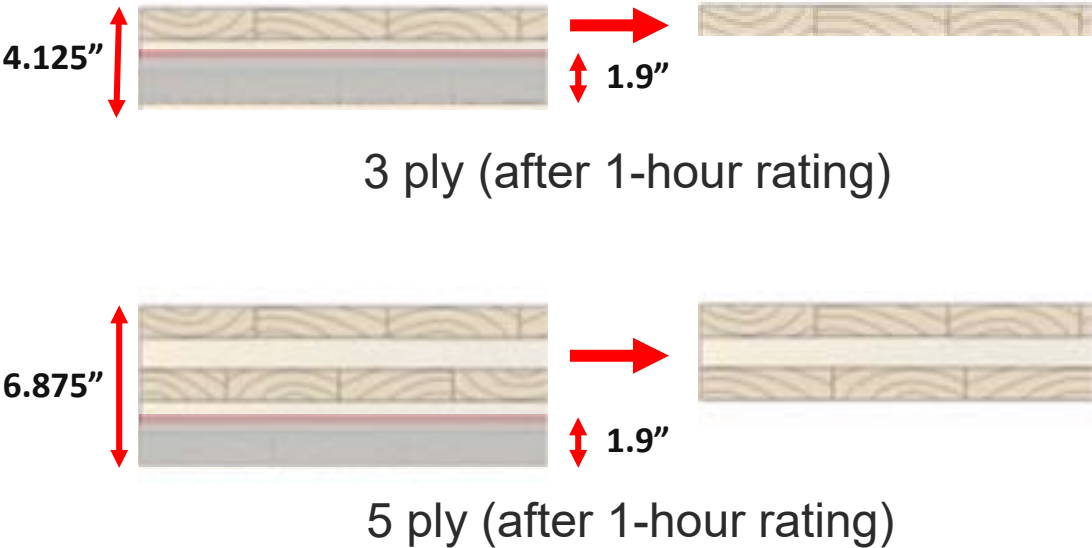
2. Factor shall be based on initial cross-section dimensions.

3. Factor shall be based on reduced cross-section dimensions.

Source: AWC's NDS

Fire Design of Mass Timber

- » Fire Resistance Ratings (FRR)
 - » Thinner panels (i.e. 3-ply) can be difficult to achieve 1+ hour FRR
 - » 5-ply CLT panels can usually achieve 1- or 2-hour FRR
 - » Construction Type -> FRR -> Member size -> Grid (order as needed)



Panel	Common Floor Span Ranges*	
	Single Span	Multi-Span
3-ply CLT (4-1/8")	10 to 13 ft	12 to 15 ft
5-ply CLT (6-7/8")	15 to 18 ft	18 to 21 ft
3" SCL CLT	8 to 10 ft	10 to 13 ft
4" SCL CLT	10 to 13 ft	12 to 15 ft
5" SCL CLT	13 to 15 ft	15 to 18 ft
2x4 NLT/DLT (3-1/2")	10 to 12 ft	12 to 14 ft
2x6 NLT/DLT (5-1/2")	15 to 17 ft	17 to 20 ft
3-1/8" GLT	9 to 11 ft	10 to 13 ft
5-1/8" GLT	14 to 16 ft	16 to 19 ft

**Examples from efficient framing layouts, NOT for final design. Allowable spans depend on loading, panel grade and lay-up, and performance criteria.*

Fire Design of Mass Timber

Chapter 16 of the 2024 NDS references the Fire Design Specification for Wood Construction



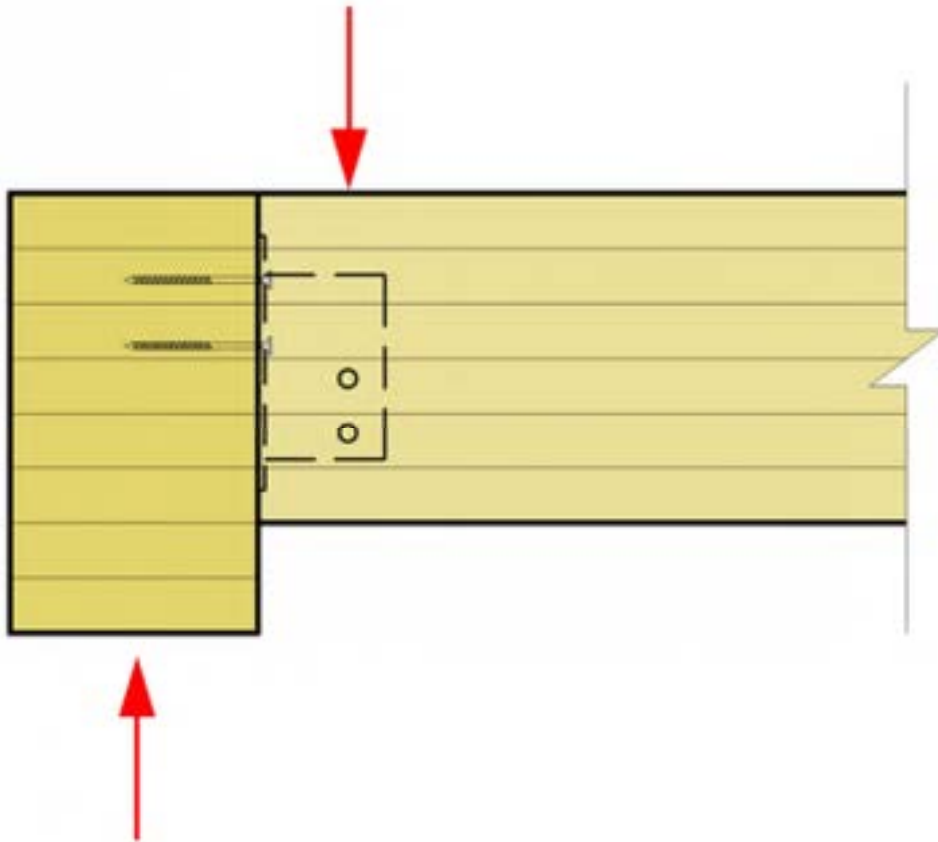
2024 NDS - 16.1 General

Where determinations of thermal separation and burn-through resistance are required, calculations shall be in accordance with the *Fire Design Specification for Wood Construction*



Connections

Steel hangers/hardware fully concealed within a timber-to-timber connection is a common method of fire protection



Connections

Connection FRR and beam reactions could impact required beam/column sizes



Photos: Simpson Strong-Tie

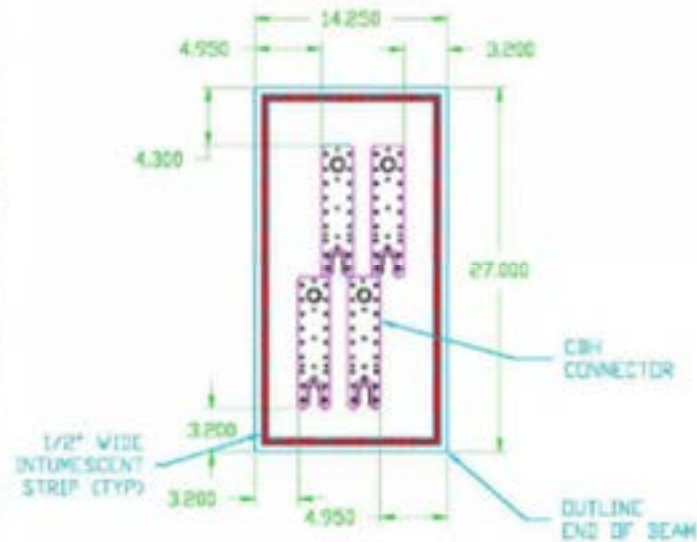


Photo: LEVER Architecture

Connections

Member to member bearing also commonly used, can avoid some/all steel hardware at connection



ACOUSTICS & SOUND CONTROL



Acoustics & Sound Control



Concrete Slab:

6" Thick

80 PSF

STC 53



CLT Slab:

6-7/8" Thick

18 PSF

STC 41



Acoustics & Sound Control

TABLE 1:
Examples of Acoustically-Tested Mass Timber Panels

Mass Timber Panel	Thickness	STC Rating	IIC Rating
3-ply CLT wall ⁴	3.07"	33	N/A
5-ply CLT wall ⁴	6.875"	38	N/A
5-ply CLT floor ⁵	5.1875"	39	22
5-ply CLT floor ⁴	6.875"	41	25
7-ply CLT floor ⁴	9.65"	44	30
2x4 NLT wall ⁶	3-1/2" bare NLT 4-1/4" with 3/4" plywood	24 bare NLT 29 with 3/4" plywood	N/A
2x6 NLT wall ⁶	5-1/2" bare NLT 6-1/4" with 3/4" plywood	22 bare NLT 31 with 3/4" plywood	N/A
2x6 NLT floor + 1/2" plywood ²	6" with 1/2" plywood	34	33

Source: Inventory of Acoustically-Tested Mass Timber Assemblies, WoodWorks⁷

Acoustics & Sound Control

Regardless of the structural materials used in a wall or floor ceiling assembly, there are 3 effective methods of improving acoustical performance:

1. Add mass
2. Add noise barriers
3. Add decouplers



Image credit: Christian Columbres

Acoustics & Sound Control

Common mass timber floor assembly:

- » Finish floor (if applicable)
- » Underlayment (if finish floor)
- » 1.5" to 4" thick concrete/gypcrete topping
- » Acoustical mat
- » WSP (if applicable)
- » Mass timber floor panels



STRUCTURAL GRID



Mass Timber Products

Cross-Laminated Timber (CLT)



Nail-Laminated Timber (NLT)



Photo: Think Wood

Glue-Laminated Timber (GLT)

Plank orientation



Photo: StructureCraft

Dowel-Laminated Timber (DLT)



Photo: StructureCraft



Photo: Ema Peter

STRUCTURAL SOLUTIONS | MT Panels on Beams and Posts - POST + BEAM



Photo: Seagate Structures

STRUCTURAL SOLUTIONS | Point Supported MT Panels and Posts - POST + PLATE



Photo: Stantec Architecture



Photo: John Klein



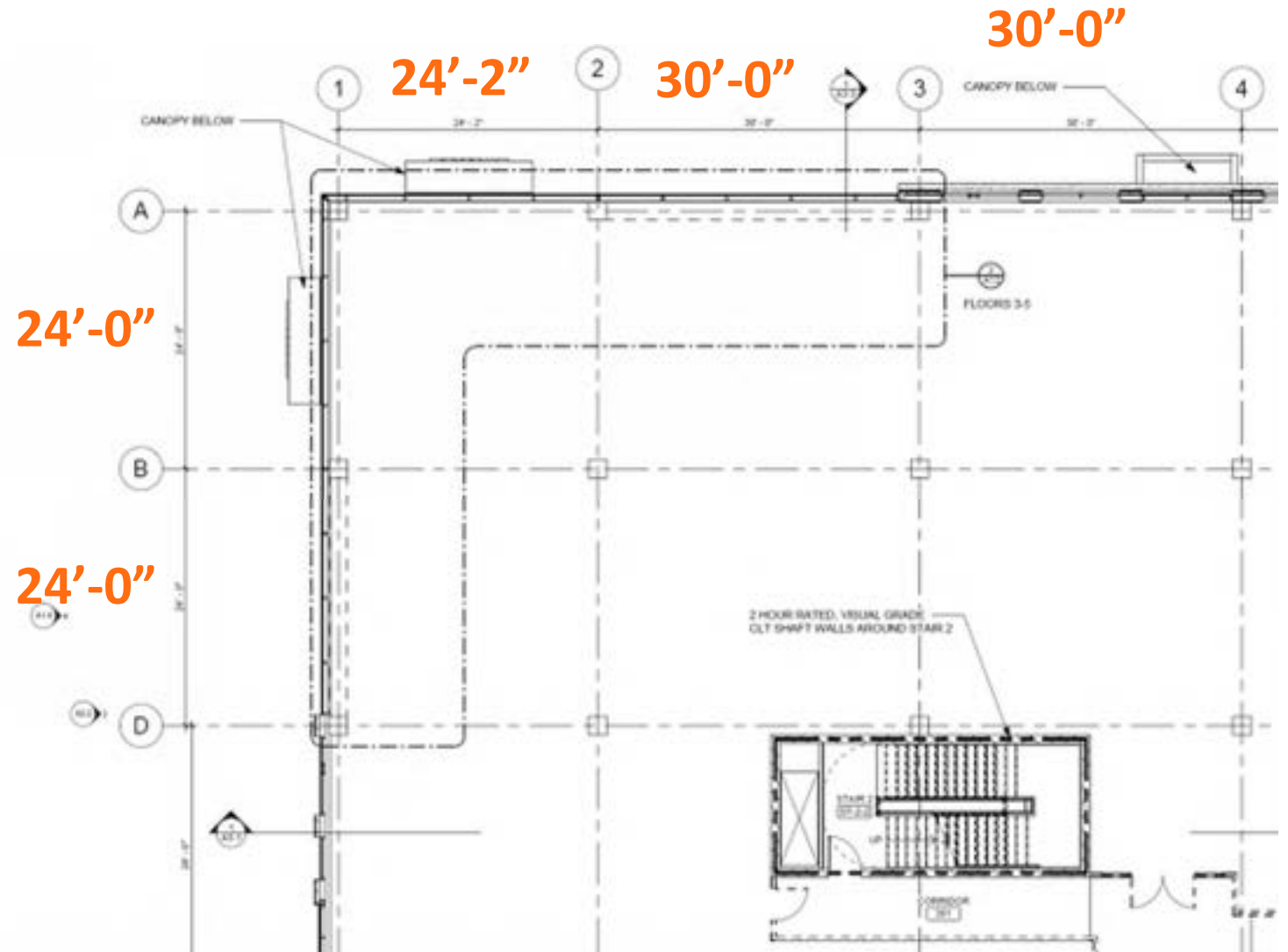
LEVER Architecture, photo Jeremy Bittermann

STRUCTURAL SOLUTIONS | HYBRID CONCRETE + MASS TIMBER

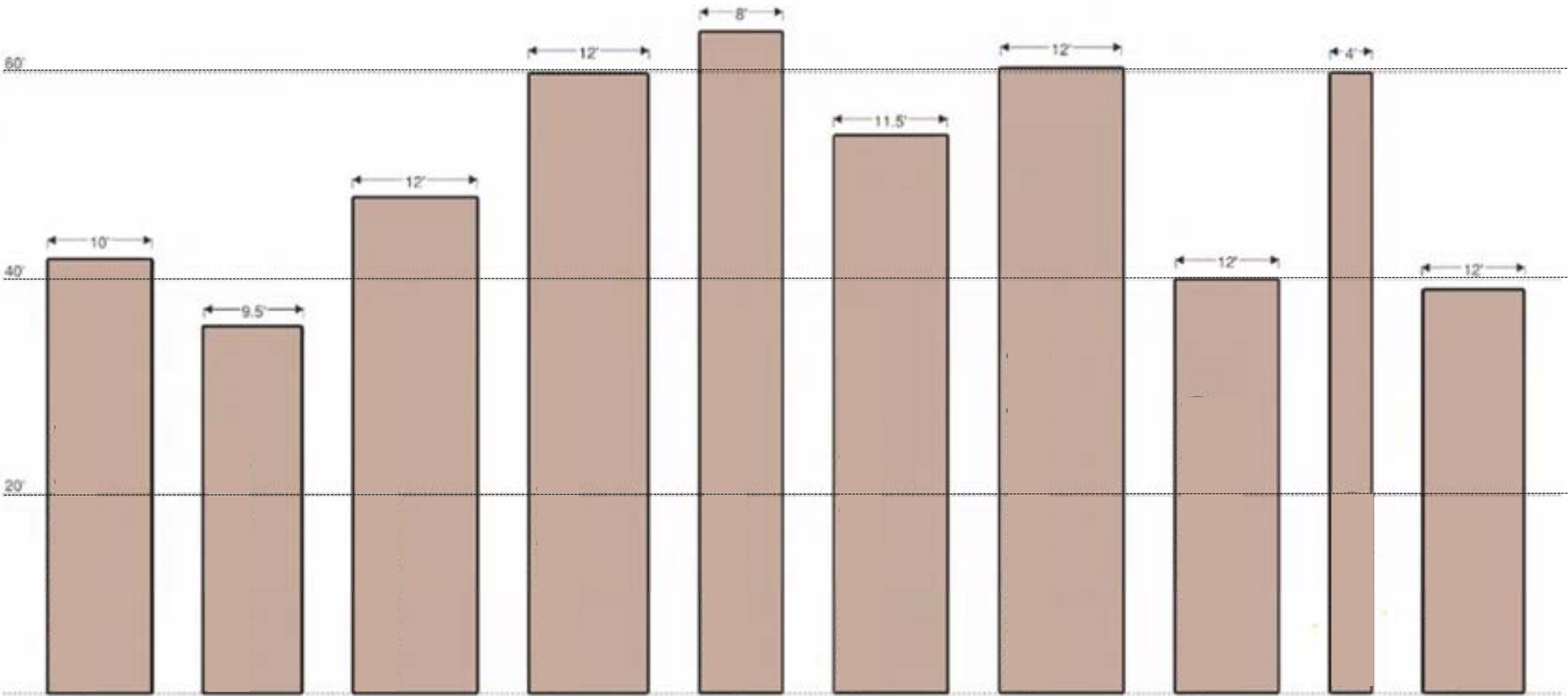
Structural Grid

Grids & Spans

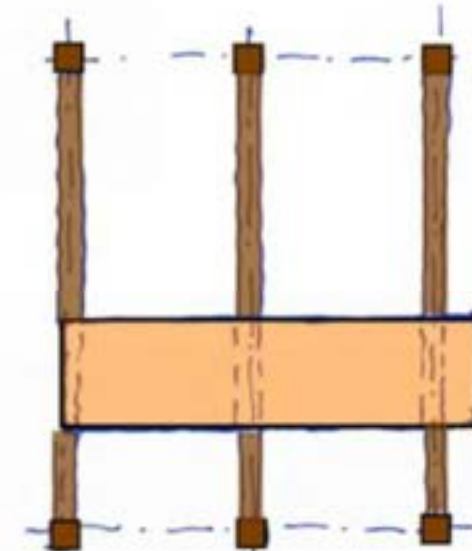
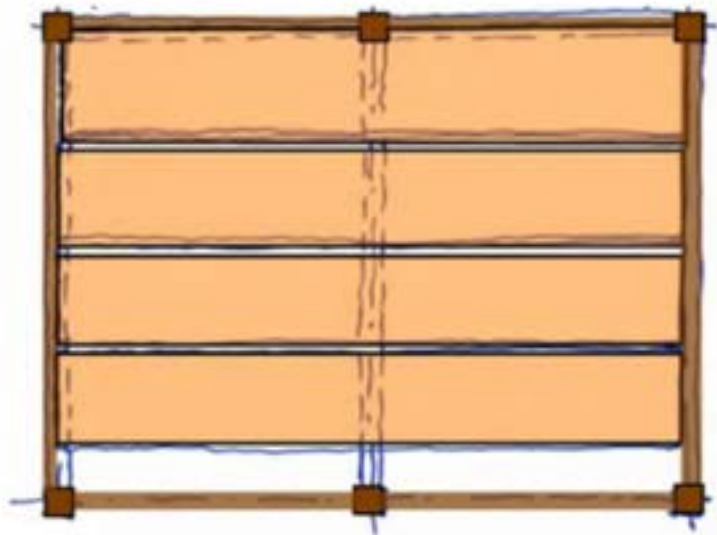
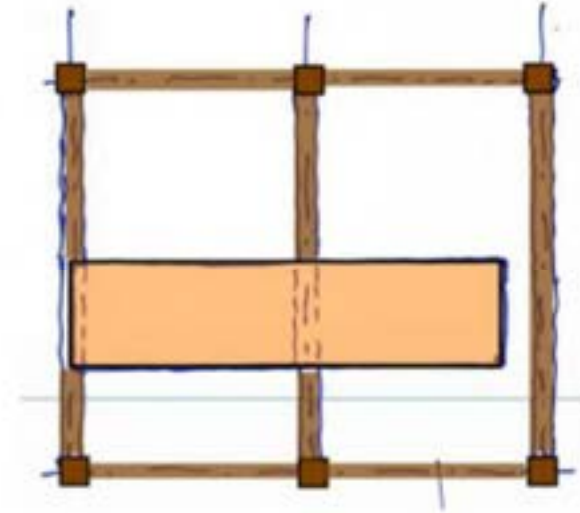
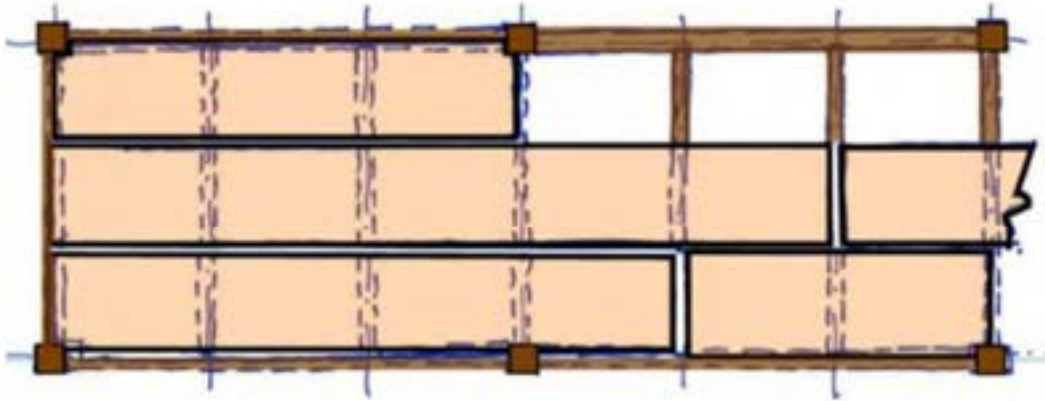
- » Consider Efficient Layouts
- » Repetition & Scale
- » Manufacturer Panel Sizing
- » Transportation



Understand Manufacturer's Capabilities



Understand Manufacturer's Capabilities



MEP Layout & Integration



MEP Layout & Integration

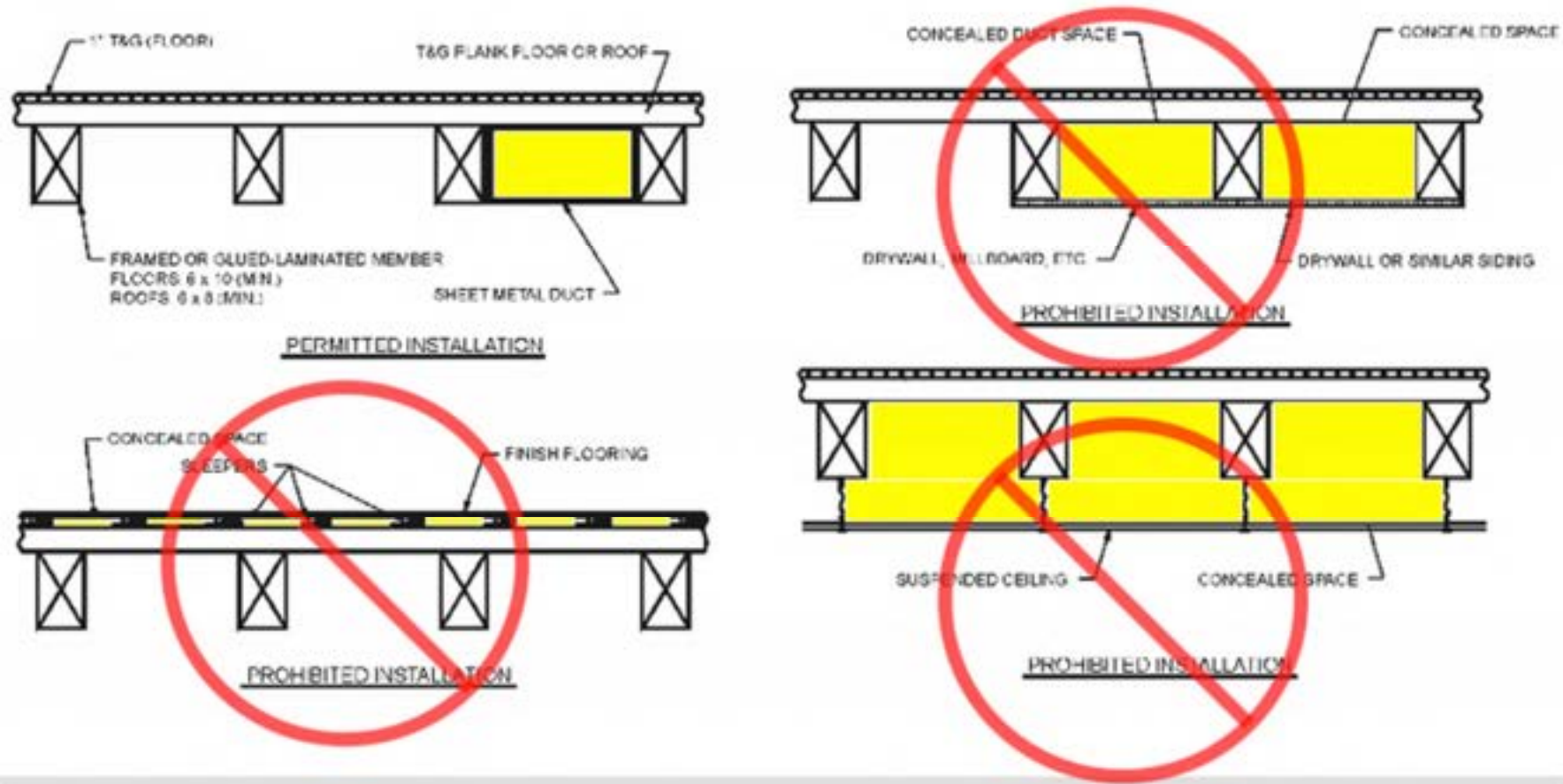
Set Realistic Owner Expectations About Aesthetics



Construction Types

Type IV concealed spaces

Until 2021 IBC, Type IV-HT provisions

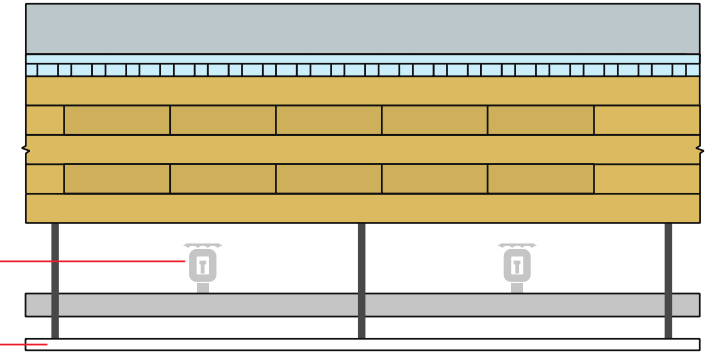


Concealed Spaces in Type IVHT (2021 IBC)

Option 1:

Sprinklers in concealed spaces

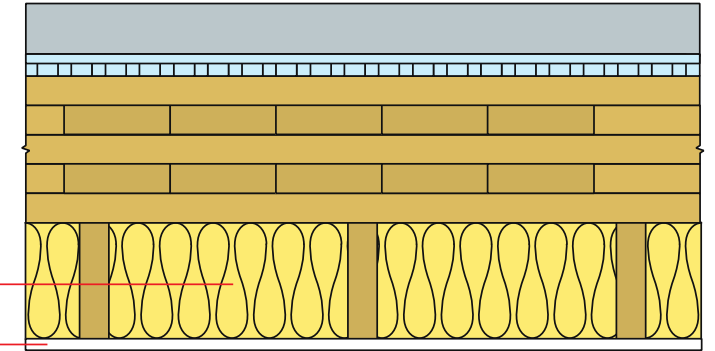
Dropped ceiling



Option 2:

Noncombustible insulation

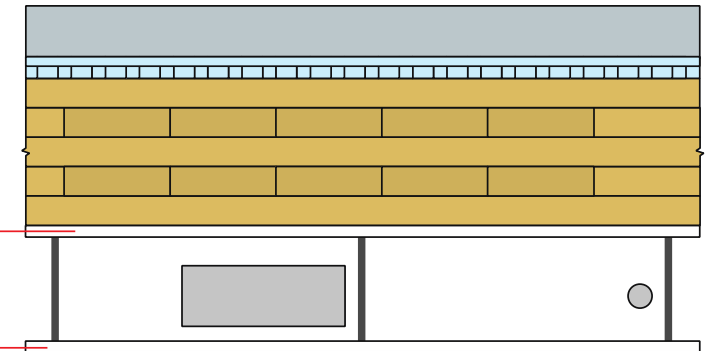
Dropped ceiling



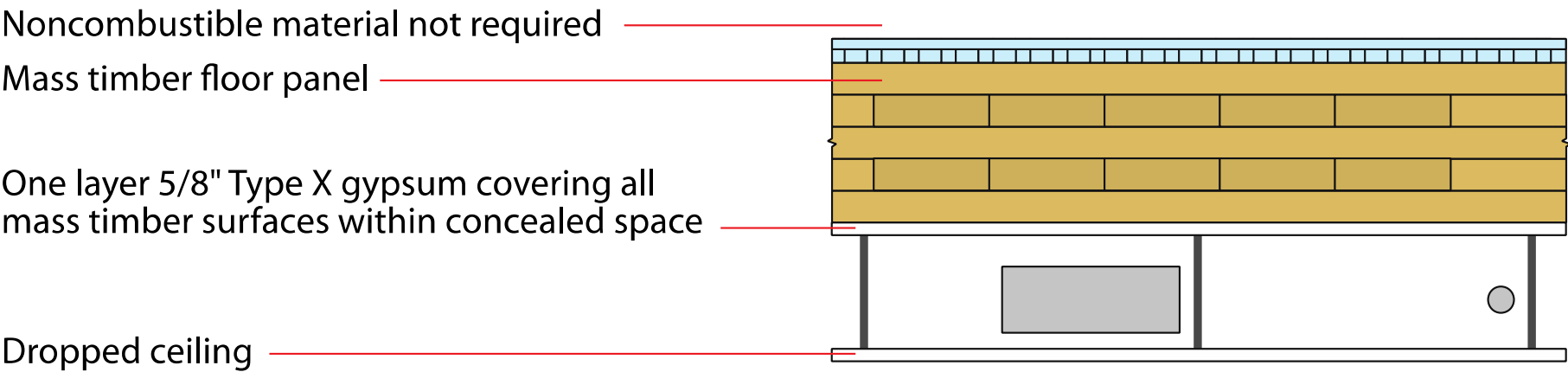
Option 3:

5/8" Type X gypsum on all mass timber surfaces within concealed space

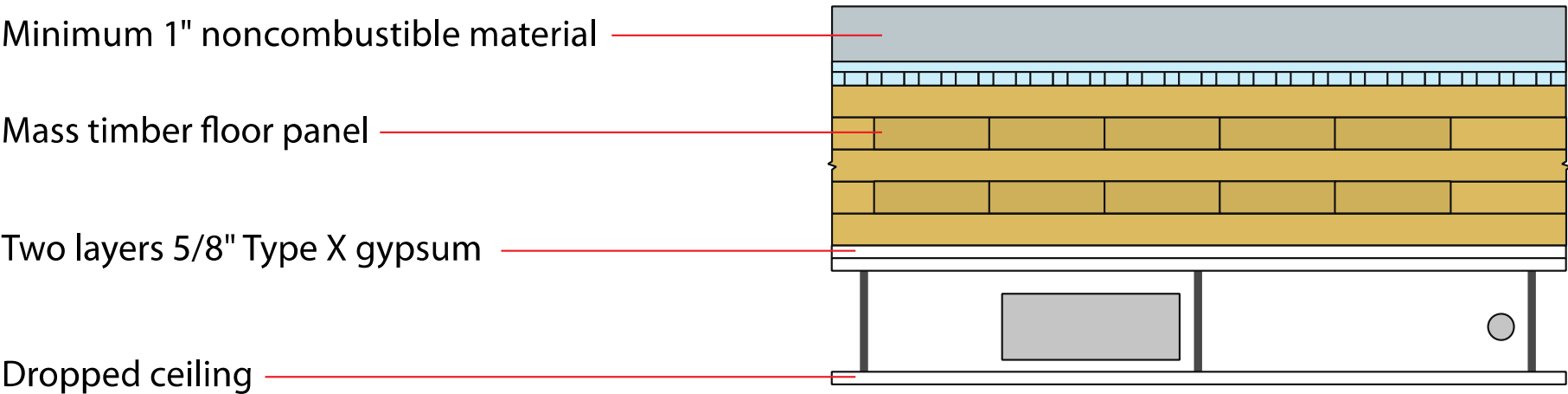
Dropped ceiling



Concealed Spaces in Type IV-C



Vs. Type IV-A and IV-B



Construction Types

Concealed spaces solutions paper



Concealed Spaces in Mass Timber and Heavy Timber Structures

Concealed spaces, such as those created by a dropped ceiling in a floor/ceiling assembly or by a stud wall assembly, have unique requirements in the International Building Code (IBC) to address the potential of fire spread in non-visible areas of a building. Section 718 of the 2018 IBC includes prescriptive requirements for protection and/or compartmentalization of concealed spaces through the use of draft stopping, fire blocking, sprinklers and other means. For information on these requirements, see the WoodWorks Q&A, *Are sprinklers required in concealed spaces such as floor and roof cavities in multi-family wood-frame buildings?*

For mass timber building elements, the choice of construction type can have a significant impact on concealed space requirements. Because mass timber products such as cross-laminated timber (CLT) are prescriptively recognized for Type IV construction, there is a common misperception that exposed mass timber building elements cannot be used or exposed in other construction types. This is not the case.

In addition to Type IV buildings, structural mass timber elements—including CLT, glue-laminated timber (glulam), nail-laminated timber (NLT), structural composite lumber (SCL), and tongue-and-groove (T&G) decking—can be utilized and exposed in the following construction types, whether or not a fire-resistance rating is required:

- **Type III** – Floors, roofs and interior walls may be any material permitted by code, including mass timber; exterior walls are required to be noncombustible or fire retardant-treated wood.
- **Type V** – Floors, roofs, interior walls and exterior walls (i.e., the entire structure) may be constructed of mass timber.
- **Types I and II** – Mass timber may be used in select circumstances such as roof construction—including the primary frame in the 2021 IBC—in Types I-B, II-A or II-B; exterior columns and arches when 20 feet or more of horizontal separation is provided; and balconies, canopies and similar projections.



https://www.woodworks.org/wp-content/uploads/wood_solution_paper-Concealed_Spaces_Timber_Structures.pdf

MEP Layout & Integration

Dropped below MT framing

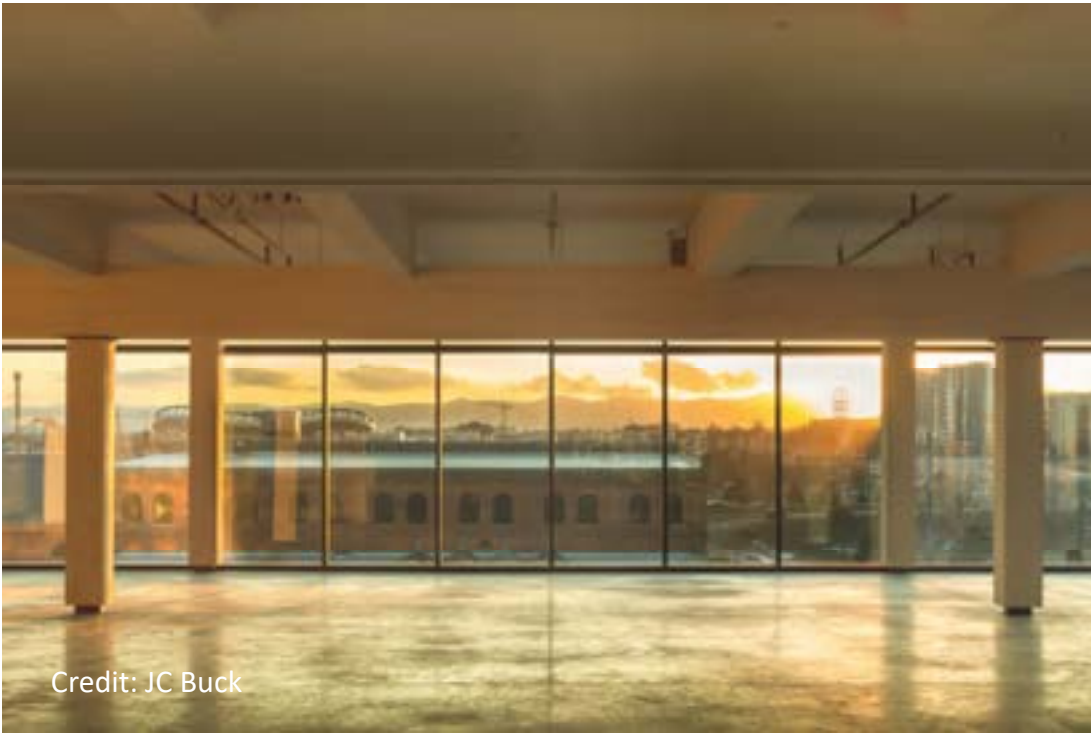
- » Can simplify coordination (fewer penetrations)
- » Bigger impact on head height



MEP Layout & Integration

In chases above beams and below panels

- » Fewer penetrations
- » Bigger impact on head height (overall structure depth is greater)
- » FRR impacts: top of beam exposure



Credit: JC Buck



Credit: KL&A Engineers & Builders

MEP Layout & Integration

Smaller grid bays at central core (more head height)

» Main MEP trunk lines around core, smaller branches in exterior bays



Credit: Blaine Brownell

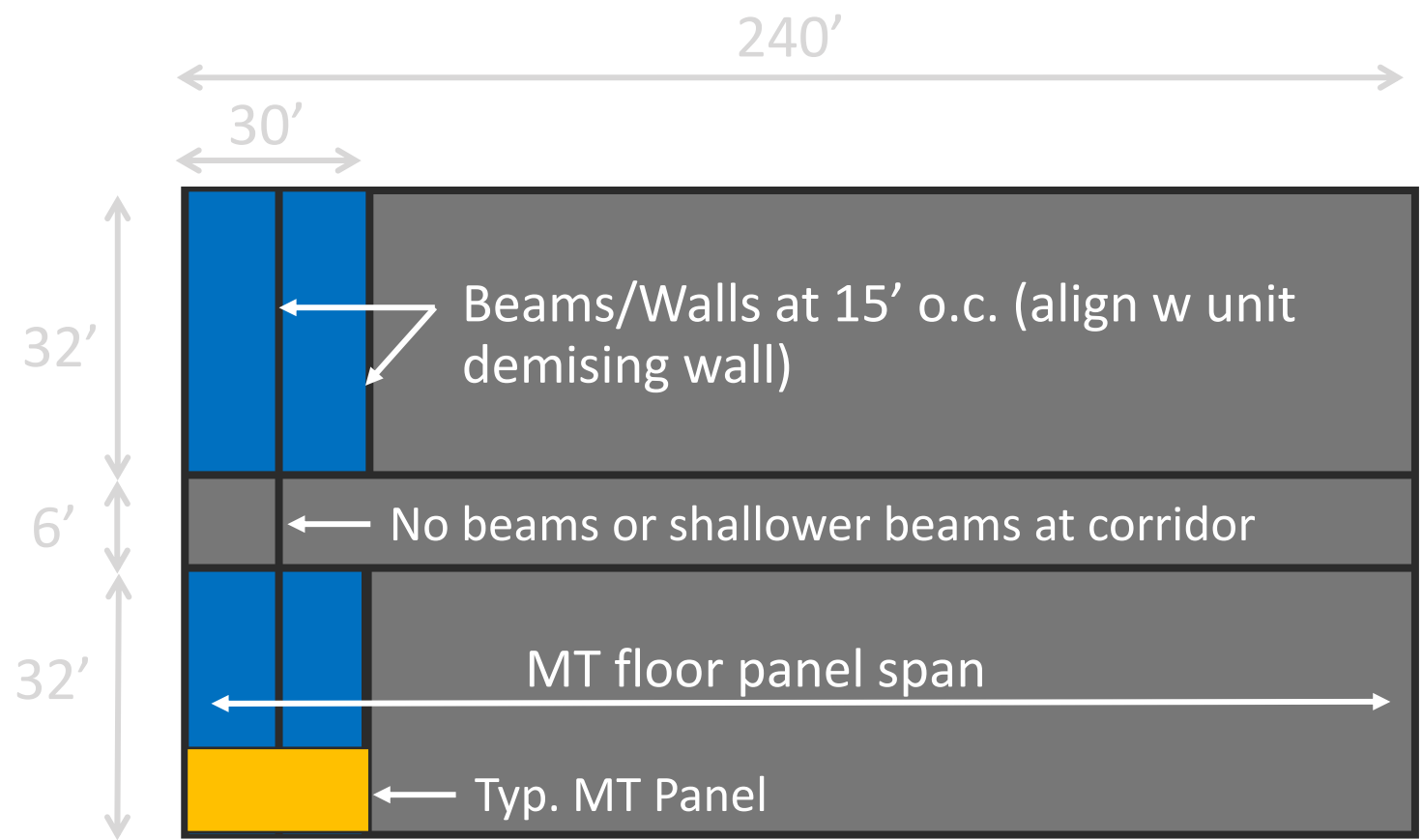


Credit: WoodWorks

Early Design Decision Example



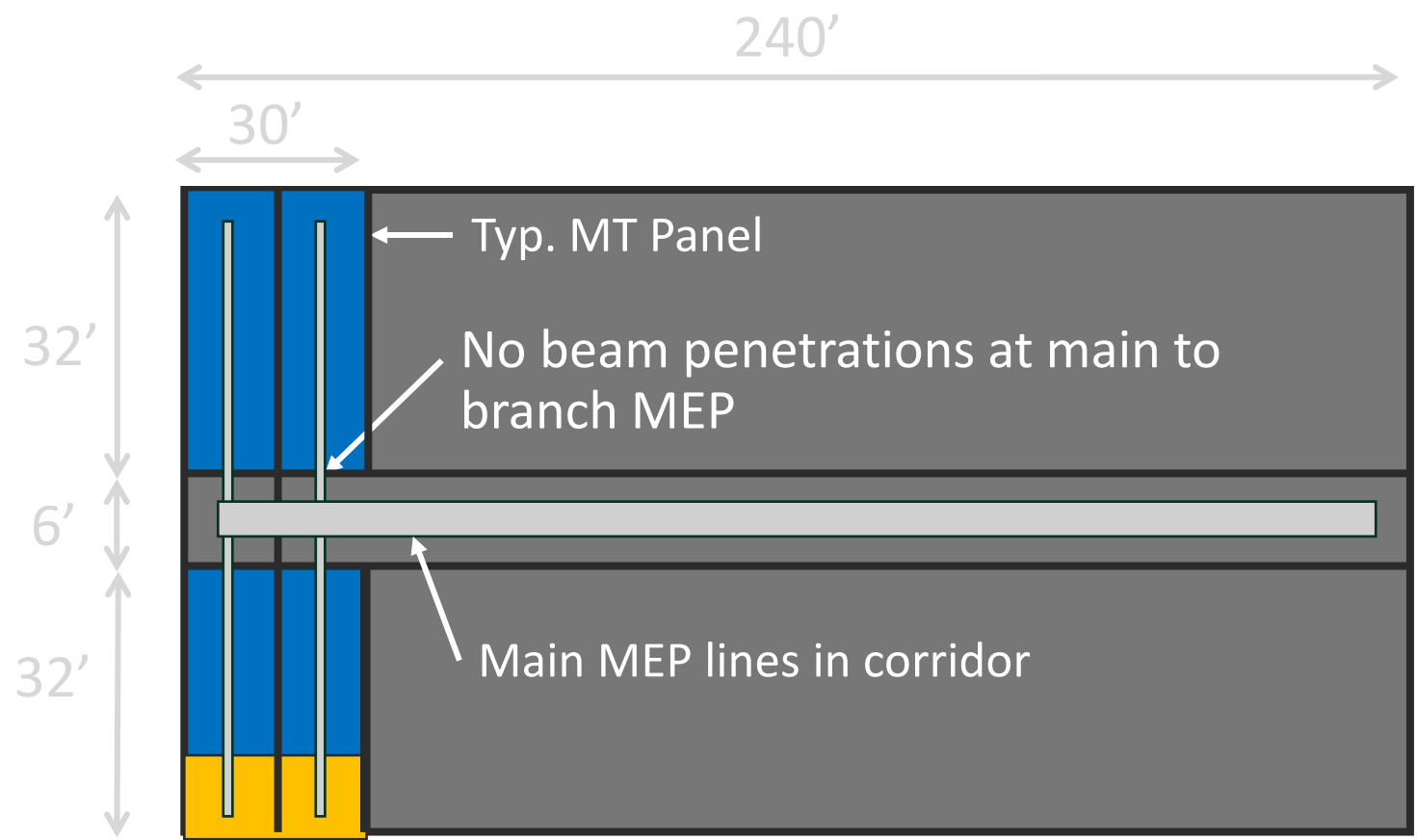
Credit: Monte French Design Studio



Early Design Decision Example



Credit: Monte French Design Studio



Floor to Ceiling Glazing Possibilities



Photos: Mark Bitterman

MEP Layout & Integration

In gaps between MT panels

- » Fewer penetrations, can allow for easier modifications later



Credit: Ema Peter/MGA



Credit: Hacker Architects

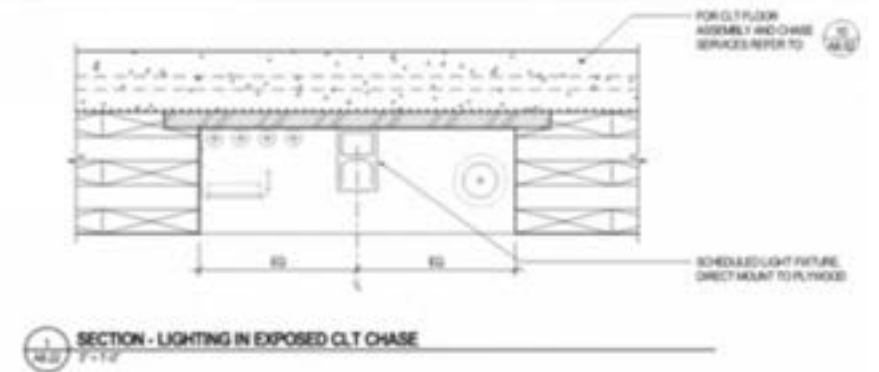
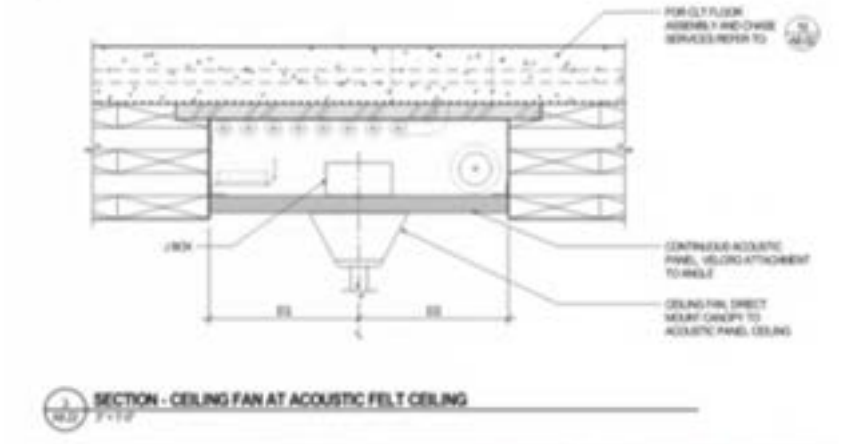
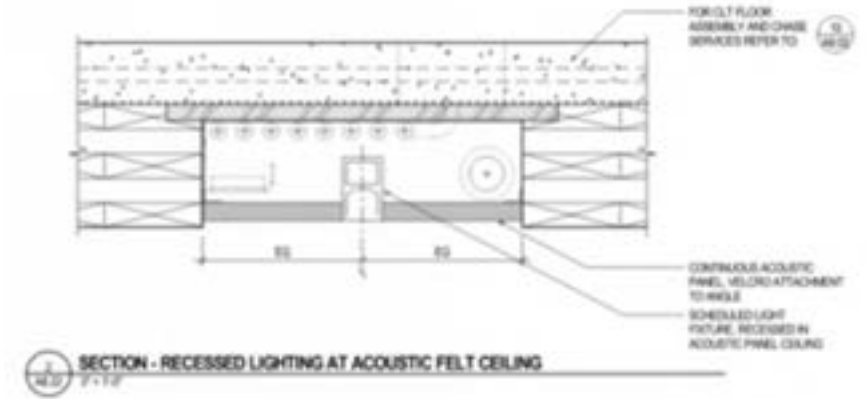
MEP Layout & Integration

In gaps between MT panels

» Greater flexibility in MEP layout



Credit: WoodWorks



Credit: PAE Consulting Engineers

MEP Layout & Integration

In raised access floor (RAF) above MT

- » Impact on head height
- » Concealed space code provisions



Credit: Global IFS



MEP Layout & Integration

In topping slab above MT

- » Greater need for coordination prior to slab pour
- » Limitations on what can be placed (thickness of topping slab)
- » No opportunity for renovations later



MEP Layout & Integration

In penetrations through MT framing

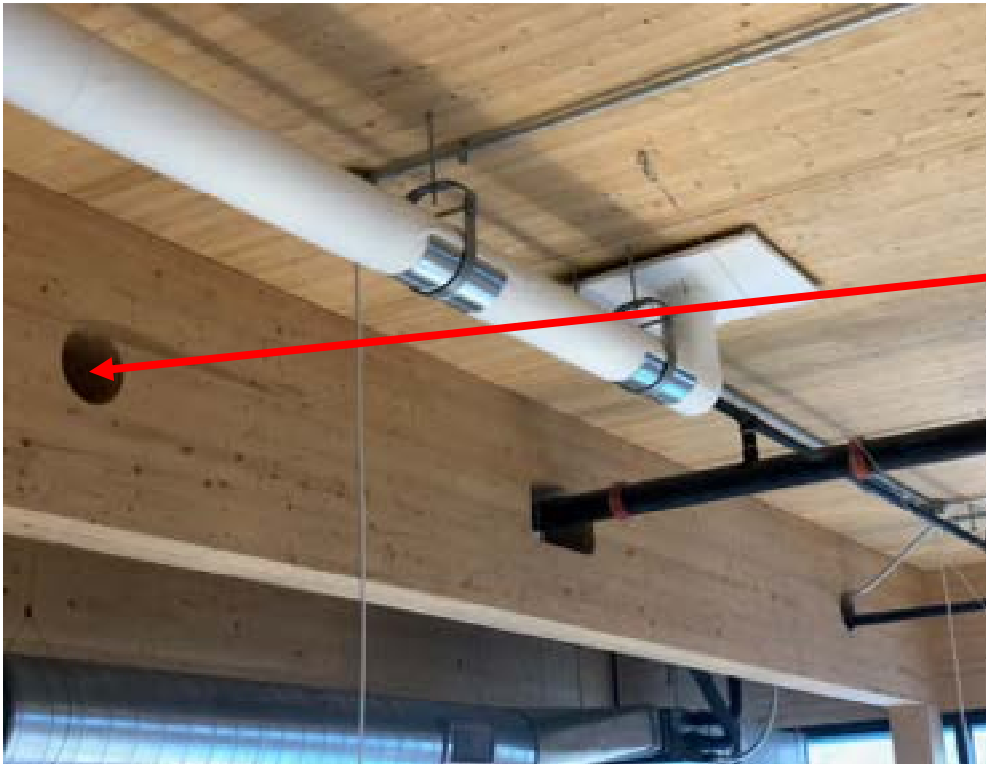
- » Requires more coordination (penetrations)
- » Bigger impact on structural capacity of penetrated members
- » Minimal impact on head height



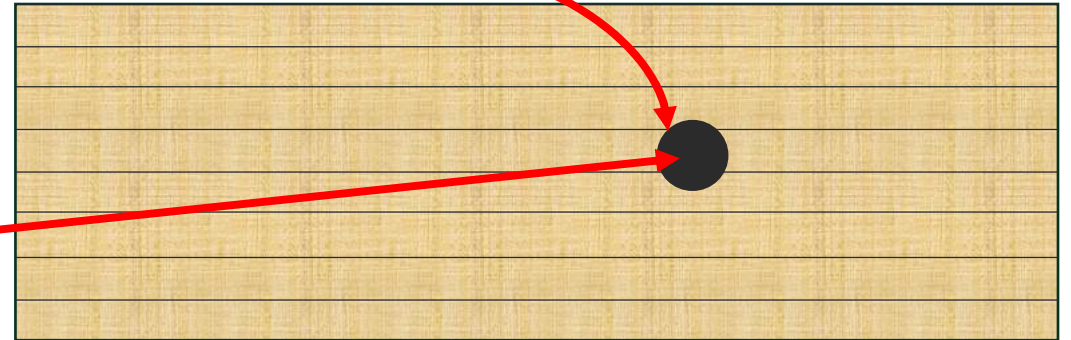
MEP Layout & Integration

Beam penetrations:

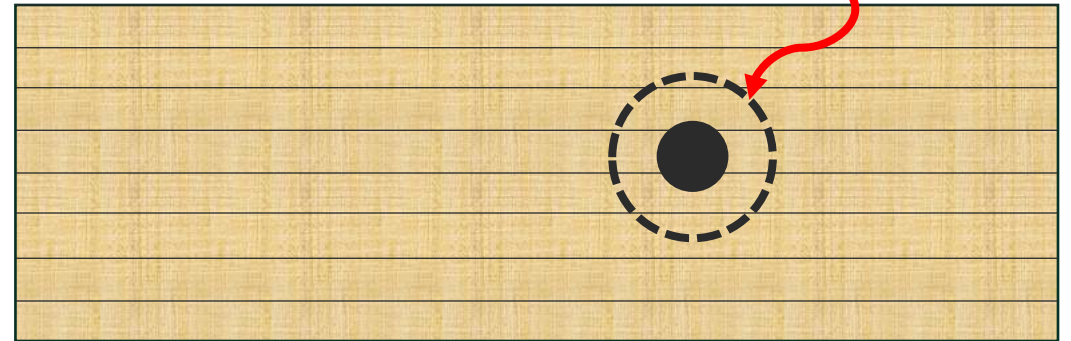
- » If FRR = 0-hr, analyze structural impact of hole diameter only
- » If FRR > 0-hr, account for charred hole diameter or firestop penetration



Hole diameter

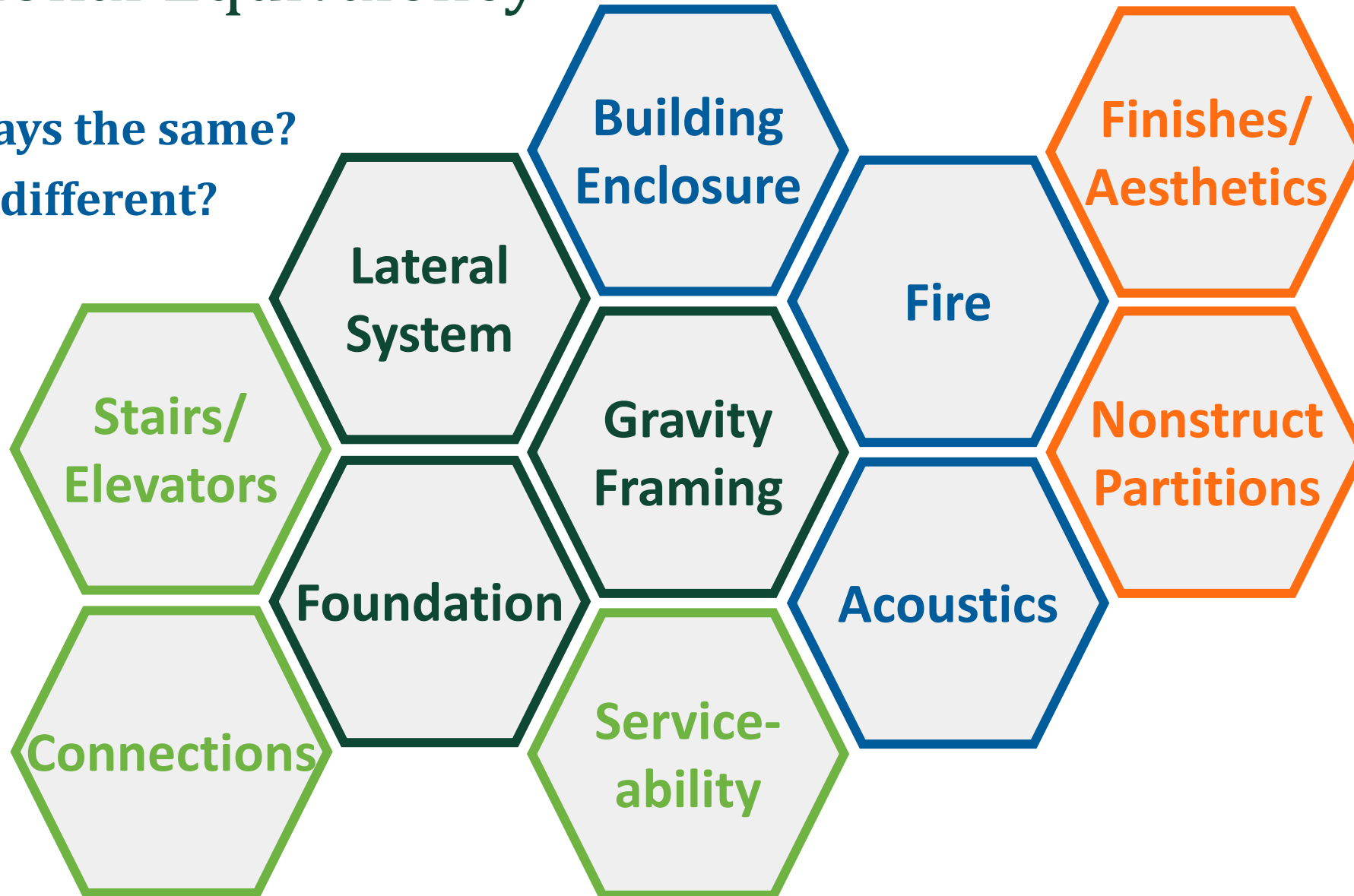


Hole diameter after 1-hr char

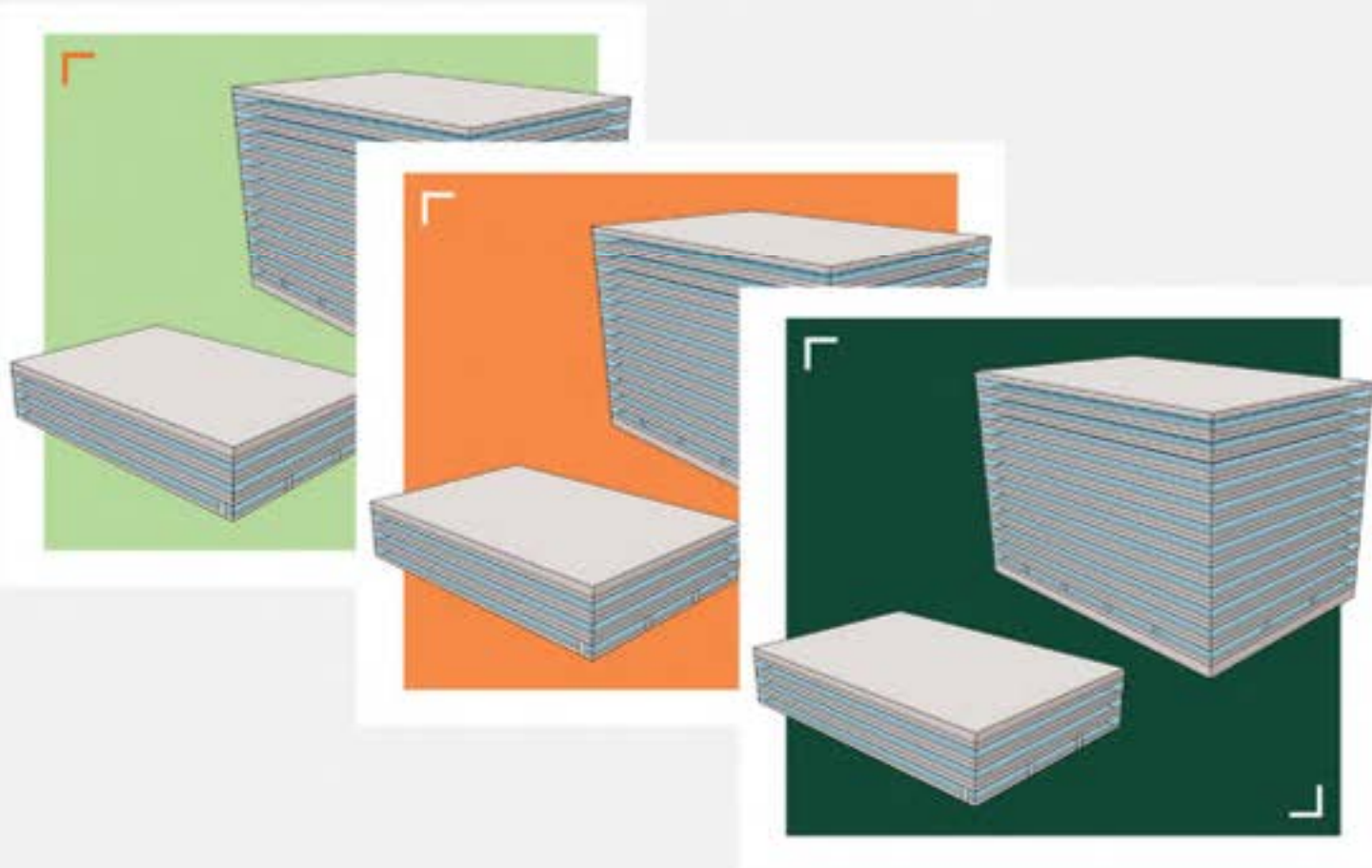


Functional Equivalency

What stays the same?
What is different?



Considerations for Setting Building-Level Benchmarks for Life Cycle Assessment



Highlights the complexities of building design and life cycle assessment (LCA) methodologies and considerations for setting accurate benchmarks to compare carbon performance



WBLCA Considerations & Worksheet



Considerations and Worksheet for Structural WBLCA of Mass Timber Buildings

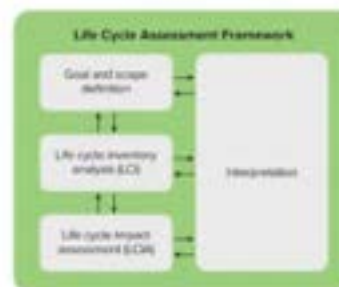
Guidance for mass timber building designers undertaking whole building life cycle assessment (WBLCA)

The design community has embraced the use of whole building life cycle assessment (WBLCA) as a means to quantify, and sometimes compare, the environmental impacts of buildings. While this momentum is exciting, detailed standards for a unified approach to WBLCA are still in development, leaving designers without clear direction during the assessment process. This document seeks to outline requirements pertaining to life cycle assessment (LCA) found in international standards, and provide guidance on how WBLCA for mass timber buildings are performed using commercially available LCA tools.

Requirements and guidelines for LCA are provided in the International Organization for Standardization's ISO 14040 (Principles and terminology) and ISO 14044 (Requirements and guidelines). ISO 14040 Section 4.3.1 outlines four phases of an LCA as shown in Figure 1:

- Goal and scope definition
- Life cycle inventory (LCI) analysis
- Life cycle impact assessment (LCIA)
- Interpretation

As illustrated by the arrows in the figure, these phases are interlinked and performing an LCA is an iterative process. This paper will step through common decisions building designers need to make in each phase of the LCA. It is accompanied by a worksheet—sections of which are included here—to help the designer answer these questions when performing a WBLCA. The worksheet can be downloaded as a fillable PDF at www.woodworks.org/WBLCA_worksheet.



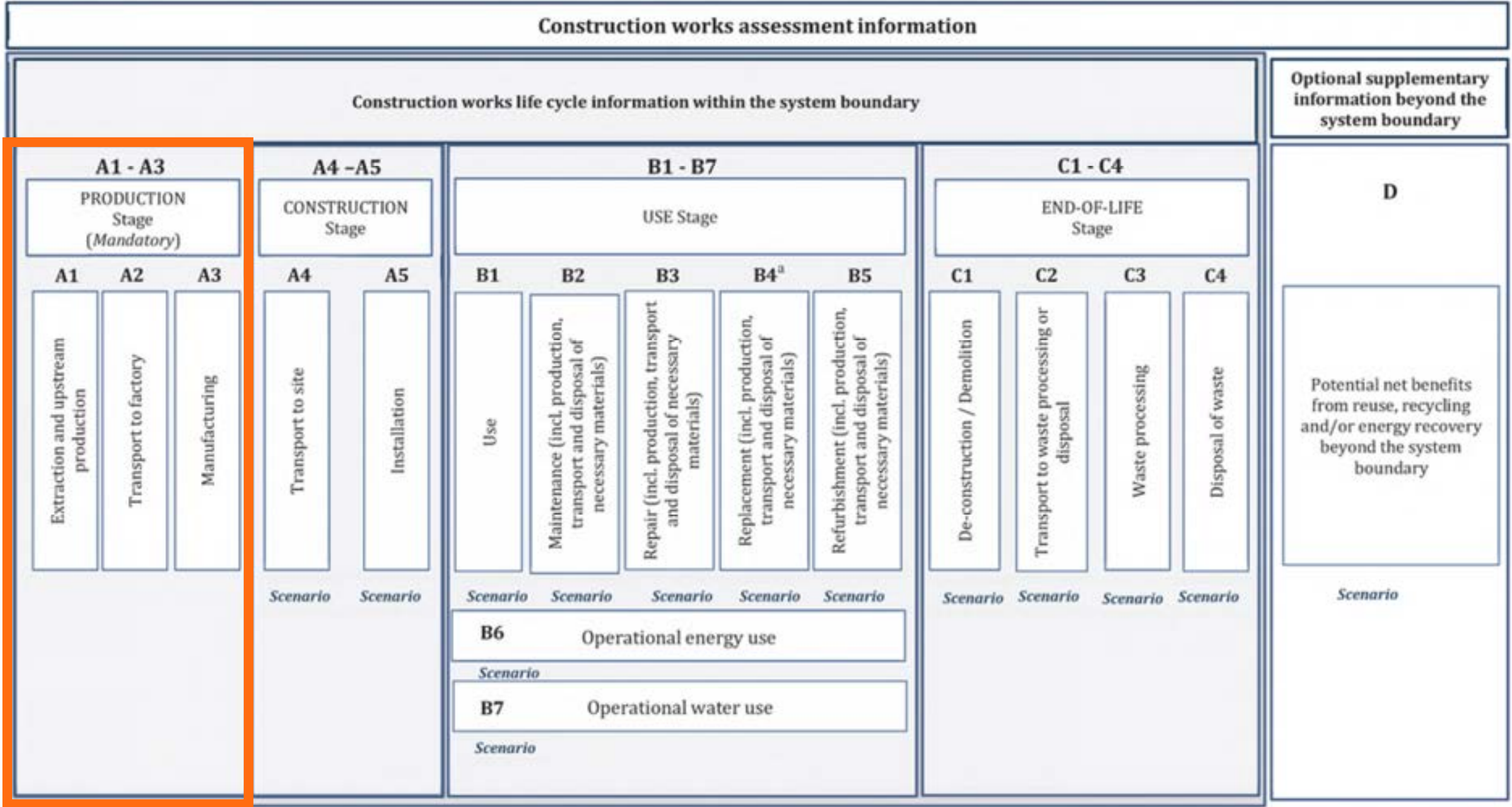
Worksheet for Structural WBLCA of Mass Timber Buildings

This fillable PDF accompanies the WoodWorks paper, *Considerations and Worksheet for Structural WBLCA of Mass Timber Buildings*, which steps through common decisions building designers need to make in each phase of a life cycle assessment (LCA). The paper can be downloaded at [woodworks.org](https://www.woodworks.org).

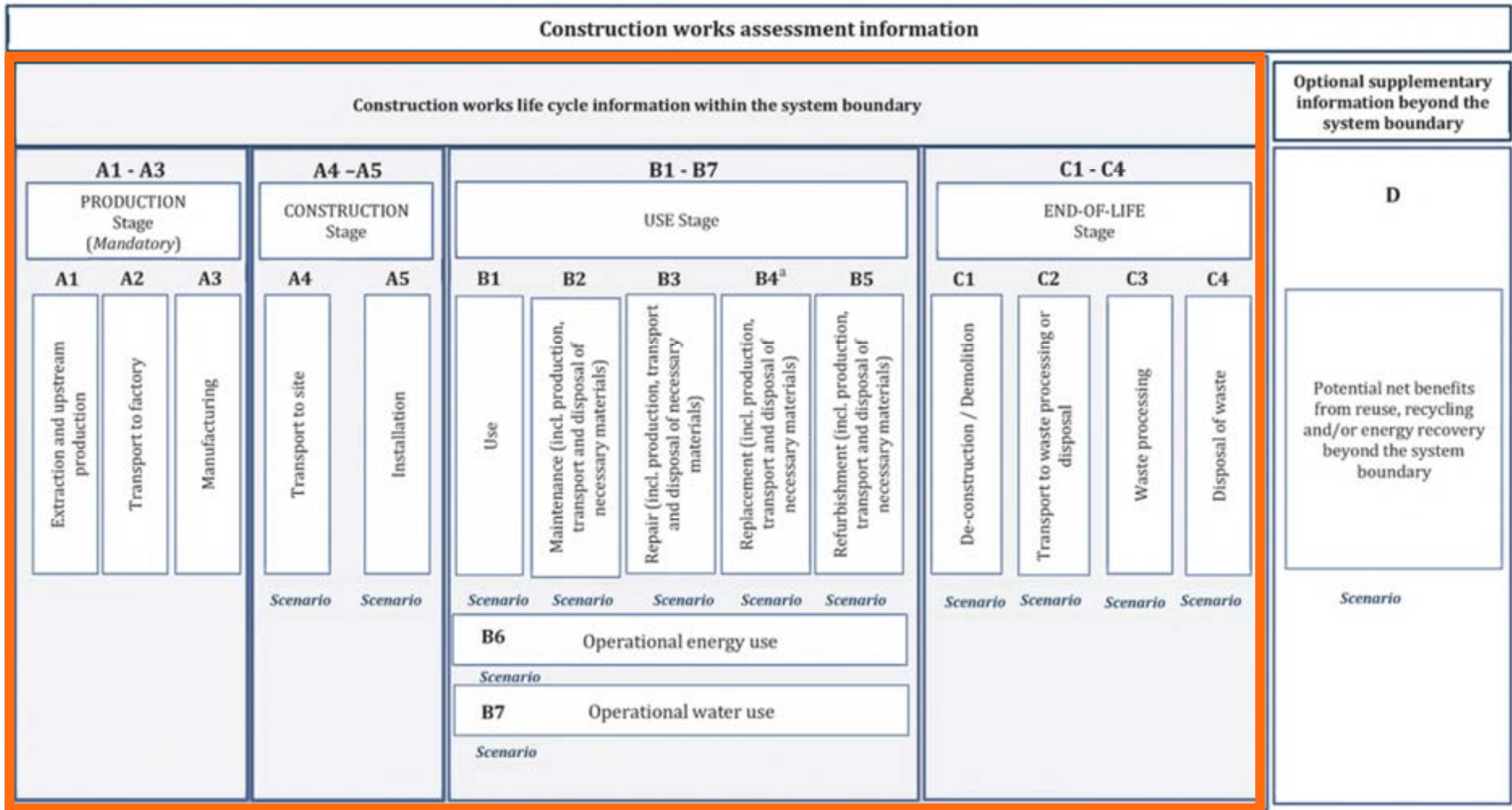
For questions or assistance with the LCA process, please contact WoodWorks at help@woodworks.org.

TABLE 1:

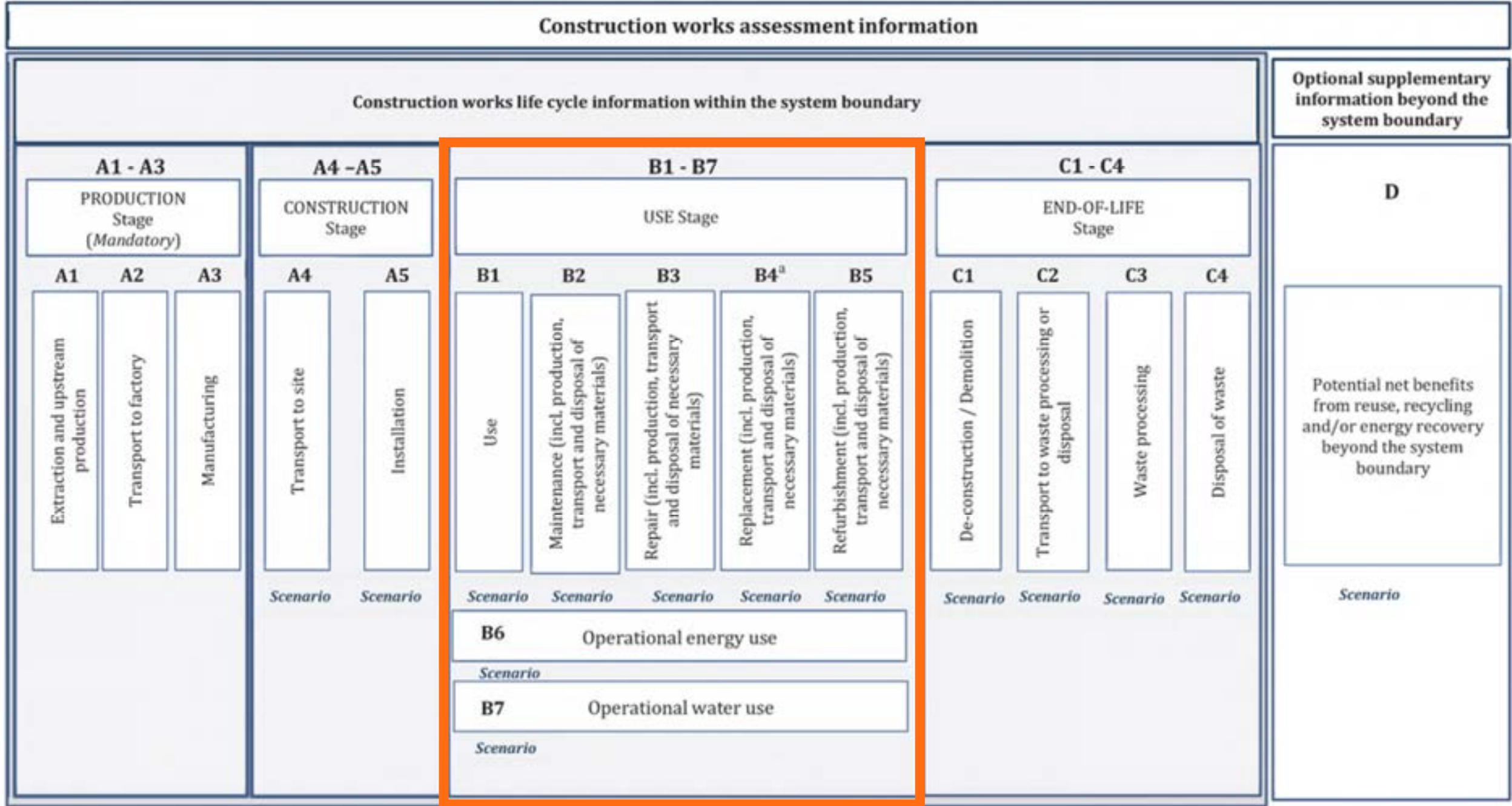
Goal Components	Notes
Intended application (What)	
Reason for study (Why)	
Intended audience (Who)	
Will results be made public?	



^a Replacement information module (B4) not applicable at the product level.



^a Replacement information module (B4) not applicable at the product level.



^a Replacement information module (B4) not applicable at the product level.

Use Stage: B1-B7

Embodied:

- » B1: Use
- » B2: Maintenance
- » B3: Repair
- » B4: Replacement
- » B5: Refurbishment

Operational:

- » B6: Operational energy use
- » B7: Operational water use

B1-B5 (Embodied) for Wood Products

B1: Use

- » Normal use not covered in B2-B7

B2: Maintenance

- » Preventative & regular maintenance throughout the service life

B3: Repair

- » e.g. a window with a broken pane of glass

B4: Replacement

- » e.g. replacing carpet at the end of its service life

B5: Refurbishment

- » Maintenance, repair and/or replacement over a significant part of the building; includes restoration

Be aware of default service life of wood products in the tools!
Structural wood products should have service life = building life

What makes wood different?

The closed loop of
FOREST CARBON
in the **ATMOSPHERE**

Carbon Cycle

Fossil fuel use is an **OPEN SYSTEM** where CO_2 remains in the atmosphere.

Wood products can store carbon and can **substitute** for emission-intensive products such as concrete & steel.



Bioenergy from forest biomass can **substitute** for fossil fuel energy.

BIOMASS



Fires & decomposition following disturbance events **release** carbon into the atmosphere.

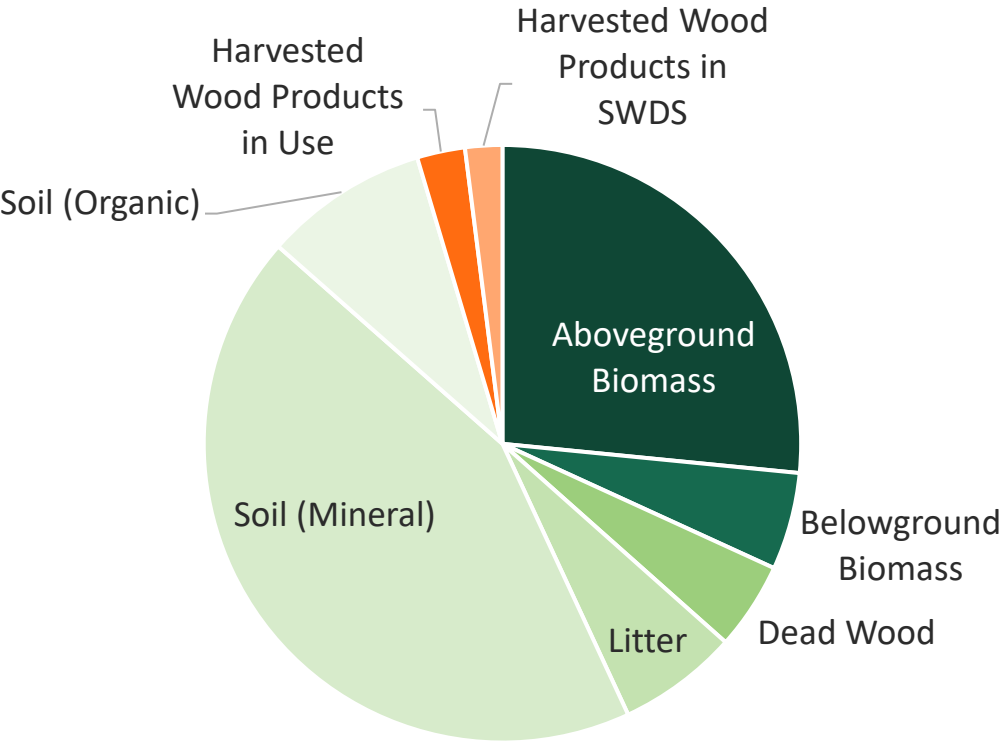


Growing forests **remove** carbon from the atmosphere.

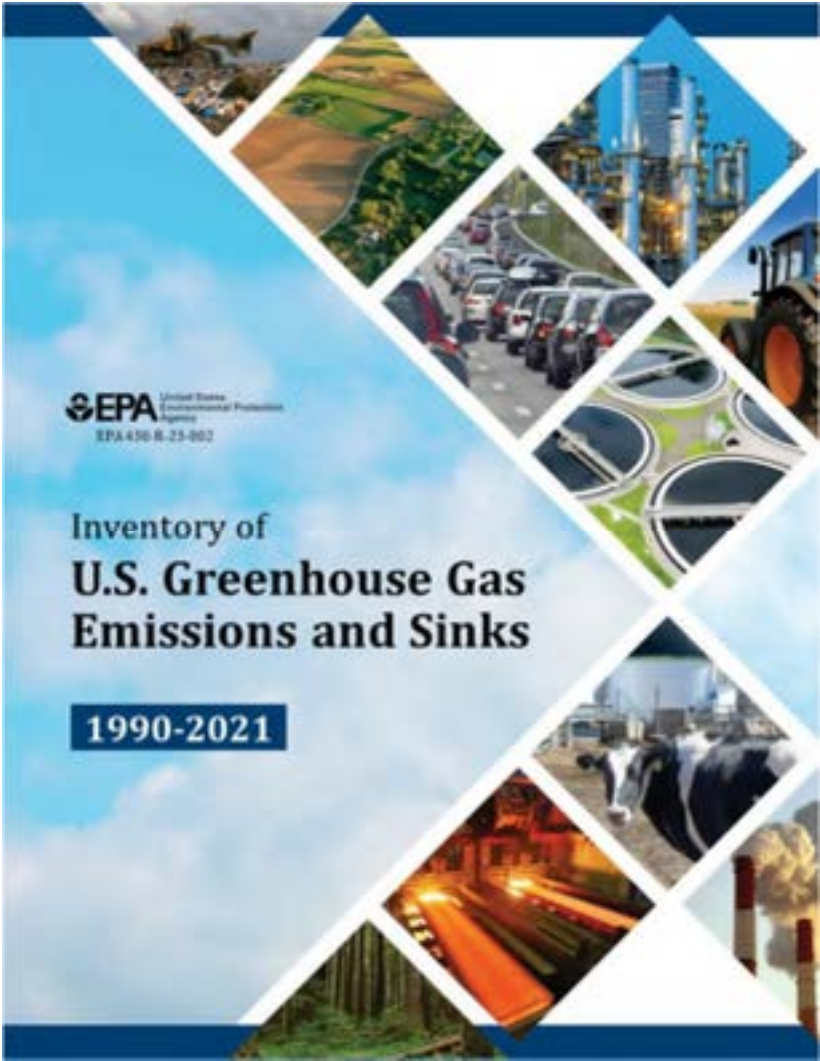


Carbon Storage in Harvested Wood Products

As of 2022, carbon stock for **Harvested Wood Products in Use** in conterminous 48 states and Alaska is approximately **1,549 Million Metric Tons**.



Carbon Stocks in Forest Land and Harvest Wood Pools, 2022



Carbon Storage

Wood $\approx$ **50% Carbon** (dry weight)



Image: Kaiser + Path

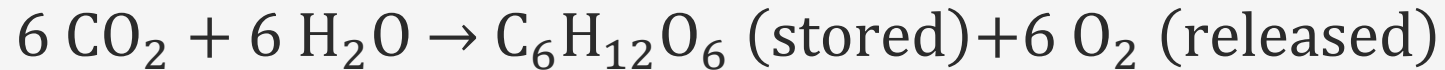


Image: Lever Architecture

Biogenic Carbon

“Carbon derived from... material of biological origin
excluding material embedded in geological formations or
transformed to fossilized material and excluding peat.”

Photosynthesis:



Carbon Storage Calculation

Douglas-Fir-Larch:

$$\begin{aligned} 1 \text{ ft}^3 &= 34.5 \text{ lb (15\% MC)} \\ &= 30.0 \text{ lb (dry)} \end{aligned}$$

50% Carbon by dry weight:

$$1 \text{ ft}^3 = 15 \text{ lb Carbon stored}$$

Carbon vs CO₂



1 lb Carbon $\neq$ 1 lb CO₂

1 lb Carbon = (44/12=) 3.67 lb CO₂

Carbon Storage Calculation

Douglas-Fir-Larch:

$$\begin{aligned} 1 \text{ ft}^3 &= 34.5 \text{ lb (15\% MC)} \\ &= 30.0 \text{ lb (dry)} \end{aligned}$$

50% Carbon by (dry) weight:

$$1 \text{ ft}^3 = 15 \text{ lb Carbon stored}$$

1 lb Carbon converts to 3.67 lb CO₂:

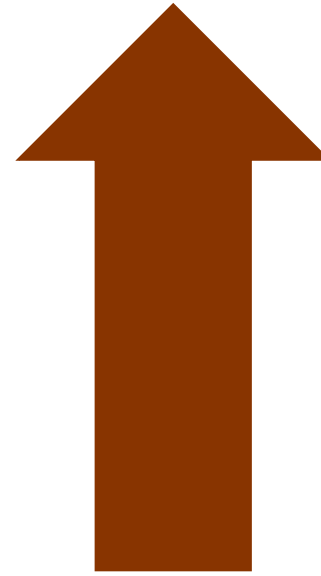
$$1 \text{ ft}^3 = 55 \text{ lb CO}_2$$

Biogenic Carbon Accounting



-1 in

Removal of
carbon from the
atmosphere



+1 out

Emission or export
of carbon from
product system

**Should I include biogenic
carbon?**

Biogenic Carbon

“For wood, biogenic carbon may be characterized with a -1...
when entering the product system **only when the wood
originates from sustainably managed forests.**”

So...

What is a sustainably managed forest?

Sustainably Managed Forests

“... zero emissions associated with land use change”

Option 1:

Includes wood products *responsibly sourced and certified* to:

- » **Standards** globally endorsed by PEFC and FSC
- » FSC, SFI, CSA, ATFS, etc.

This includes “responsible sourcing” standards and does not require that all wood come from certified forests.

Sustainably Managed Forests

“... zero emissions associated with land use change”

Option 1:

Includes wood products *responsibly sourced and certified* to:

- » **Standards** globally endorsed by PEFC and FSC
- » FSC, SFI, CSA, ATFS, etc.

Option 2: (NOTE 2)

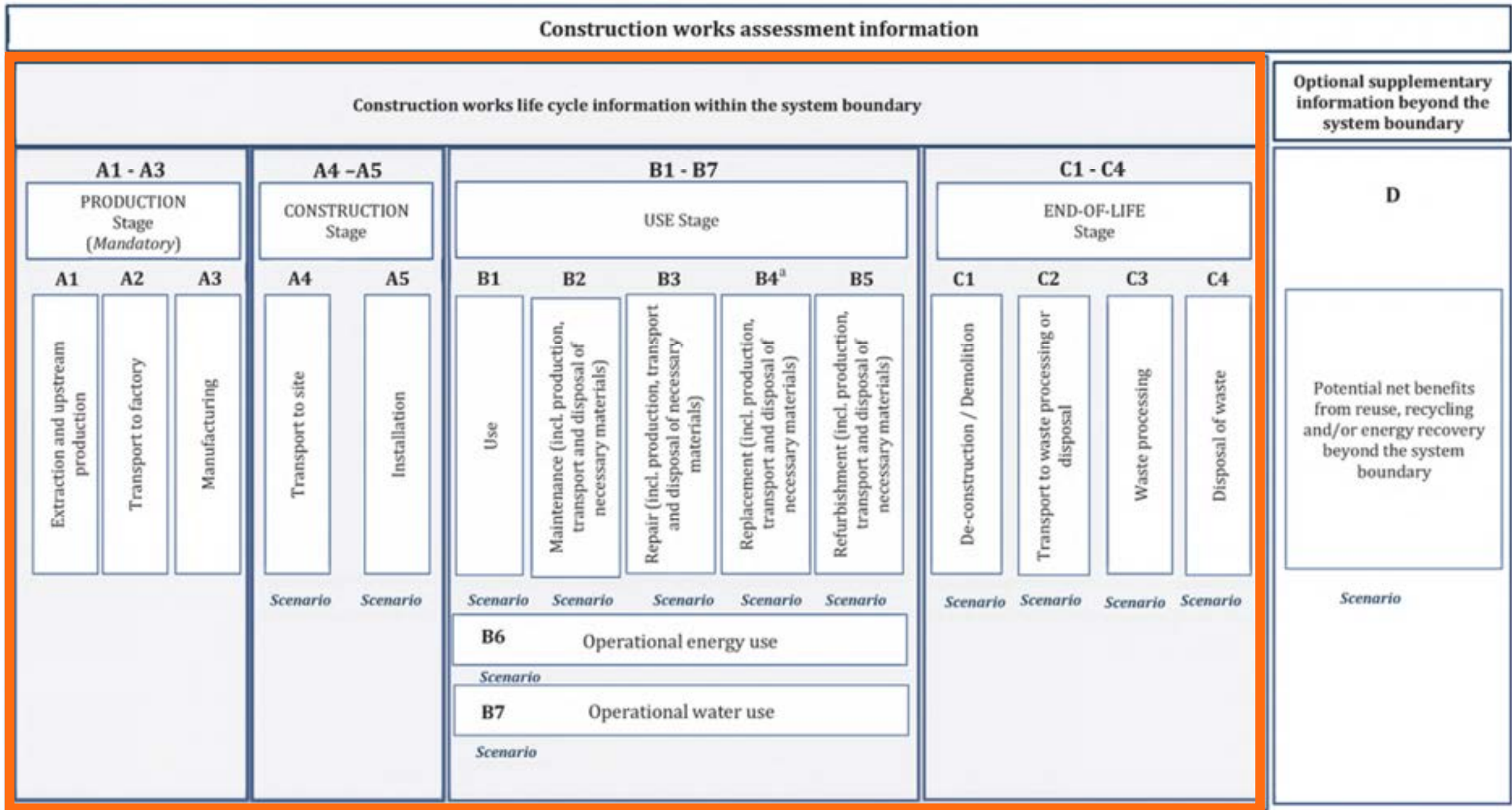
- » “The concept of sustainably managed forests is linked but not limited to respective certification schemes”
- » Evidence such as national reporting under the United Nations Framework Convention on Climate Change (UNFCCC) to identify forests with stable or increasing forest carbon stocks

Regeneration vs. Deforestation



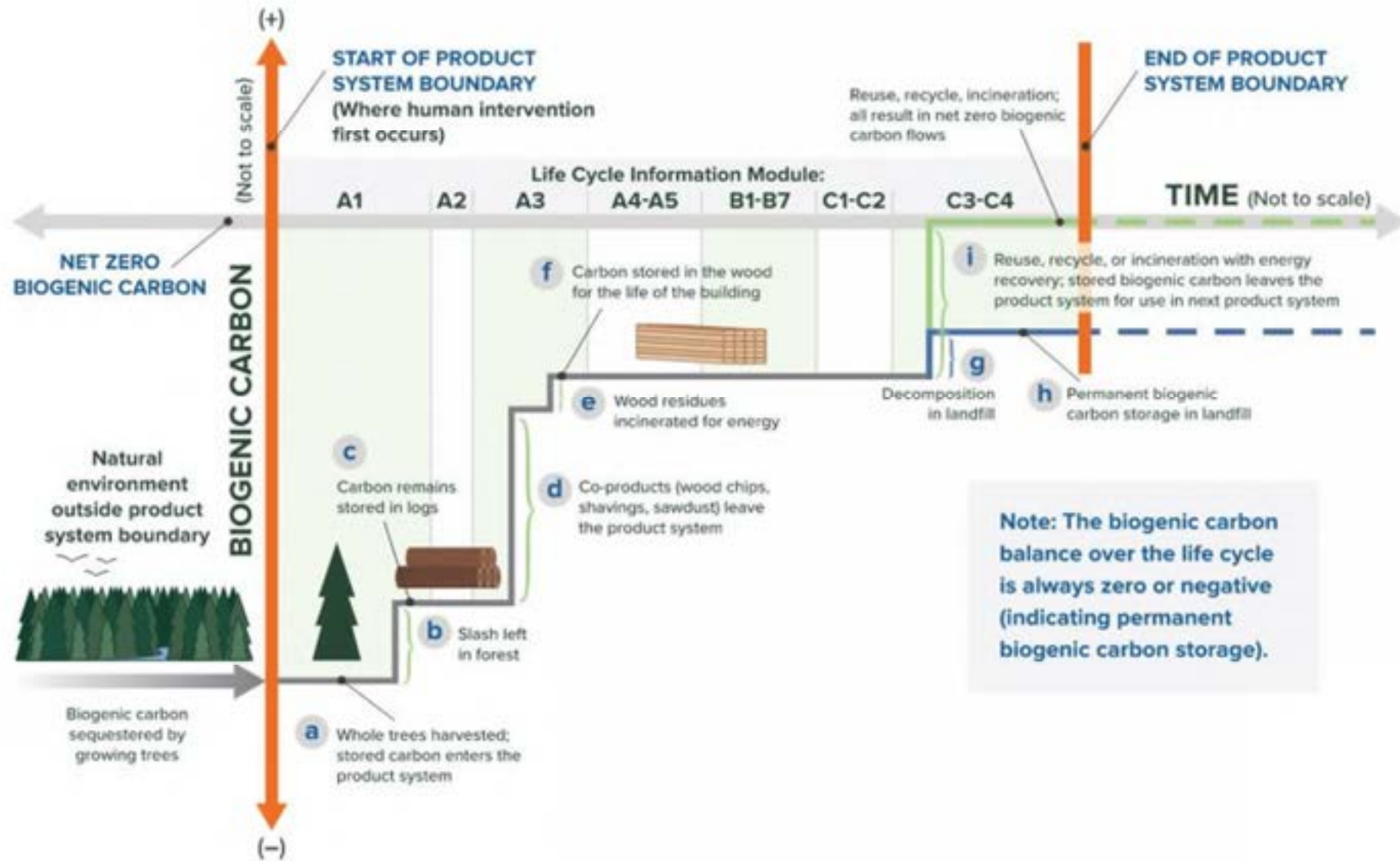
Deforestation is the permanent conversion of forest land to non-forest land.

Worldwide, agricultural expansion is the main driver of deforestation, but in the U.S., the rate of deforestation has been virtually zero for decades.

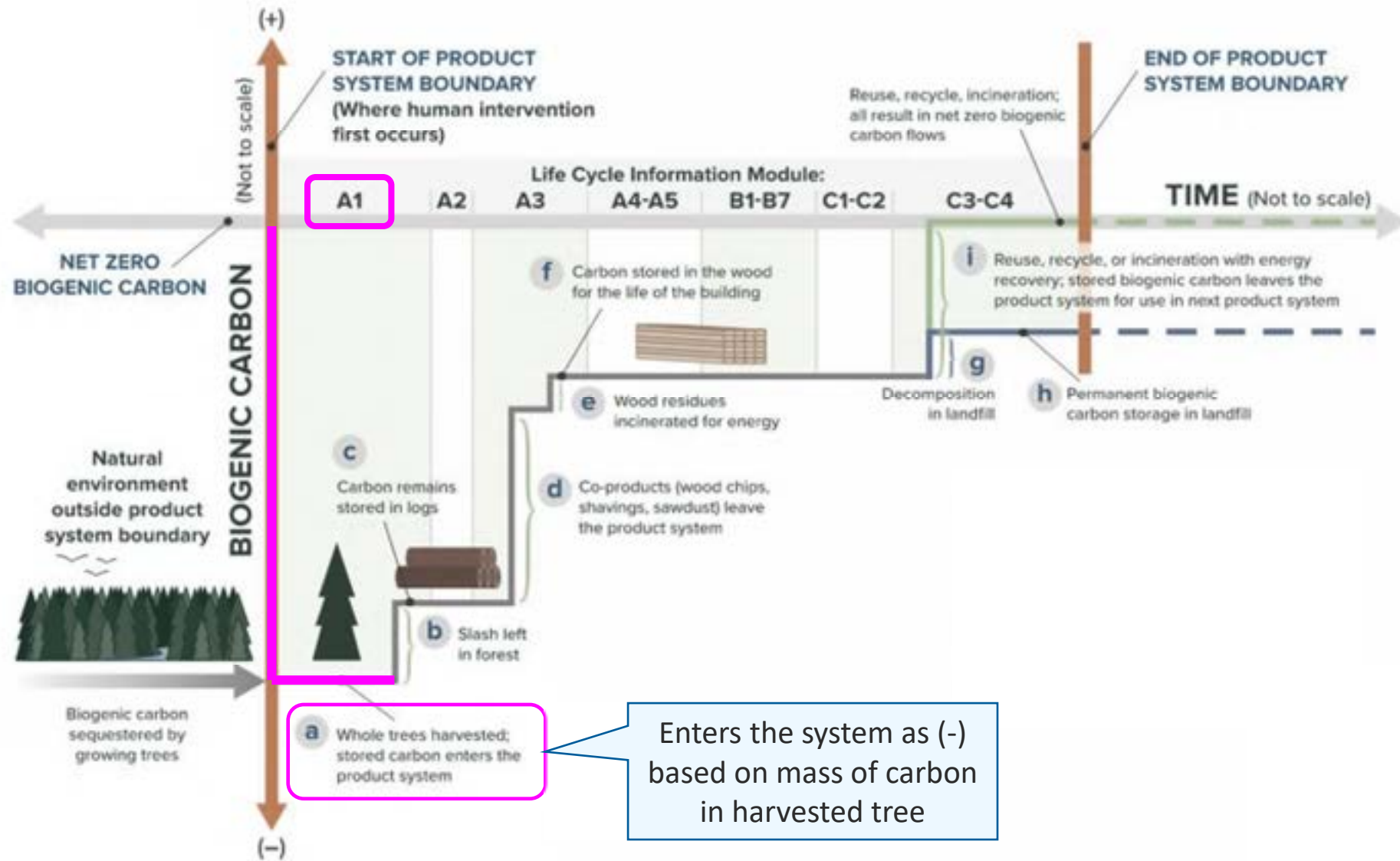


^a Replacement information module (B4) not applicable at the product level.

BIOGENIC CARBON FLOWS



BIOGENIC CARBON FLOWS

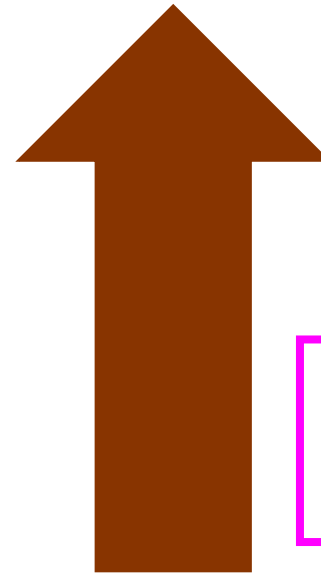


Biogenic Carbon Accounting



-1 in

Removal of
carbon from the
atmosphere

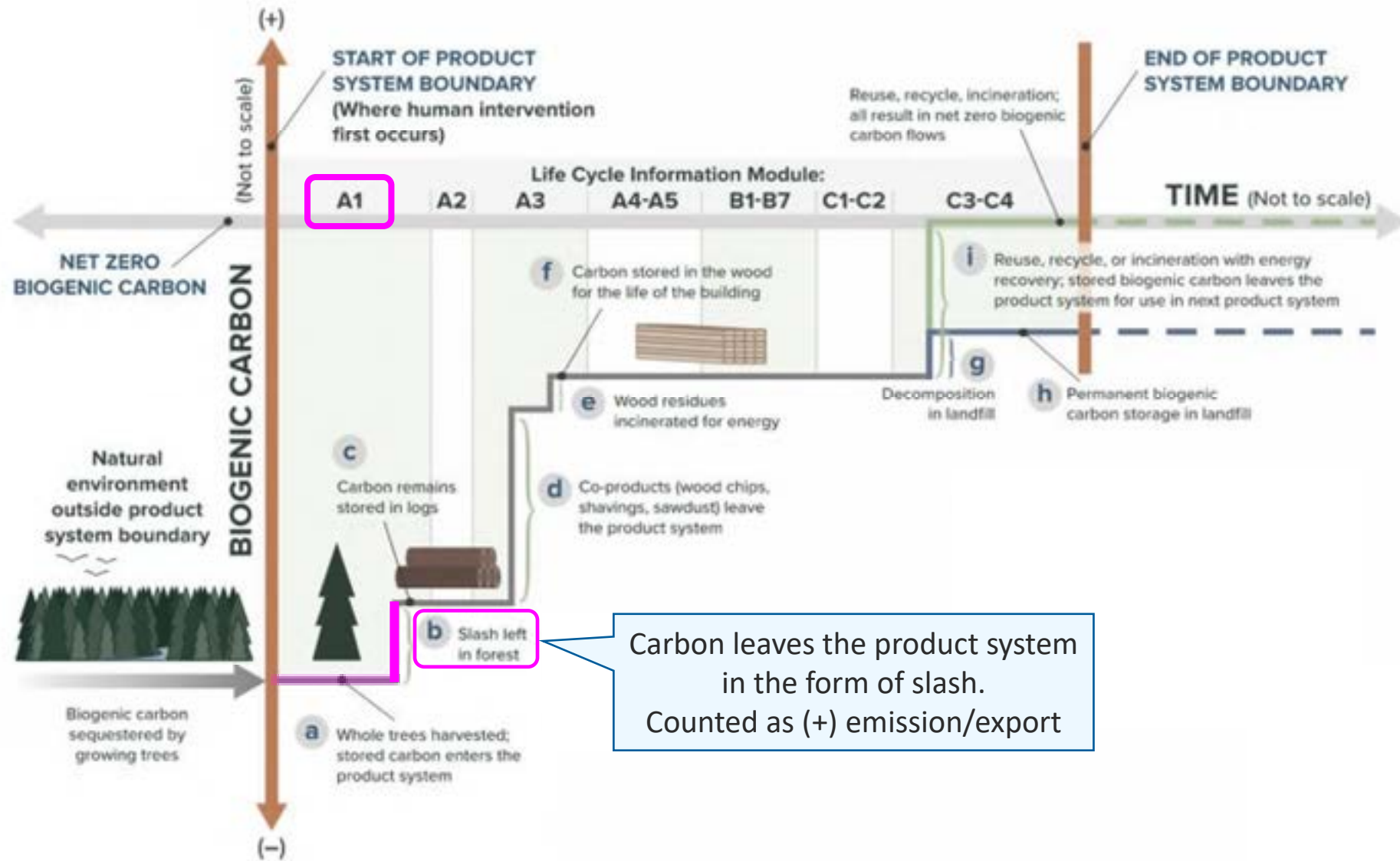


+1 out

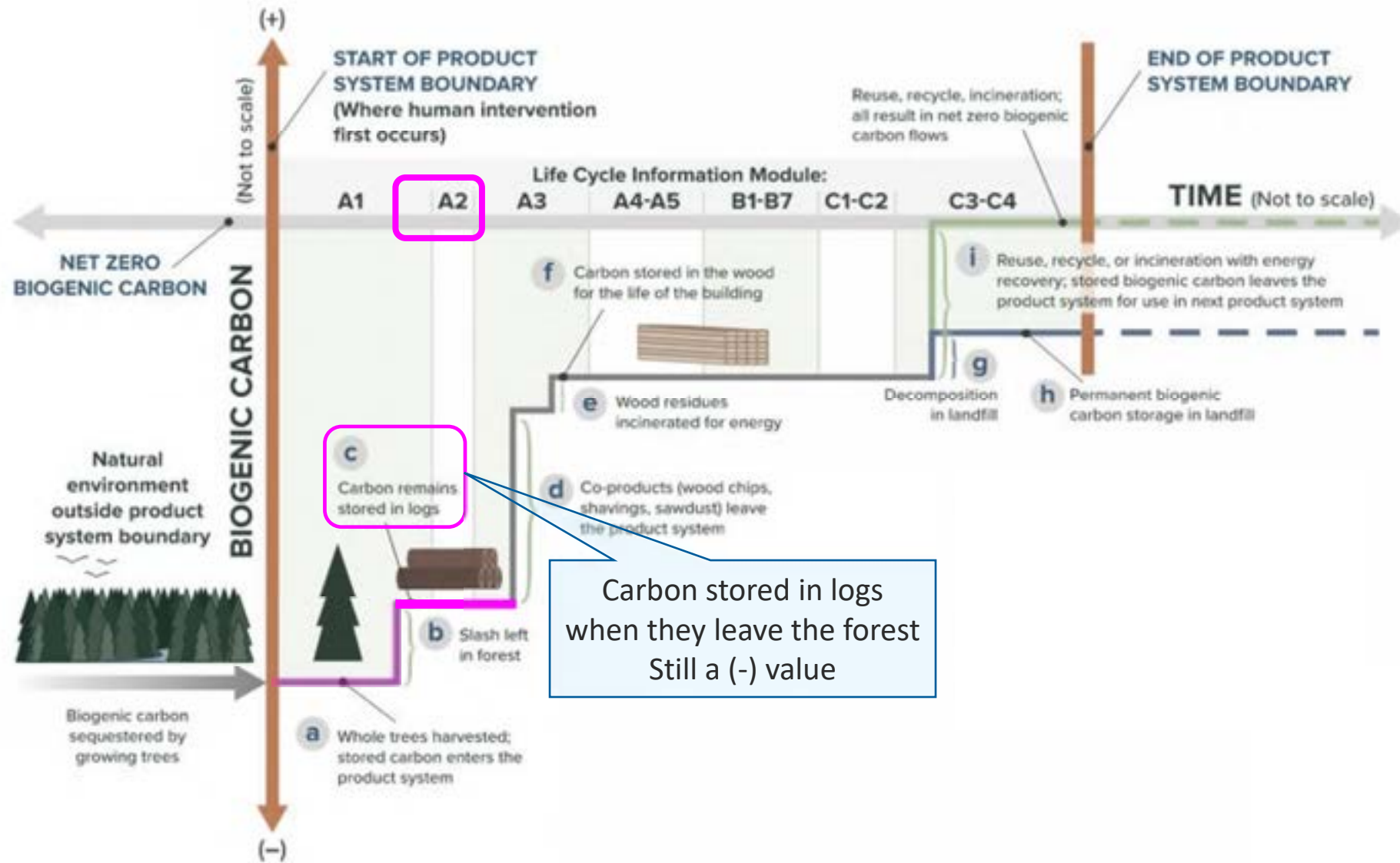
Note that “exports” are
not direct emissions to
the atmosphere.

Emission or export
of carbon from
product system

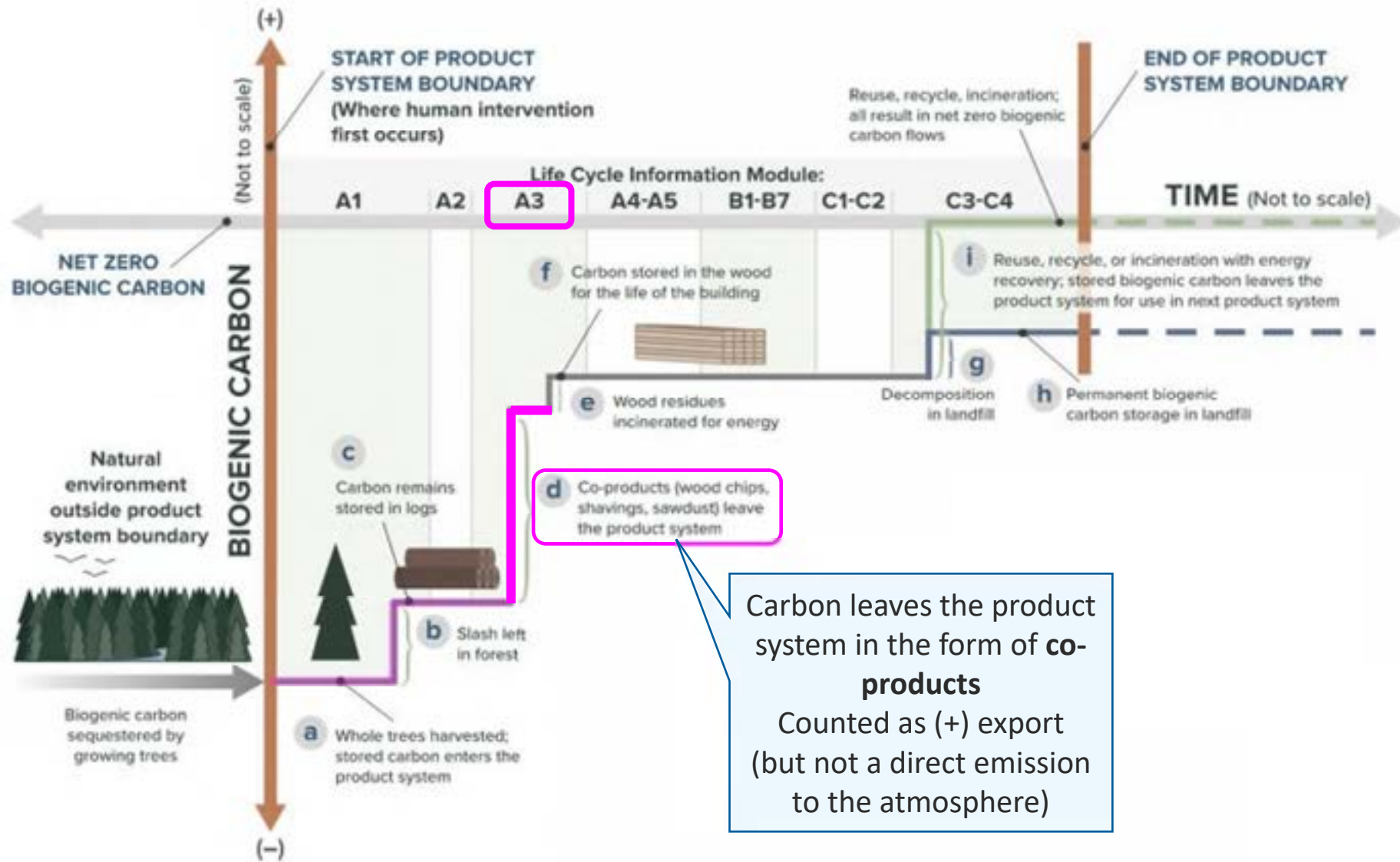
BIOGENIC CARBON FLOWS



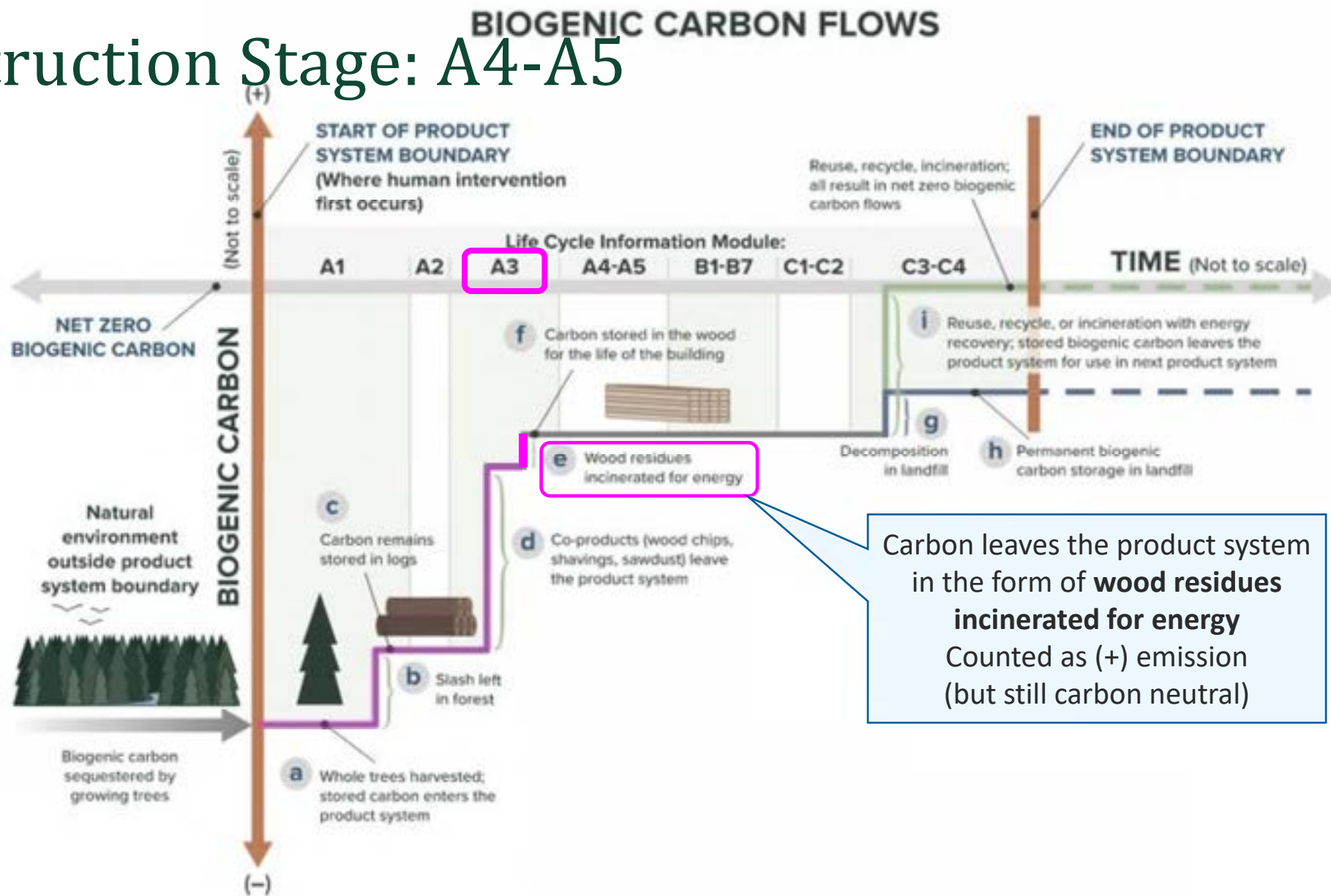
BIOGENIC CARBON FLOWS



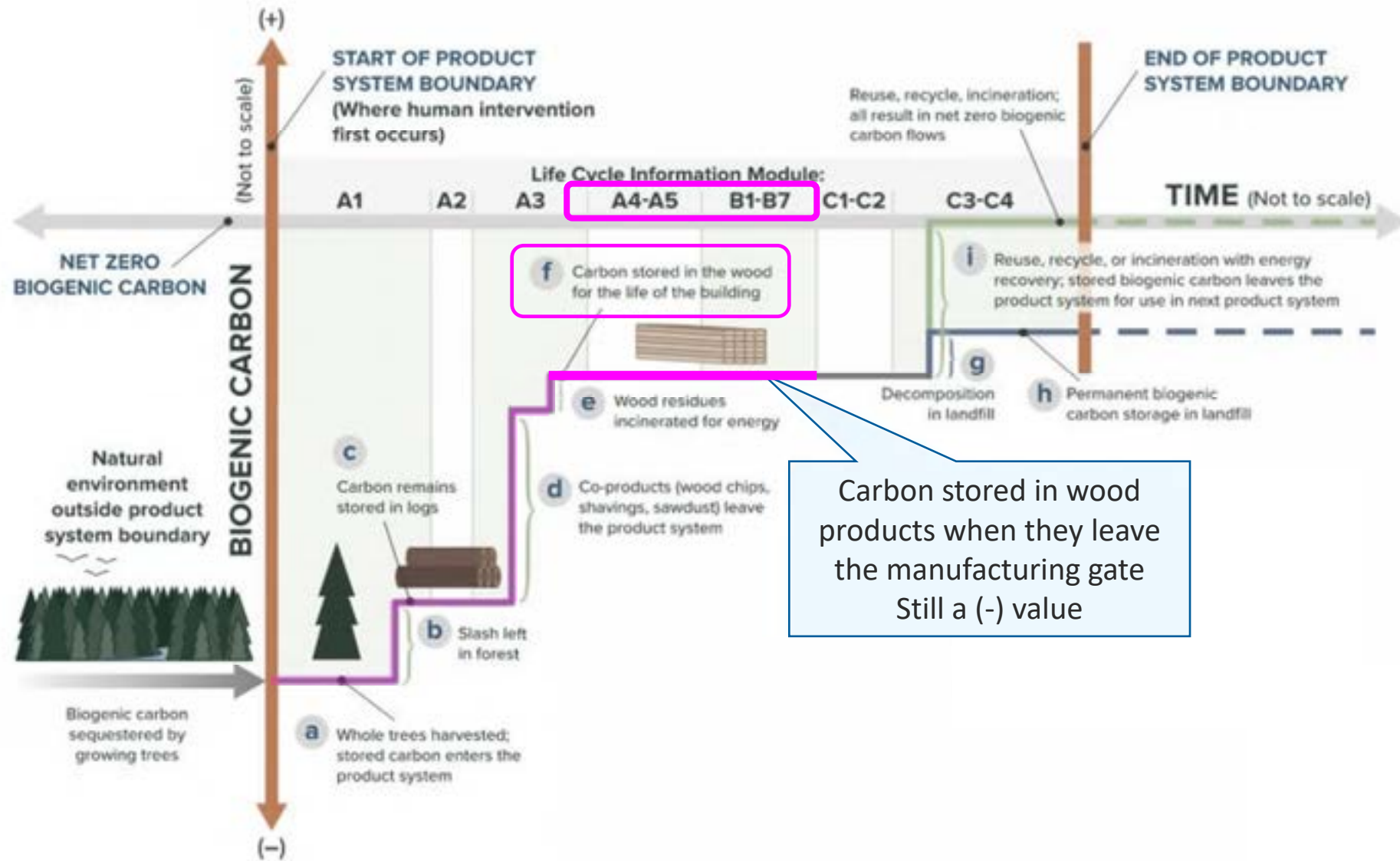
BIOGENIC CARBON FLOWS

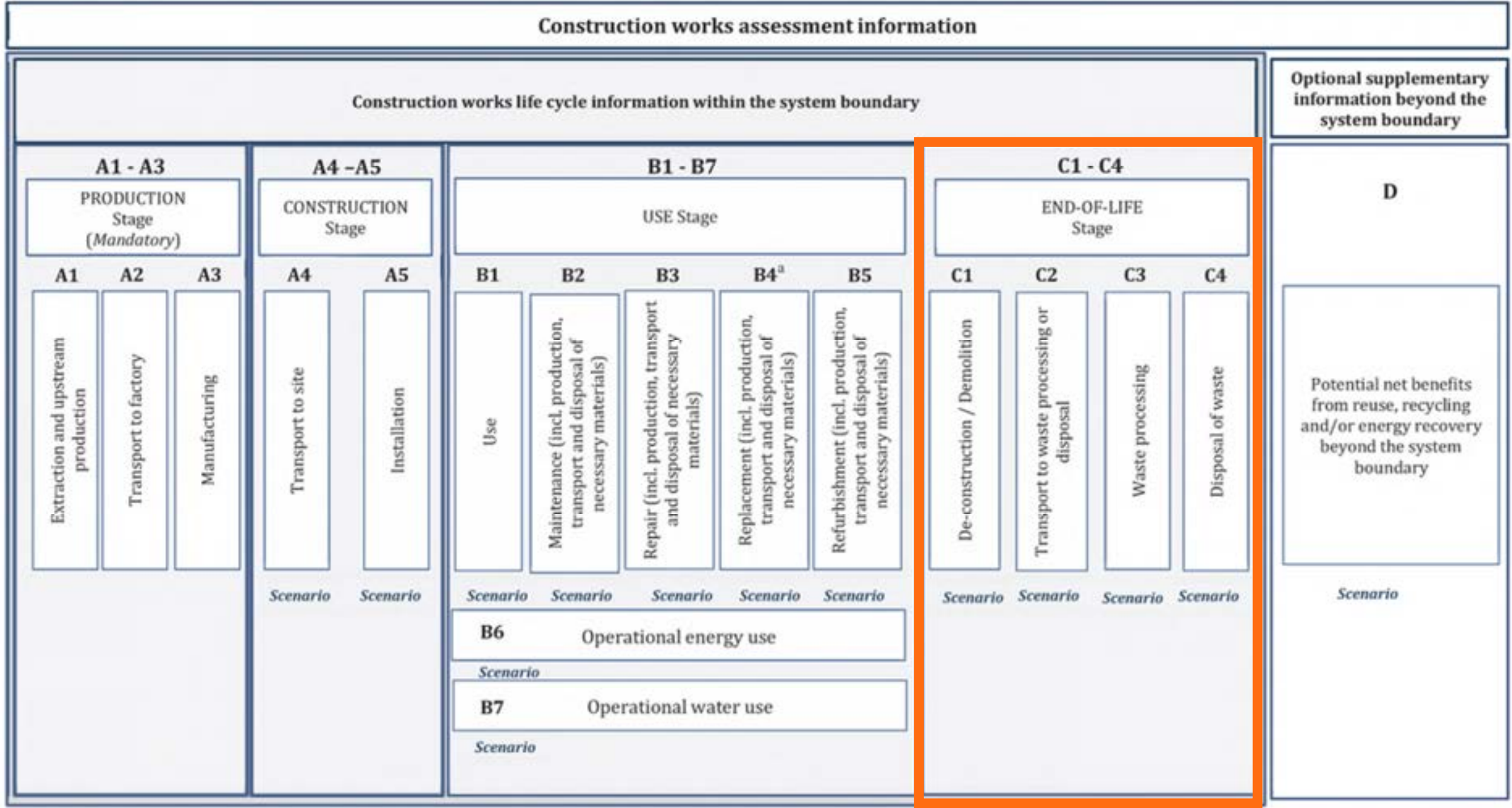


Construction Stage: A4-A5



BIOGENIC CARBON FLOWS





^a Replacement information module (B4) not applicable at the product level.

C3-C4 for Wood Products

C1: Deconstruction / Demolition

- » Dismantling the building

C2: Transport to waste processing or disposal

- » Transportation to recycling site and/or solid waste disposal site

C3: Waste processing

- » Including waste generated during the creation of secondary materials

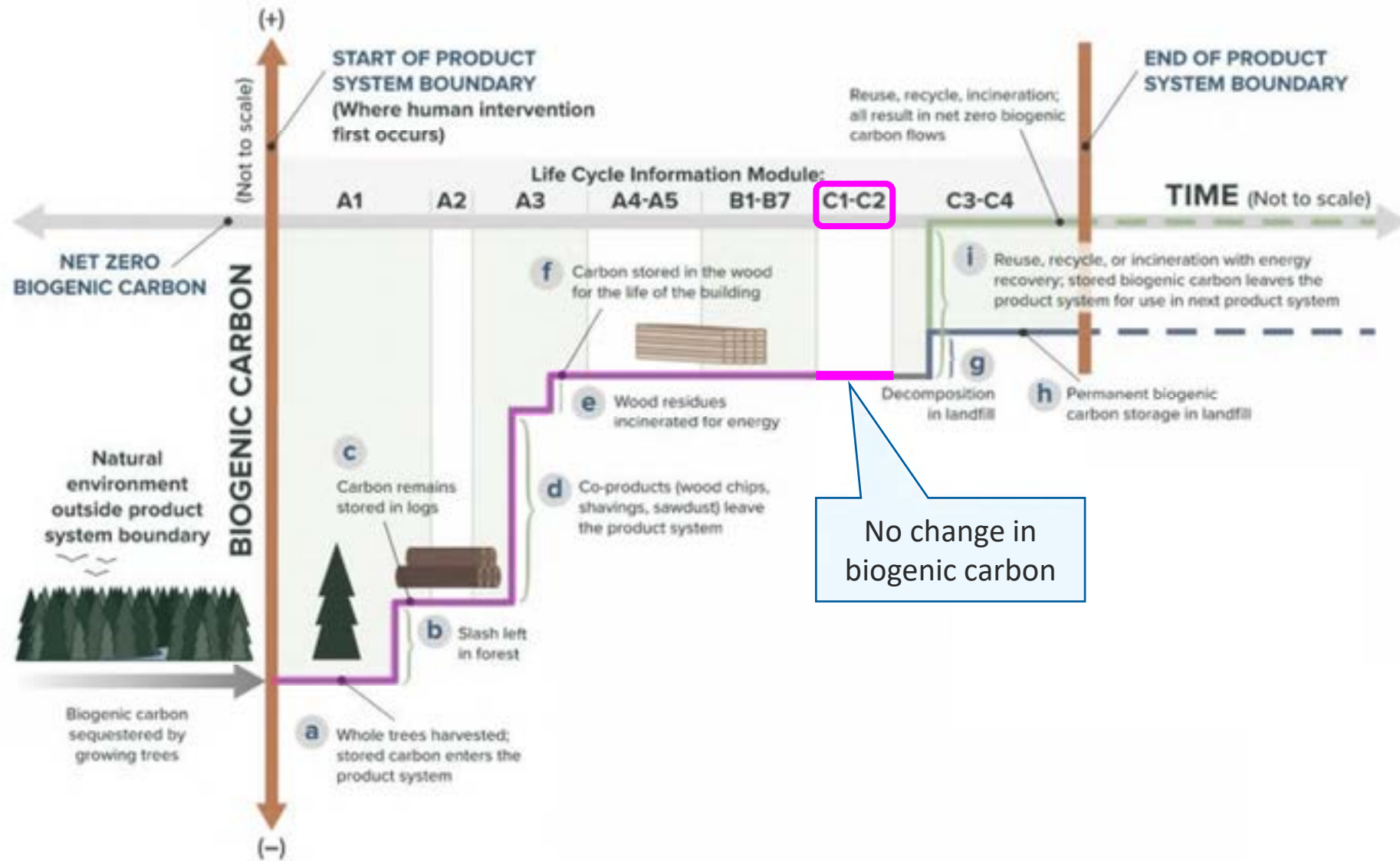
C4: Disposal of waste

- » Management of the disposal site including landfill gas energy recovery

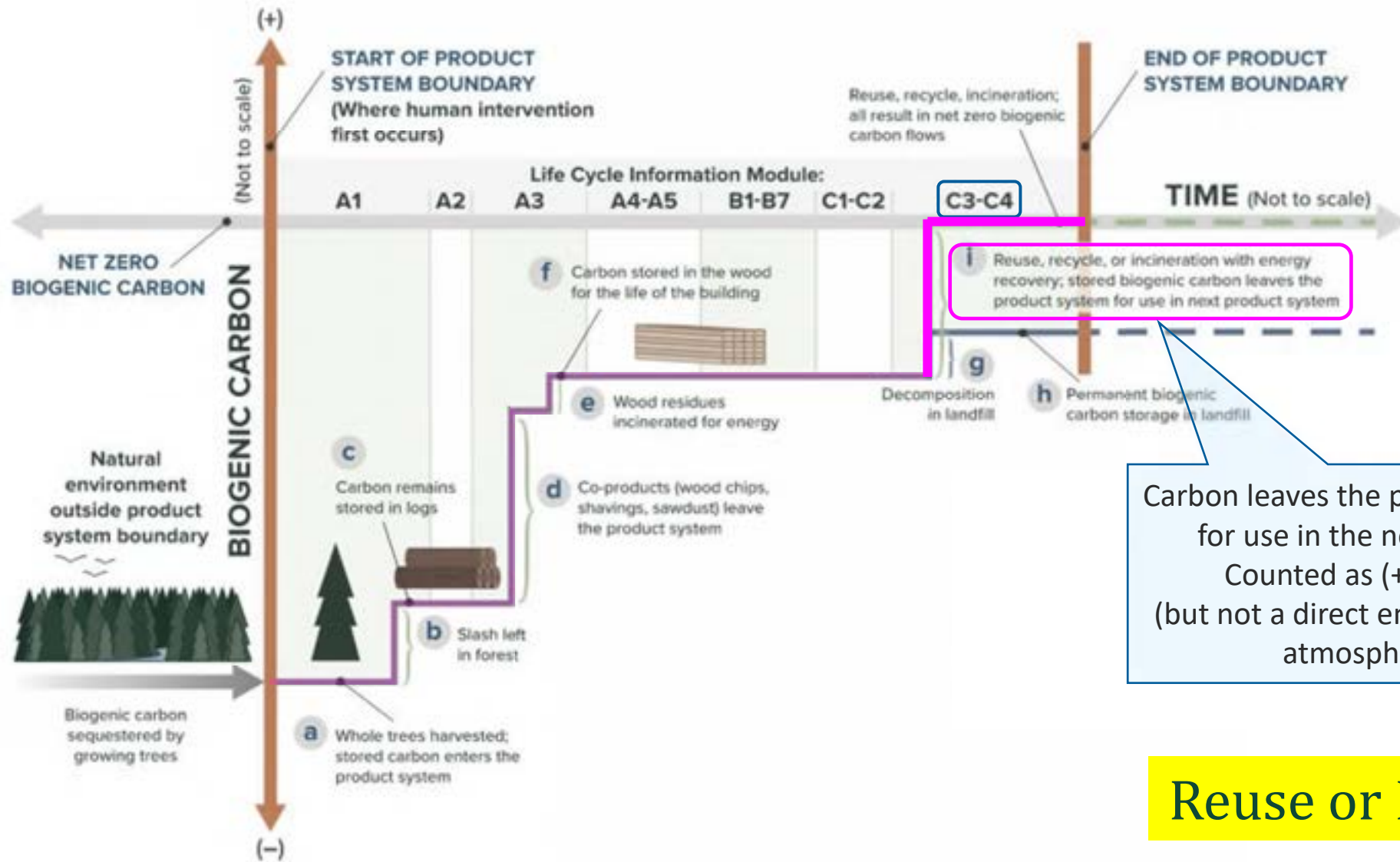
End-of-Life Scenarios:

1. Landfill
2. Incineration (energy recovery)
3. Recycle (down-cycle)
4. Direct Reuse

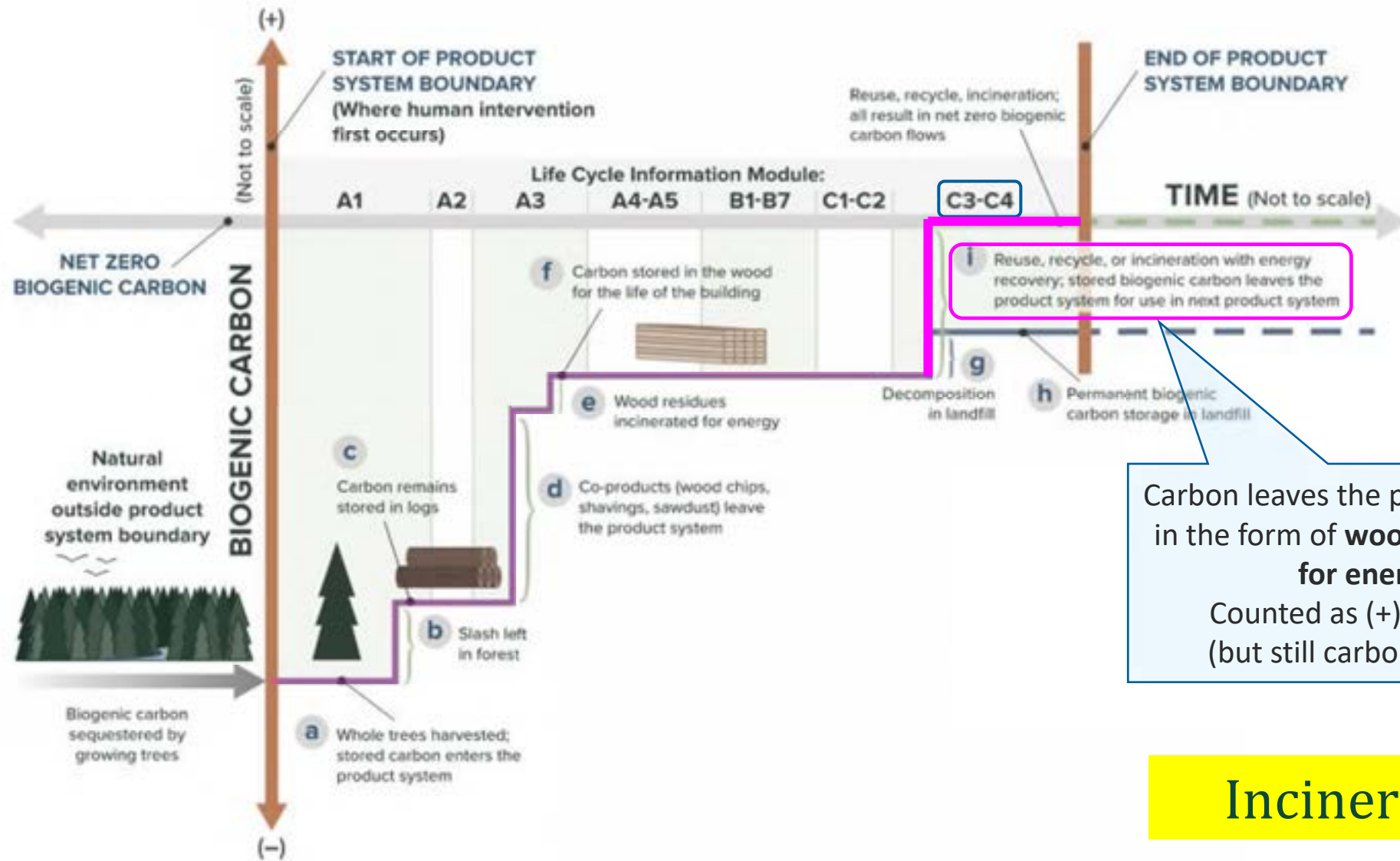
BIOGENIC CARBON FLOWS



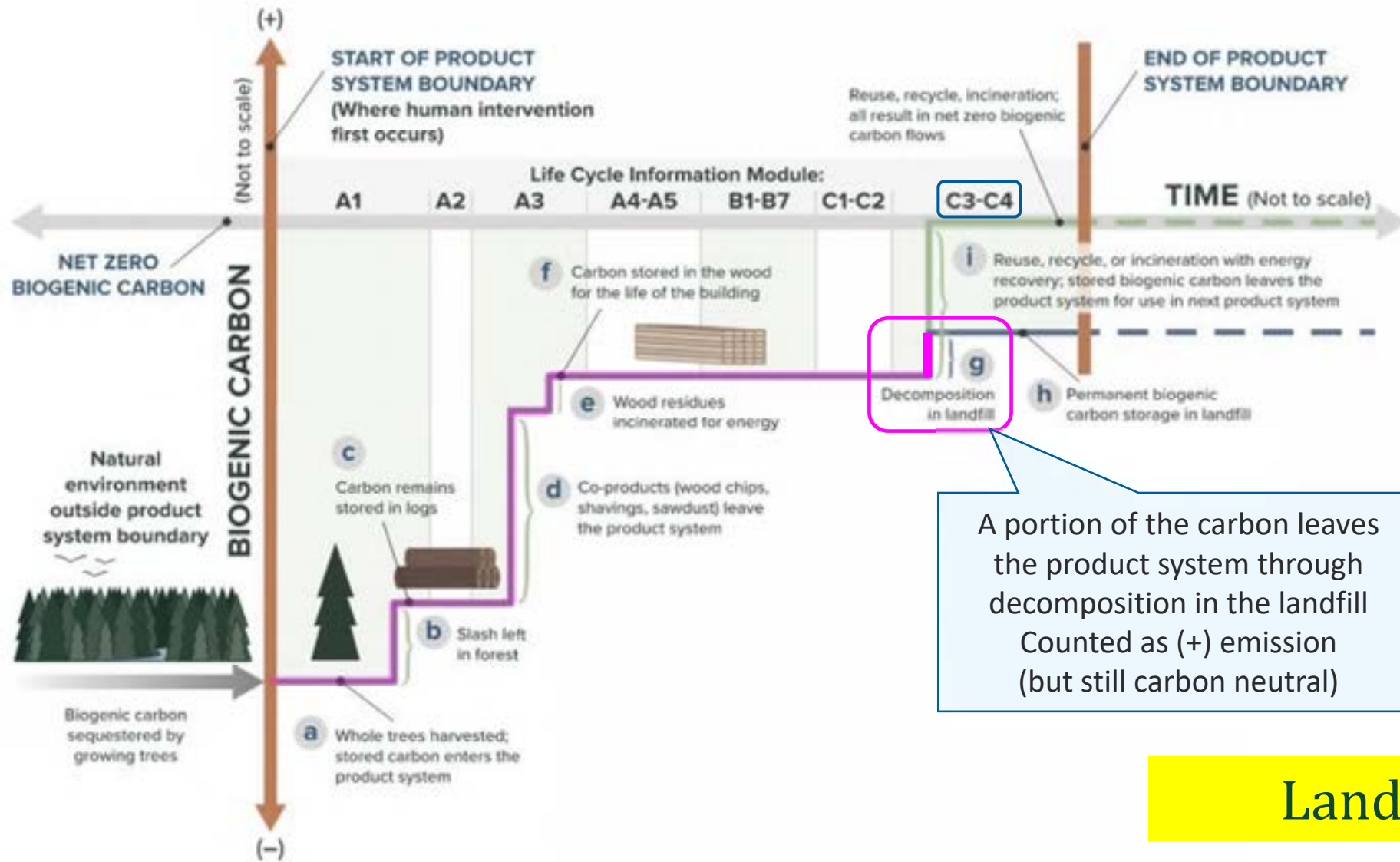
BIOGENIC CARBON FLOWS



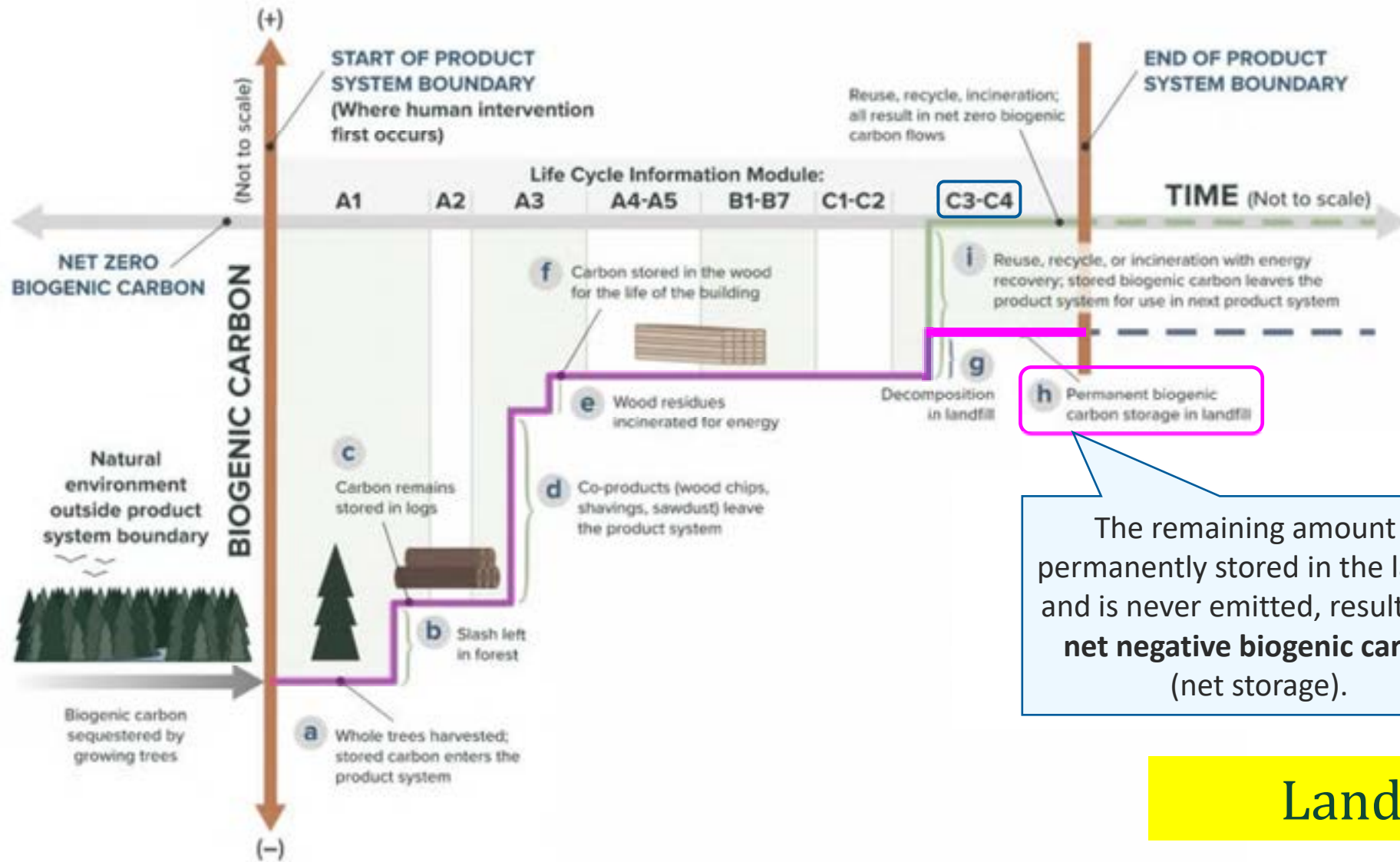
BIOGENIC CARBON FLOWS



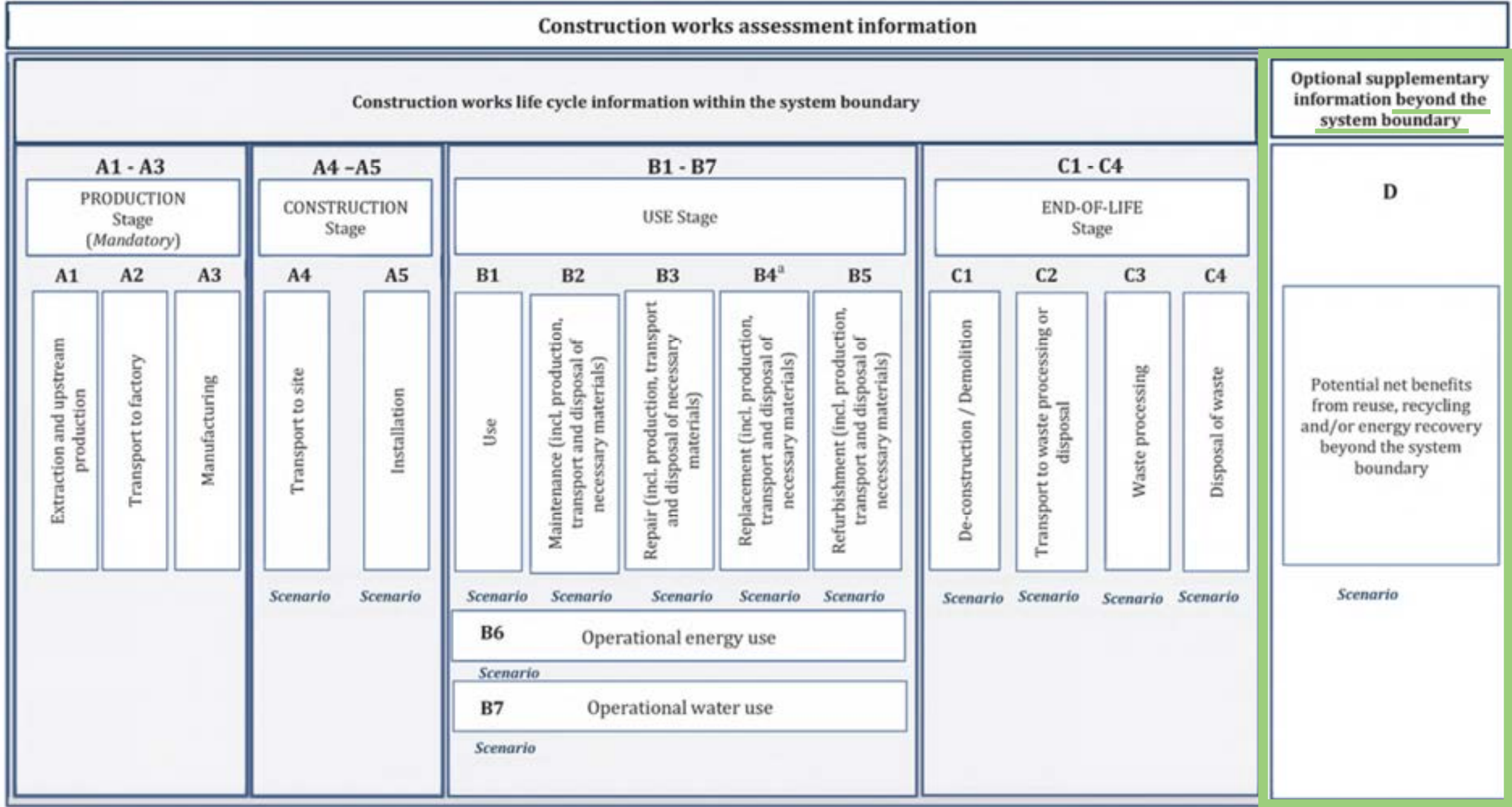
BIOGENIC CARBON FLOWS



BIOGENIC CARBON FLOWS

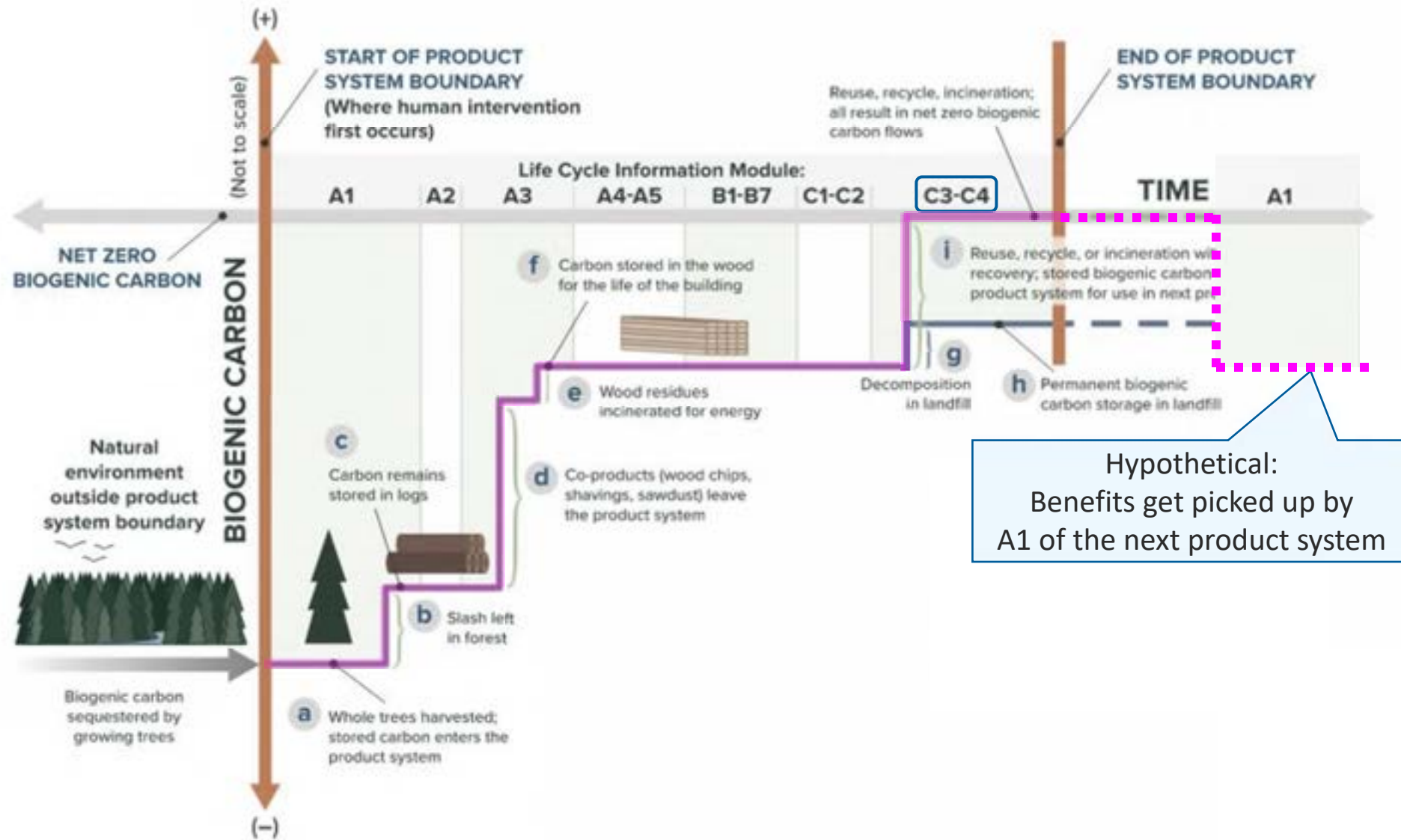


But, isn't reuse better?



^a Replacement information module (B4) not applicable at the product level.

BIOGENIC CARBON FLOWS



Wood in LEED

VERSION 5



Potential Wood Points:

LEED v5 Credit	Potential Points
MRp2: Qualify and Assess Embodied Carbon	0 (pre-req)
MRc1: Building and Materials Reuse	1-2
MRc2: Reduce Embodied Carbon	1-6
MRc3: Low-Emitting Materials	1-2
MRc4: Building Product Selection and Procurement	1-5
MRc5: Construction and Demolition Waste Diversion	1-2
EQc2: Occupant Experience	1-3

Source: *Dovetail Partners*



APEX PLAZA

CHARLOTTESVILLE, VA

Office building

CLT panels / glulam frame & braced
frames

8 stories (6 mass timber), 187,000 sqft



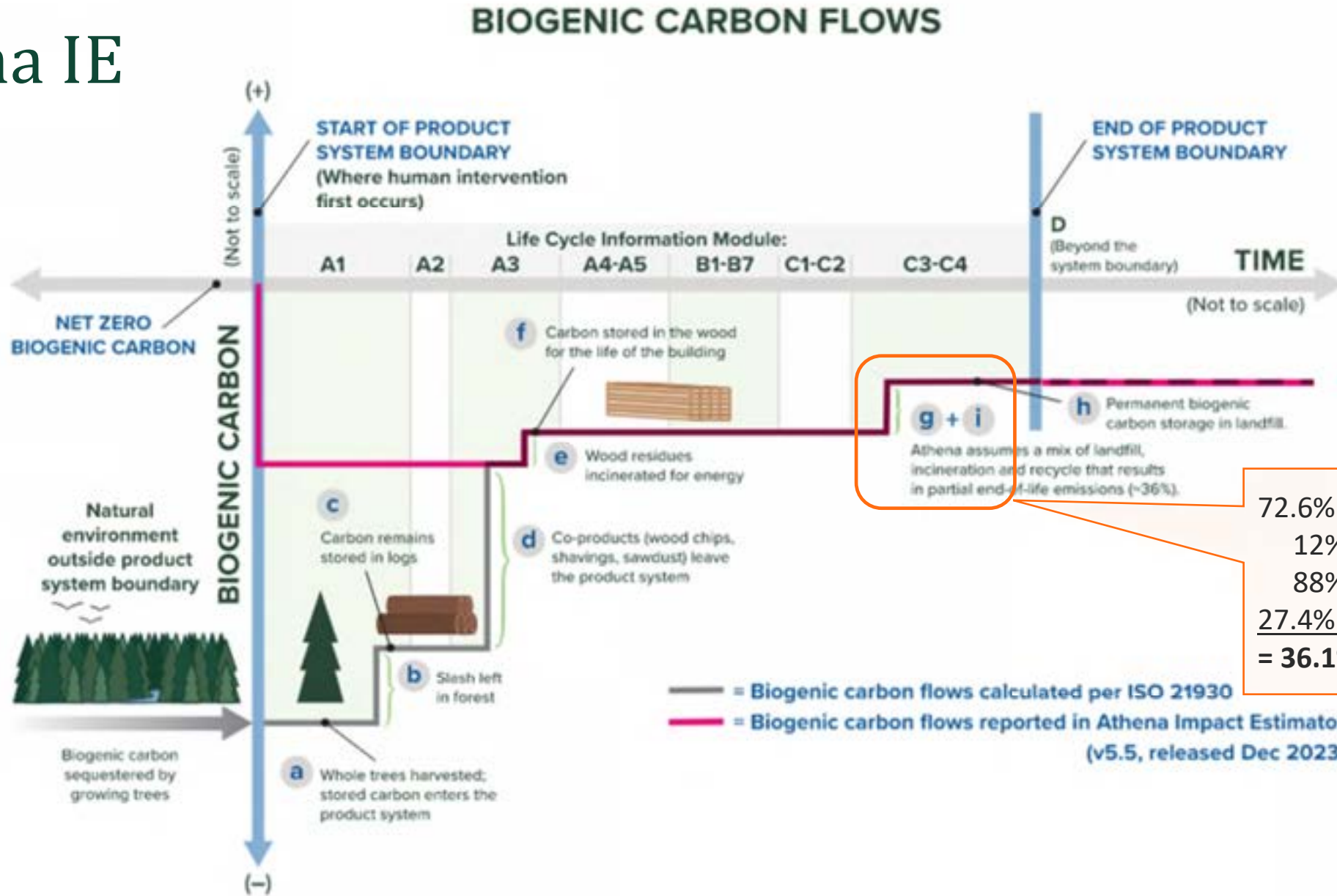
William McDonough + Partners
Simpson Gumpertz & Heger
Photo Prakash Patel

Whole Building LCA Tools

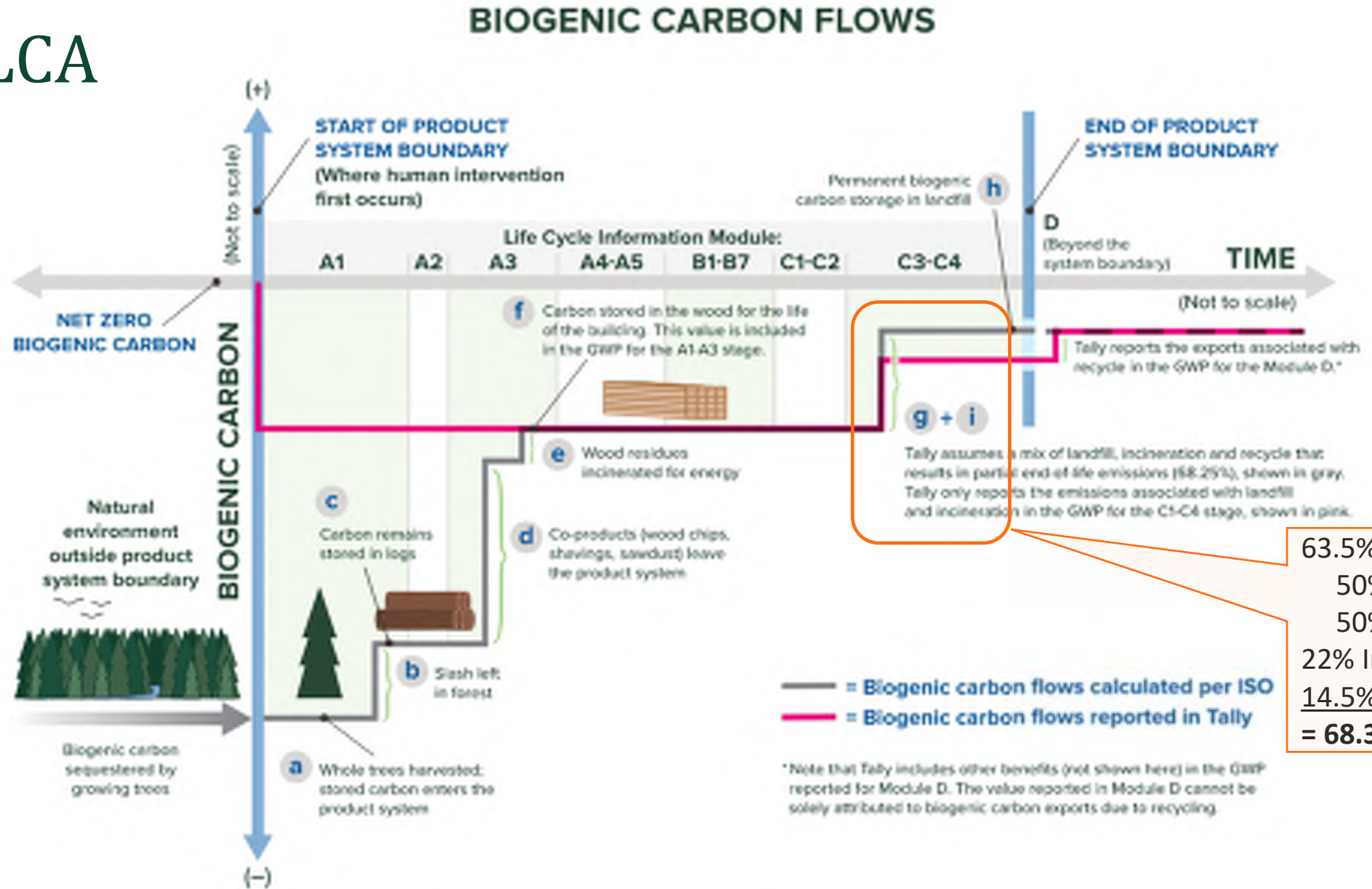
LCA tools developed for building designers that can be used for green building rating systems

	Analysis	Embodied Carbon	Biogenic Carbon	Operational Carbon	Life Cycle Inventory (LCI) Database	Custom Assemblies Possible	Used in Green Building Certification
LCA Tools that can be used for WBLCA							
Athena Impact Estimator for Buildings (IE4B)	LCA	Yes (A1-C4 + D)	Always included*	Optional	Custom database based on regional North American data	Yes	Yes
tallyLCA	LCA	Yes (A1-C4 + D)	Optional*	Optional	Custom database (combination of product specific and industry average)	Yes	
One Click LCA	LCA	Yes (A1-C4 + D)	Always calculated, reported separately*	Optional	EPD data from multiple sources	Yes, in some versions	

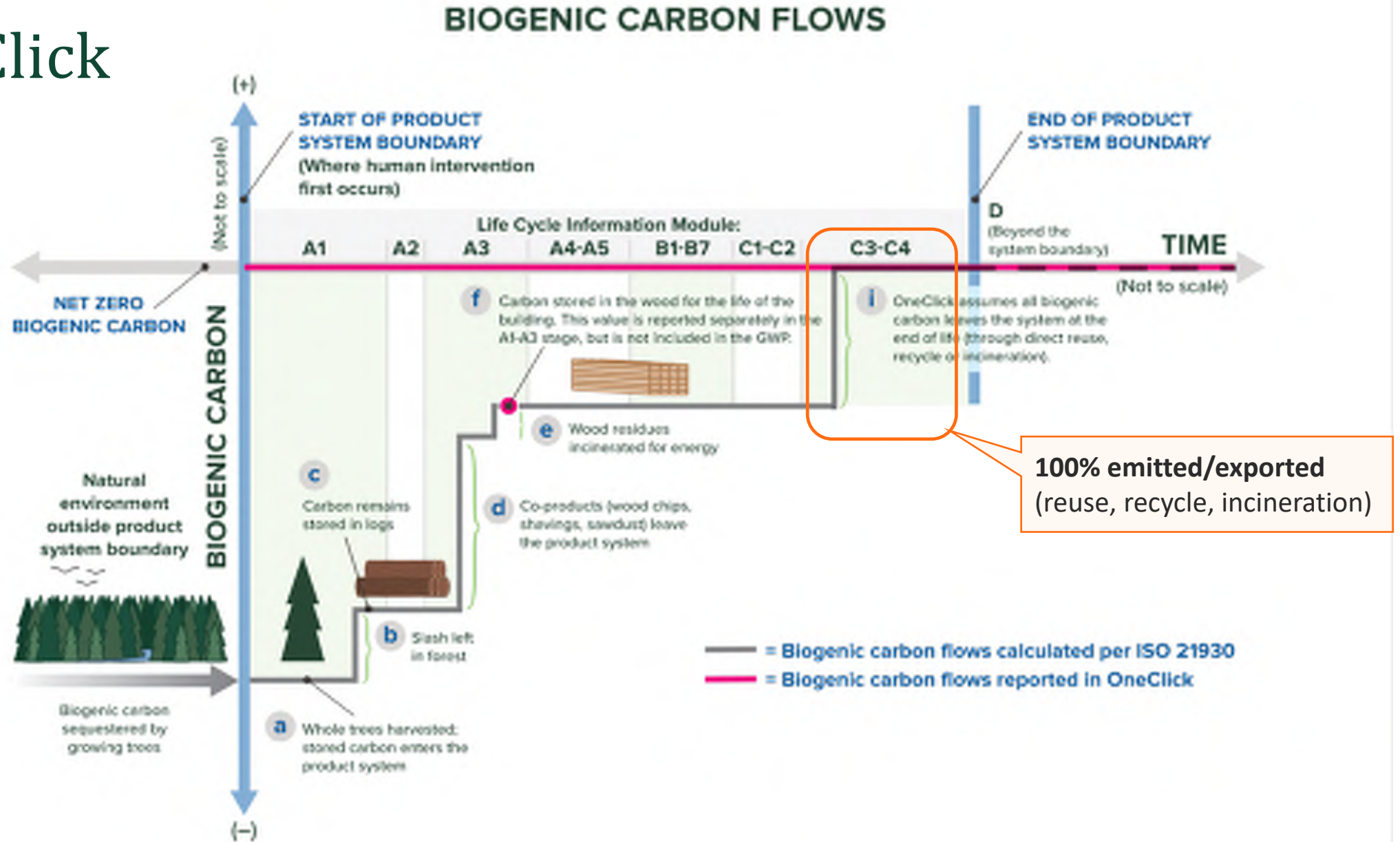
Athena IE



TallyLCA



One Click



A Note About Tools:

In addition to differences in end-of-life scenarios:

- » Where end-of-life effects are reported (C3-C4 vs Module D)
- » Methodology (ISO compliance)
- » LCI Databases (background data)
- » User interface, workflow



WoodWorks Resources

Whole Building Life Cycle Assessment (WBLCA)

- » Introduction to Whole Building Life Cycle Assessment: The Basics
- » Worksheet for Structural WBLCA of Mass Timber Buildings
- » WBLCA of Built Projects

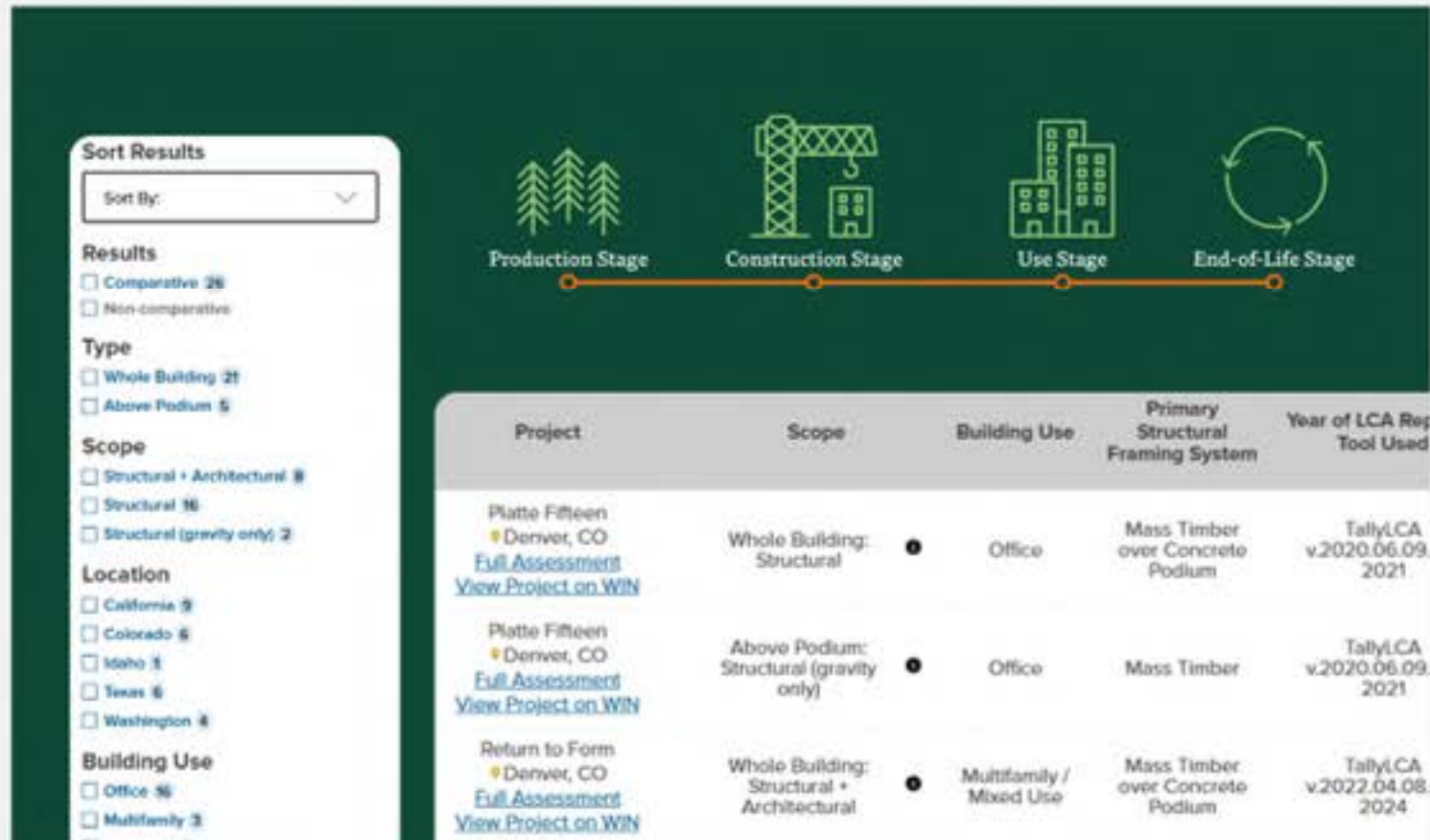
Expert articles on topics such as:

- » Biogenic Carbon in LCA Tools
- » Long-Term Biogenic Carbon Storage
- » What Net Zero Means in Building Construction
- » Environmental Product Declarations (EPDs)

*Scan for a complete list of sustainability
resources at [woodworks.org](https://www.woodworks.org)*



Life Cycle Assessment Index



Stay informed on building-level life cycle assessment (LCA) data for North American wood buildings.

Questions? Ask us anything.



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