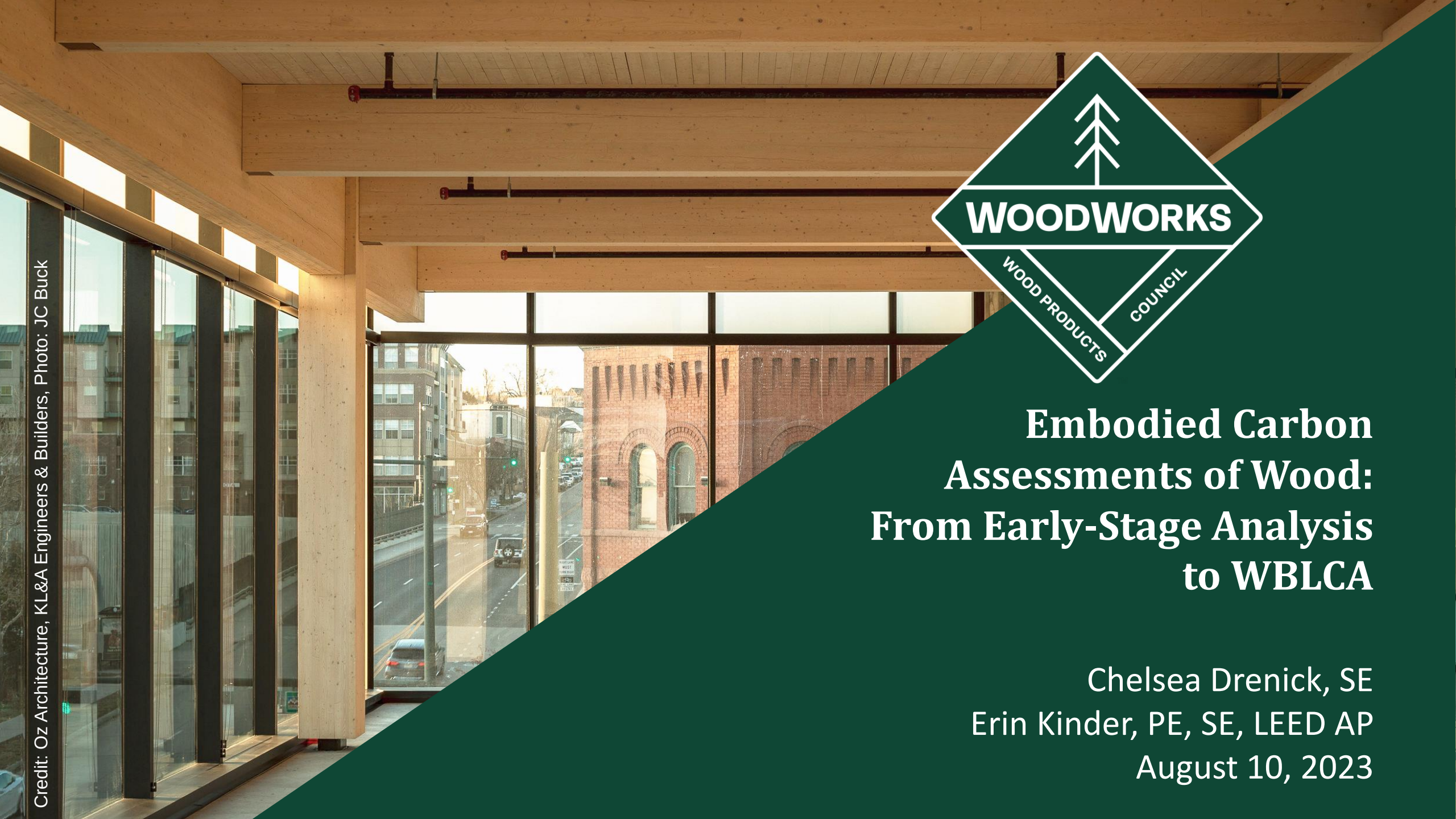

Credit: Oz Architecture, KL&A Engineers & Builders, Photo: JC Buck

Embodied Carbon Assessments of Wood: From Early-Stage Analysis to WBLCA

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August 10, 2023

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Course Description

More and more often, carbon calculations are an important component of building design as ownership and design teams strive for more sustainable structures. As architects and engineers embrace carbon accounting as part of the design process, it is important to understand how to correctly account for wood and biogenic carbon using early-stage analysis and whole building life cycle assessment (WBLCA). This webinar aims to clarify the benefits of wood construction in relation to both embodied carbon and carbon storage and provide practical guidance on how to quantify these benefits. Participants will hear from several design teams to learn more about the carbon accounting strategies they have used, both early in design and once the project is more fully developed. WoodWorks will also introduce a new resource, Considerations and Worksheet for Whole Building Life Cycle Assessment of Mass Timber Buildings.

Learning Objectives

1. Understand the embodied carbon and carbon storage benefits of wood products.

2. Explain biogenic carbon removals, emissions, and exports at each stage of a wood product's life cycle, in alignment with ISO standards.

3. Explore options for performing a carbon analysis during early design stages.

4. Review results from comparative LCAs showing the environmental impacts of mass timber versus alternative steel and concrete designs

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 (**WBLCA**)

https://www.woodworks.org/resources/introduction-to-whole-building-life-cycle-assessment-the-basics/

Source: ISO 21930:2017(E), 3.3.2

Life Cycle Assessment (LCA)

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

Environmental Impacts:

- Global Warming Potential (GWP)
- Ozone depletion
- Smog formation
- Acidification
- Eutrophication
- Depletion of nonrenewable resources
- Etc.

Source: ISO 21930:2017(E), 3.3.2

Life Cycle of a Building

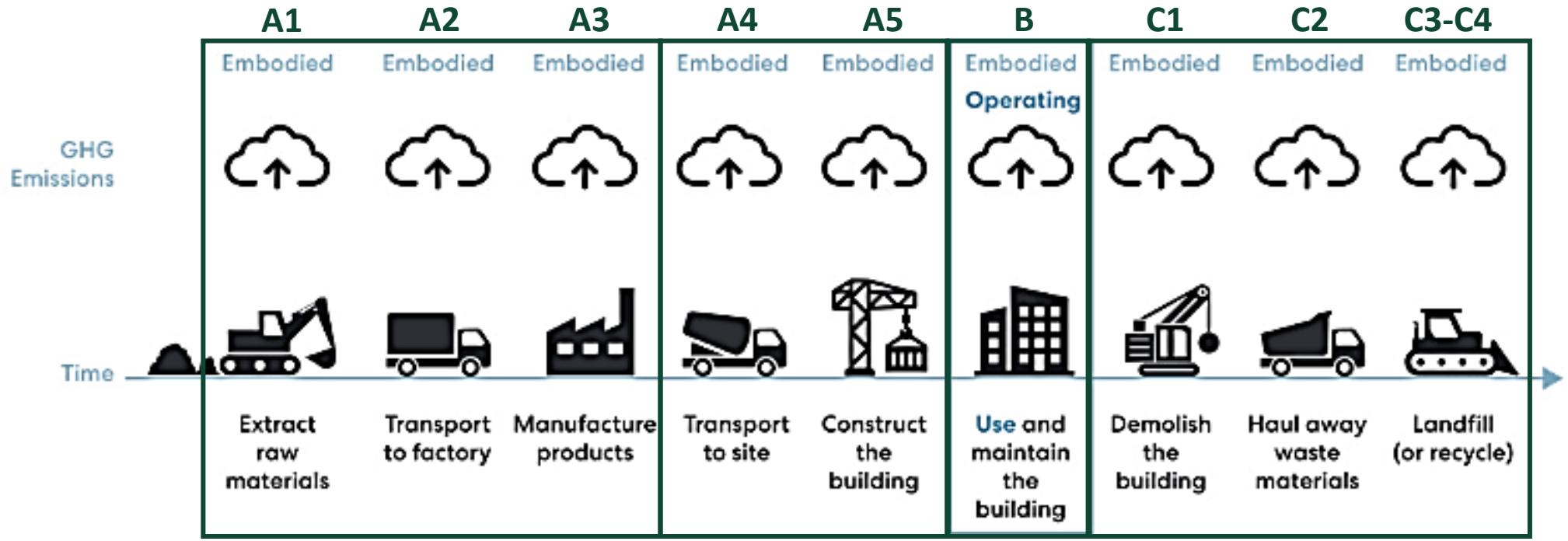
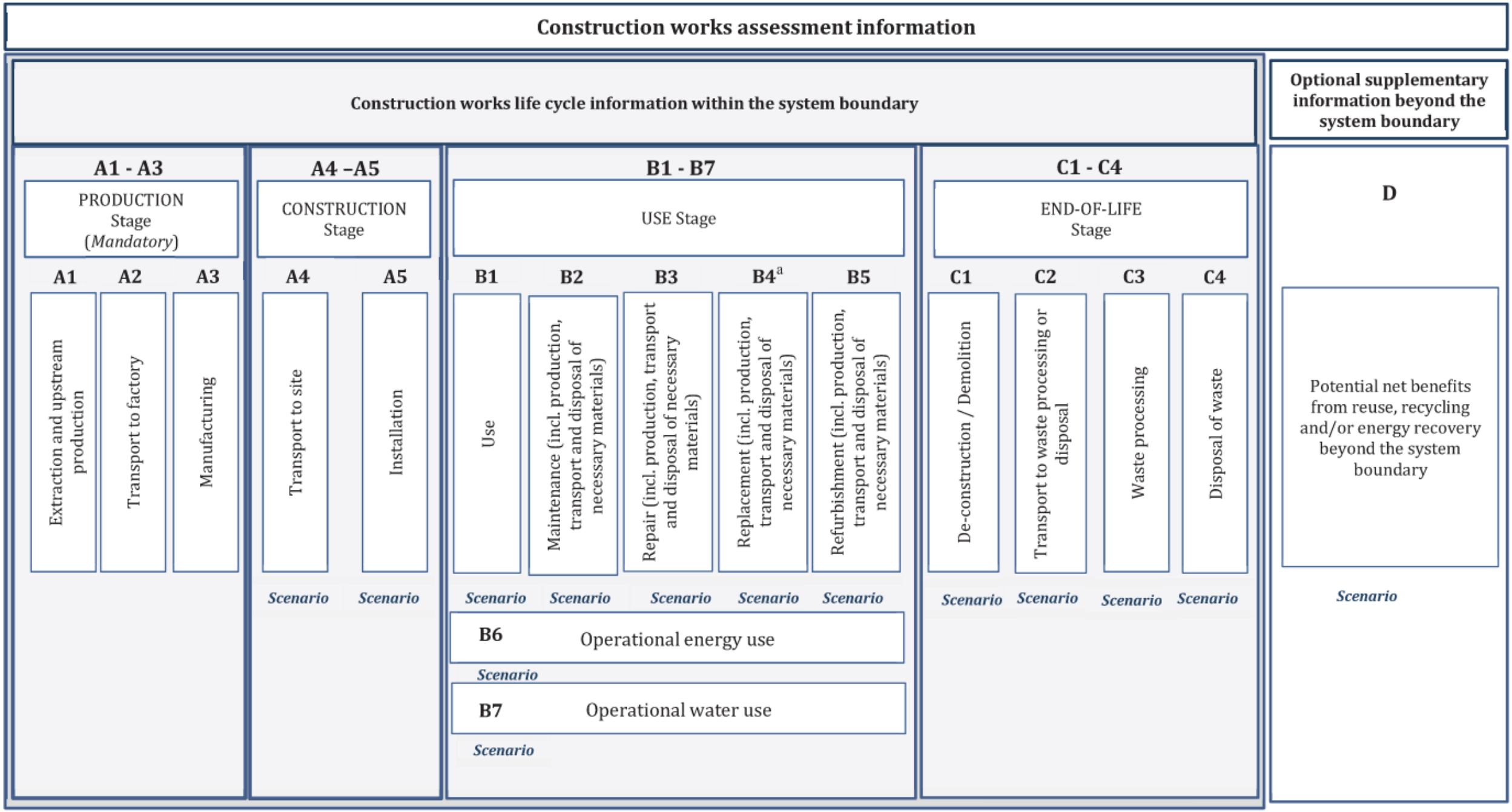


Image: Think Wood



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

Source: ISO 21930:2017(E), Figure 2

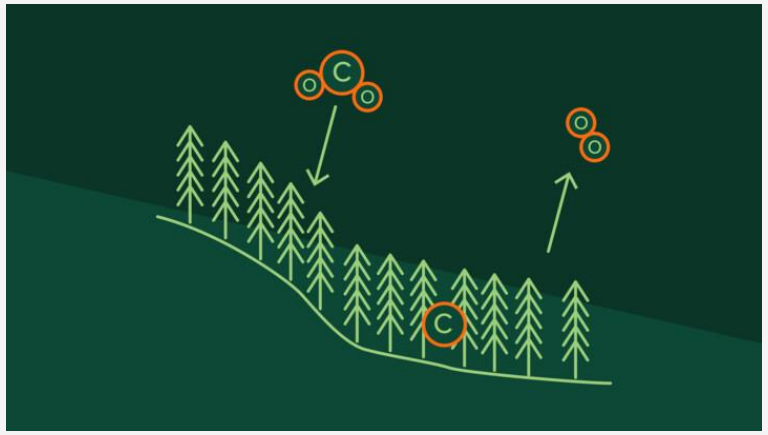
What makes wood different?
Biogenic Carbon

Biogenic Carbon

"**<u>Carbon derived from… material of biological origin</u>**
excluding material embedded in geological formations or transformed to fossilized material and excluding peat."

Photosynthesis:

$$6\ CO_2 + 6\ H_20 \rightarrow \mathbf{C_6}H_{12}O_6\ (\mathbf{stored}) + 6\ O_2\ (\text{released})$$



Source: ISO 21930:2017(E), 3.7

Biogenic Carbon

“Bio-based materials originating from renewable resources (such as wood…) contain biogenic carbon.”

- Biogenic carbon removals and emissions **shall be reported** as CO_2 in the LCI
- When entering the product system (**removal**), characterized with a factor of **-1**
- When converted to emissions (**emission**), characterized with a factor of **+1**
- When leaving the product system (**export**), characterized with a factor of **+1**

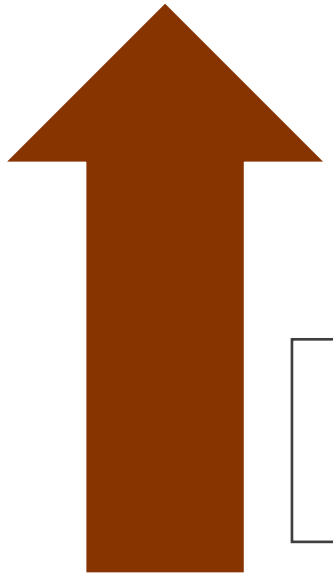
https://www.woodworks.org/resources/when-to-include-biogenic-carbon-in-an-lca/

Source: ISO 21930:2017(E), 7.2.7

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

"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?

Source: ISO 21930:2017(E), 7.2.7

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)

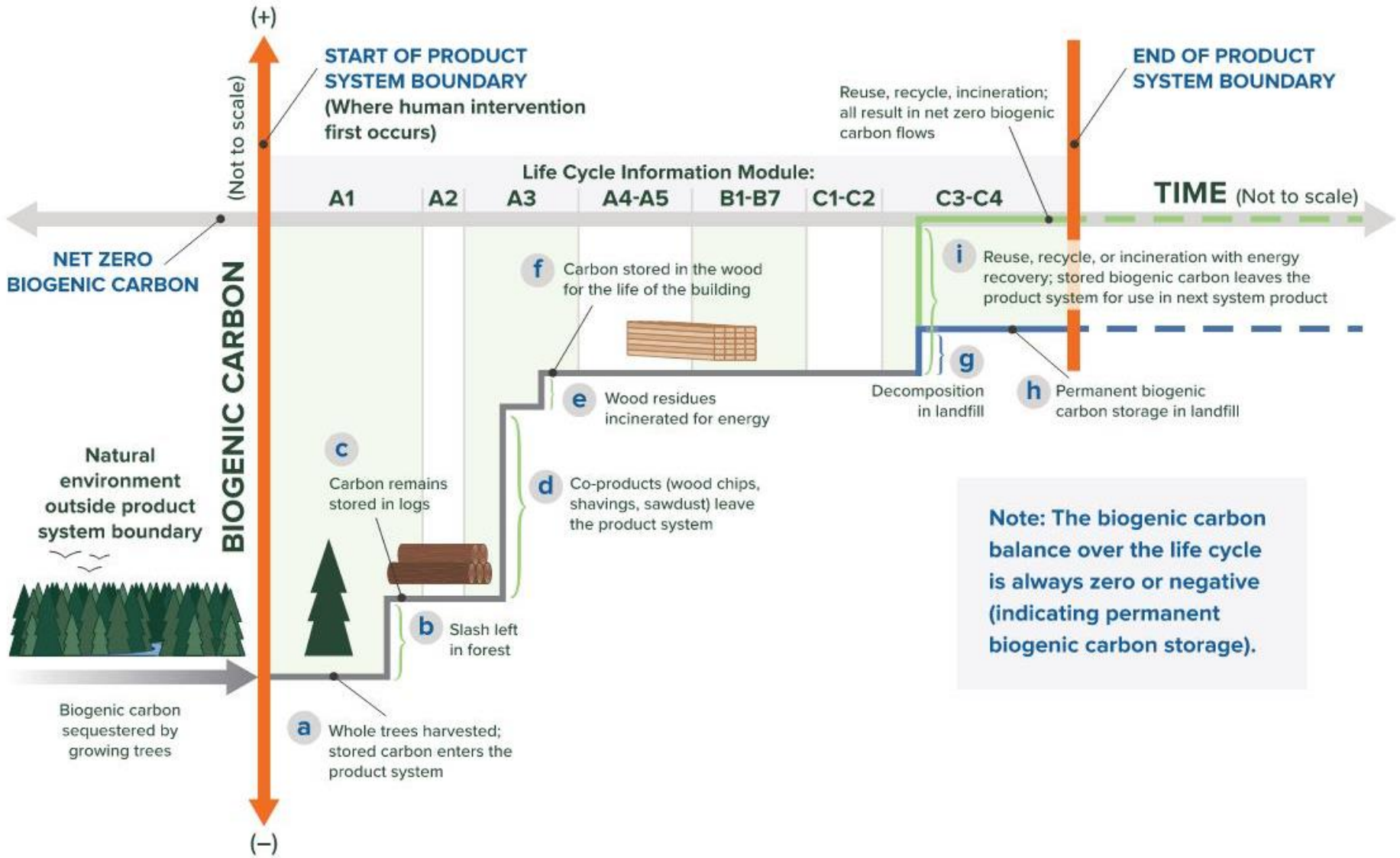
- “The concept of sustainably managed forests is linked but not limited to respective certification schemes”
- Evidence such as national reporting under UNFCCC to identify forests with stable or increasing forest carbon stocks

Source: ISO 21930:2017(E), 7.2.11

Should I include biogenic carbon?

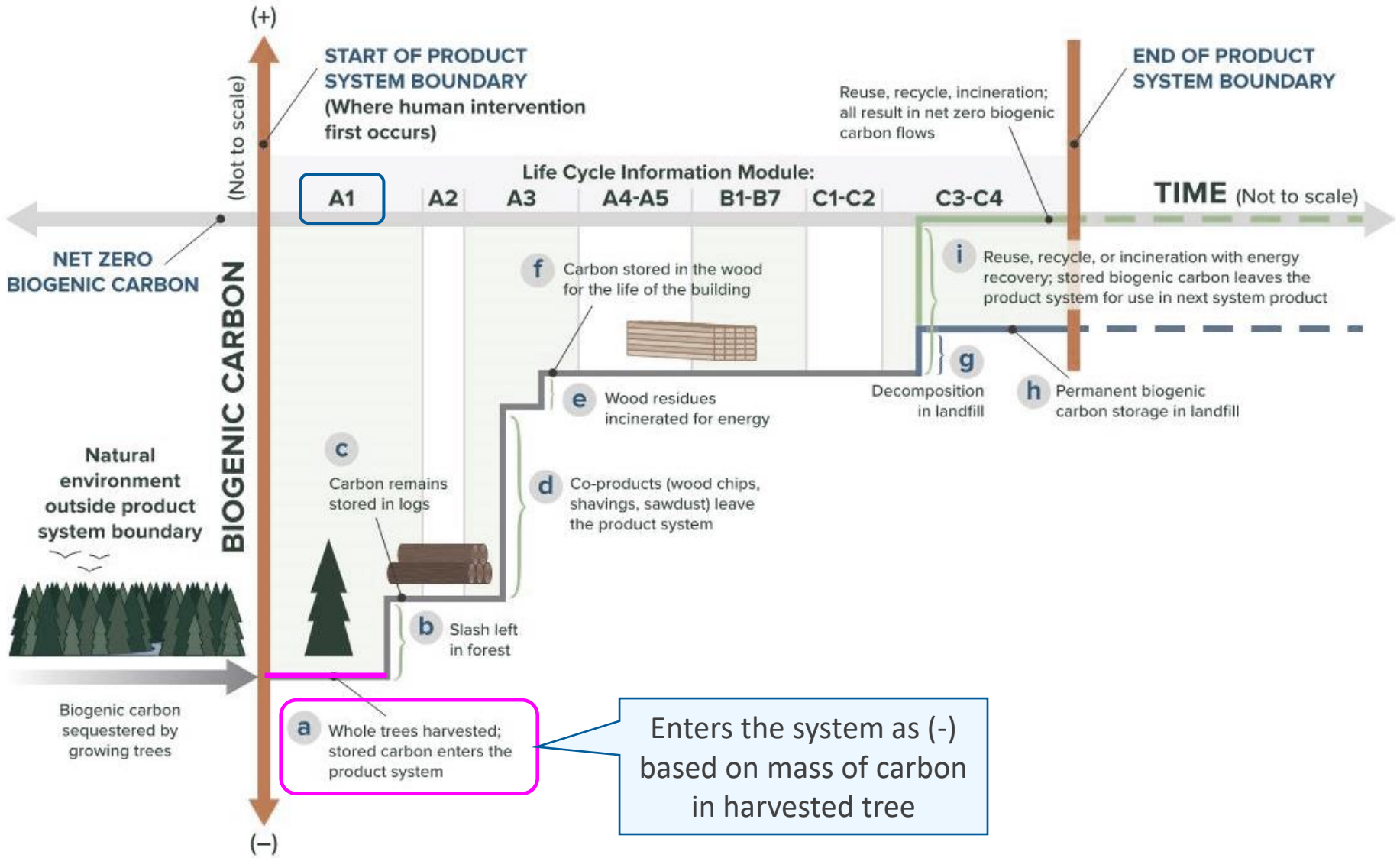
Yes! But how?

BIOGENIC CARBON FLOWS



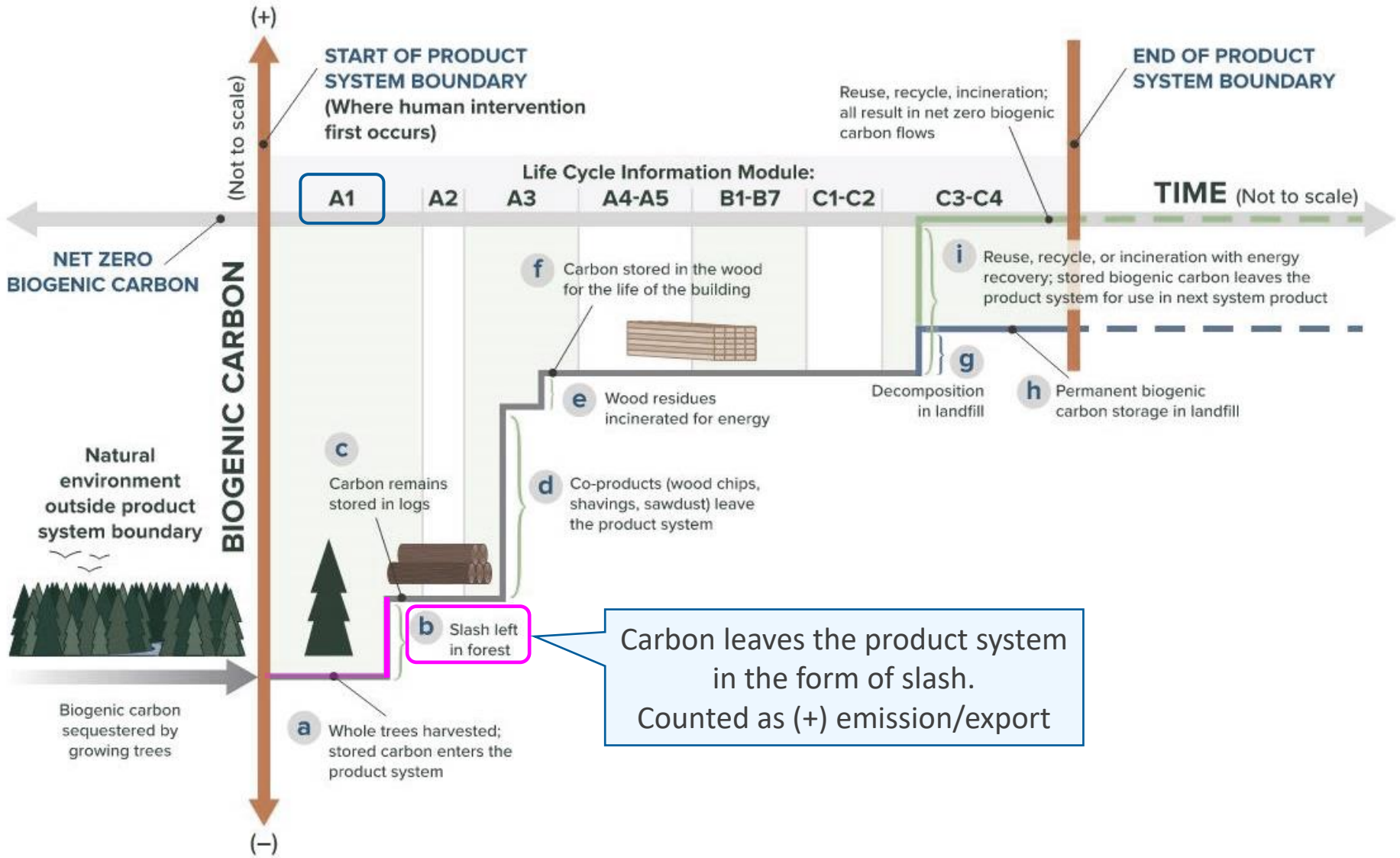
https://www.woodworks.org/resources/how-to-include-biogenic-carbon-in-an-lca/

BIOGENIC CARBON FLOWS



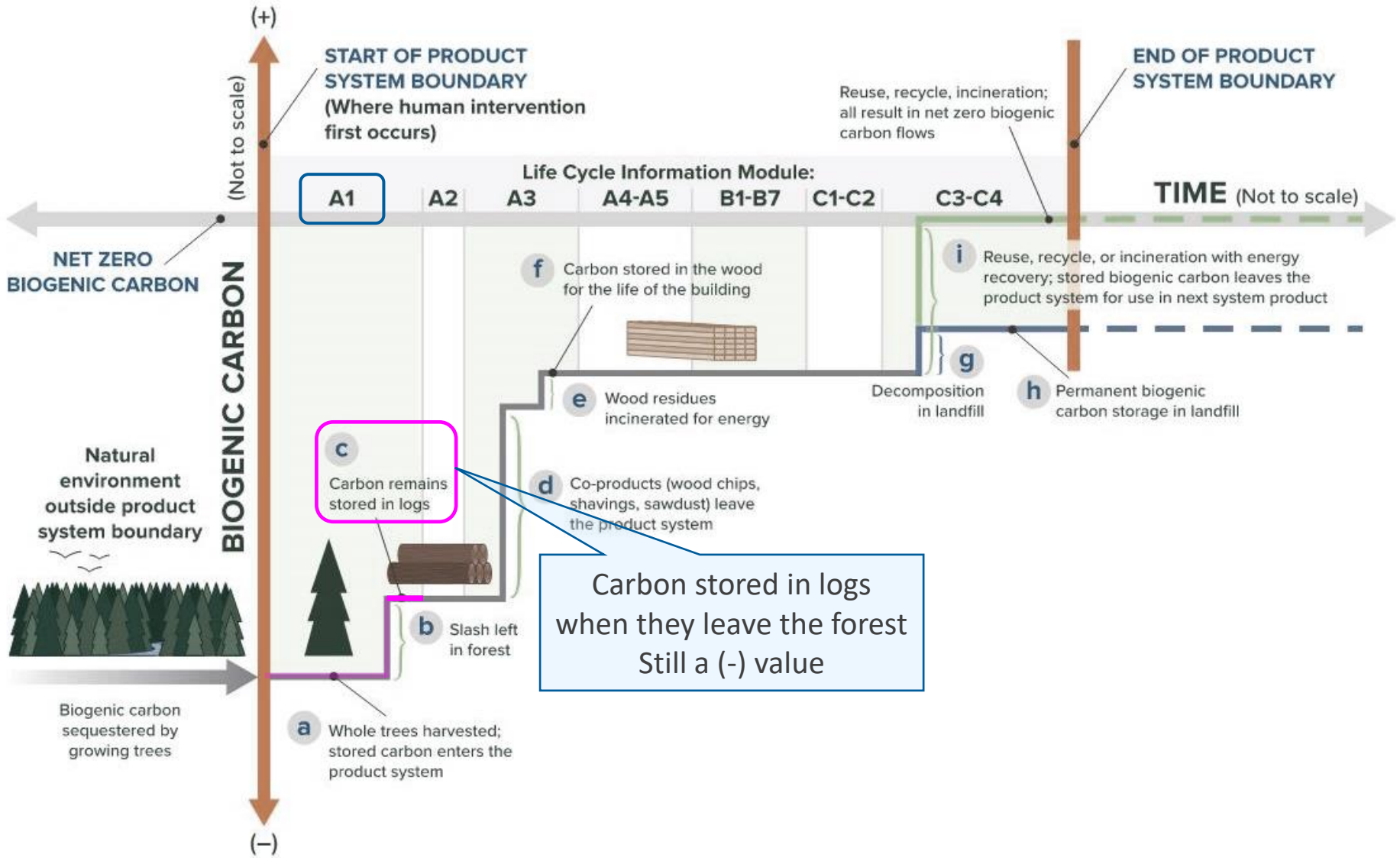
Enters the system as (-) based on mass of carbon in harvested tree

BIOGENIC CARBON FLOWS



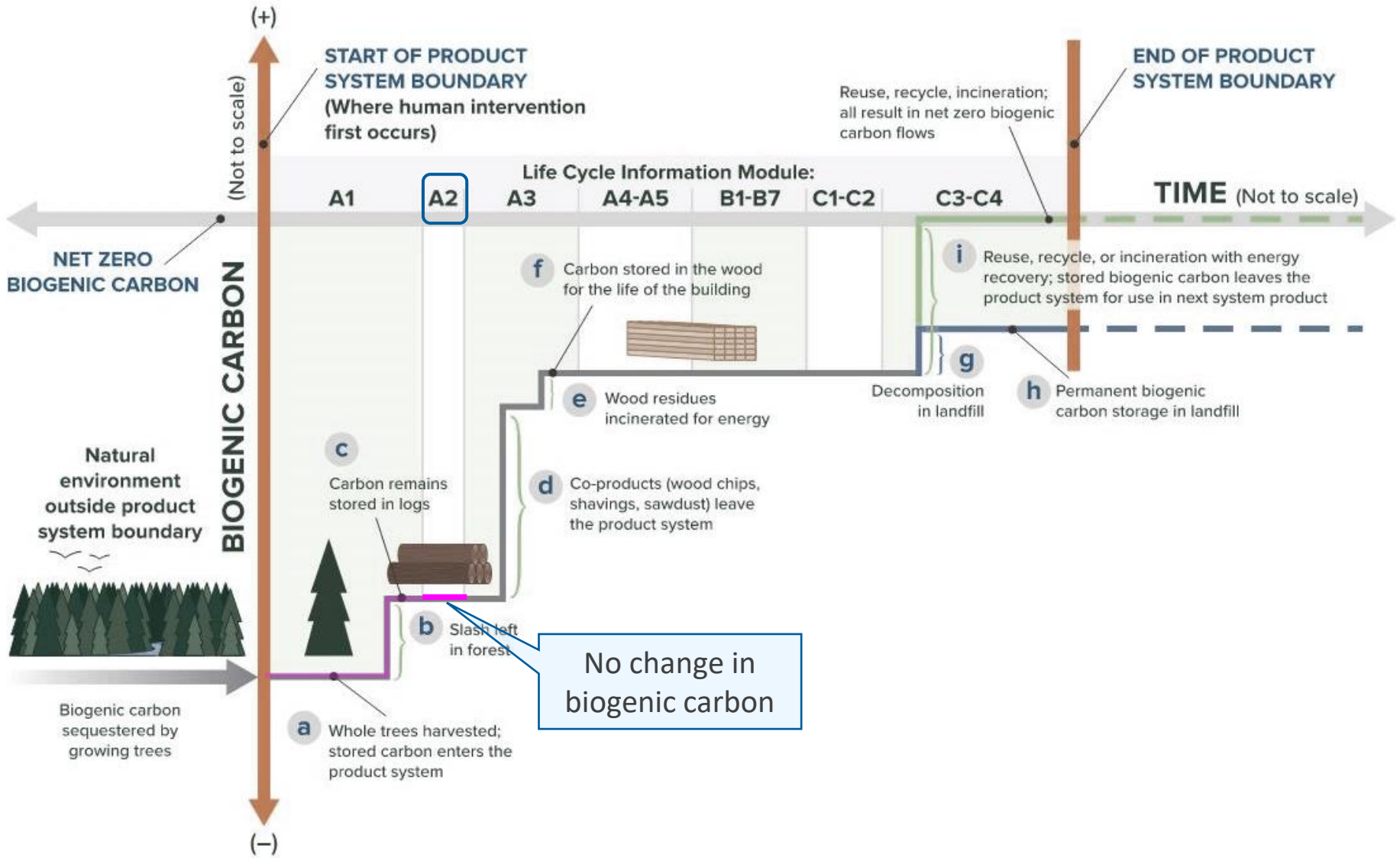
Carbon leaves the product system in the form of slash.
Counted as (+) emission/export

BIOGENIC CARBON FLOWS

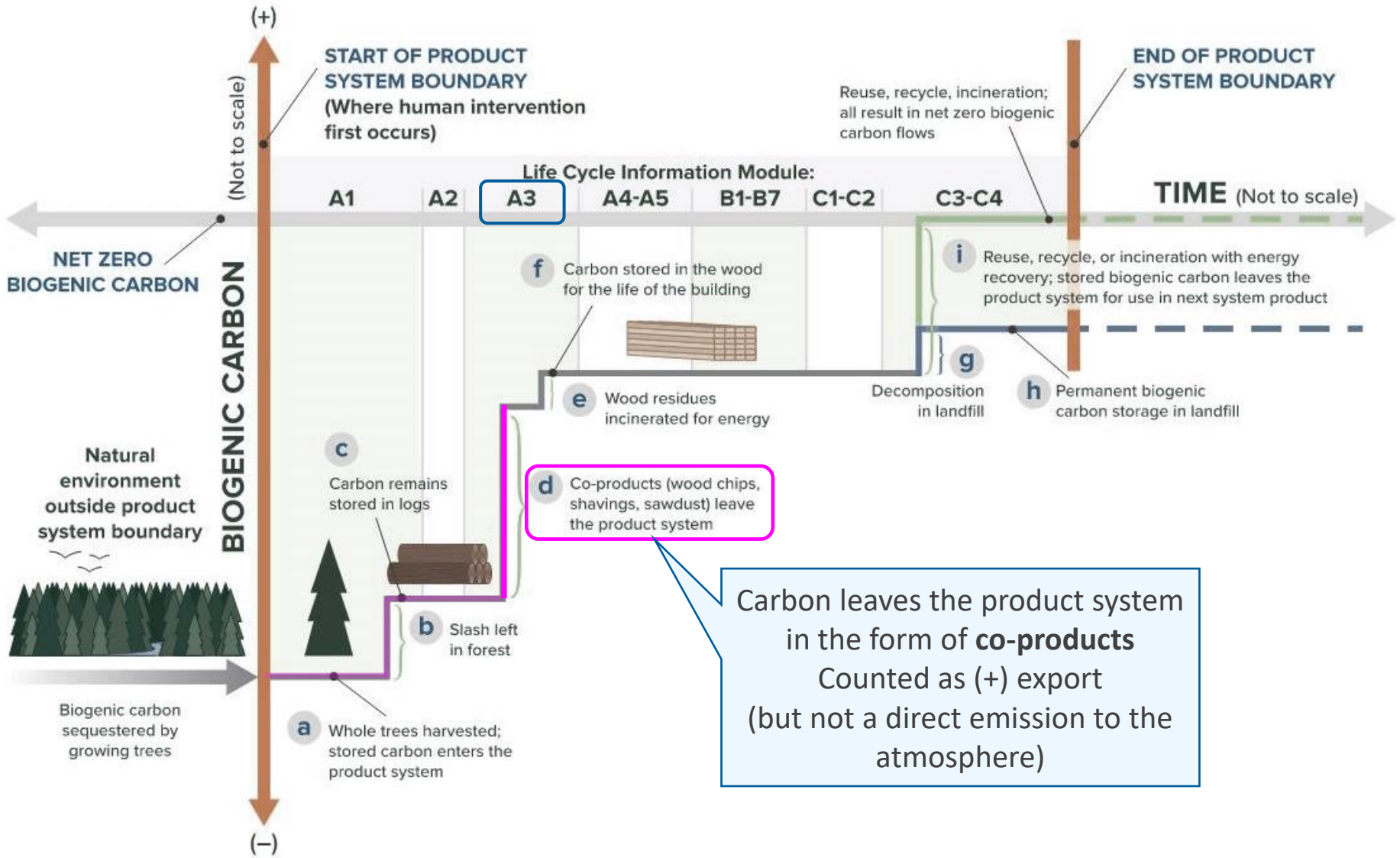


Carbon stored in logs when they leave the forest
Still a (-) value

BIOGENIC CARBON FLOWS

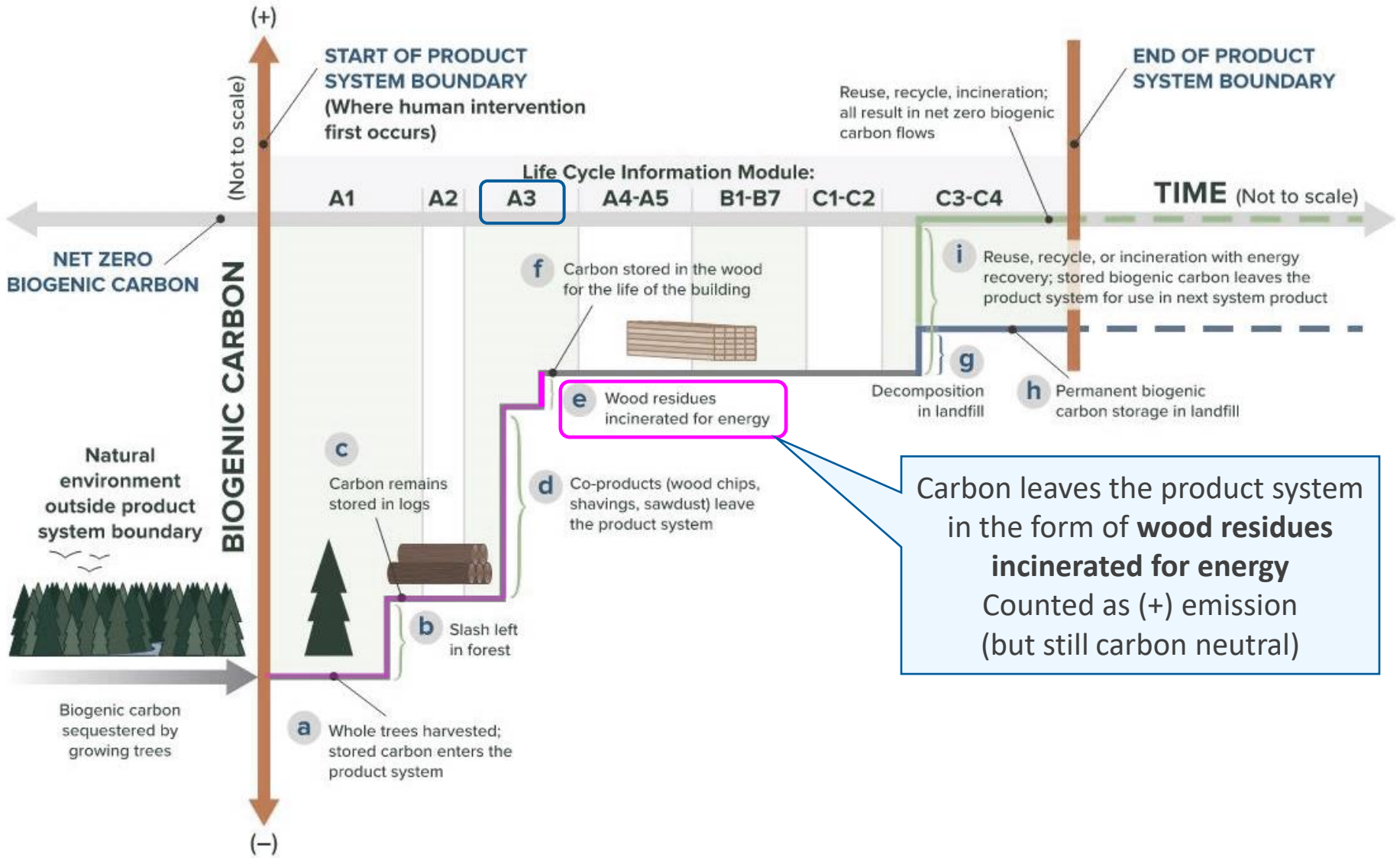


BIOGENIC CARBON FLOWS



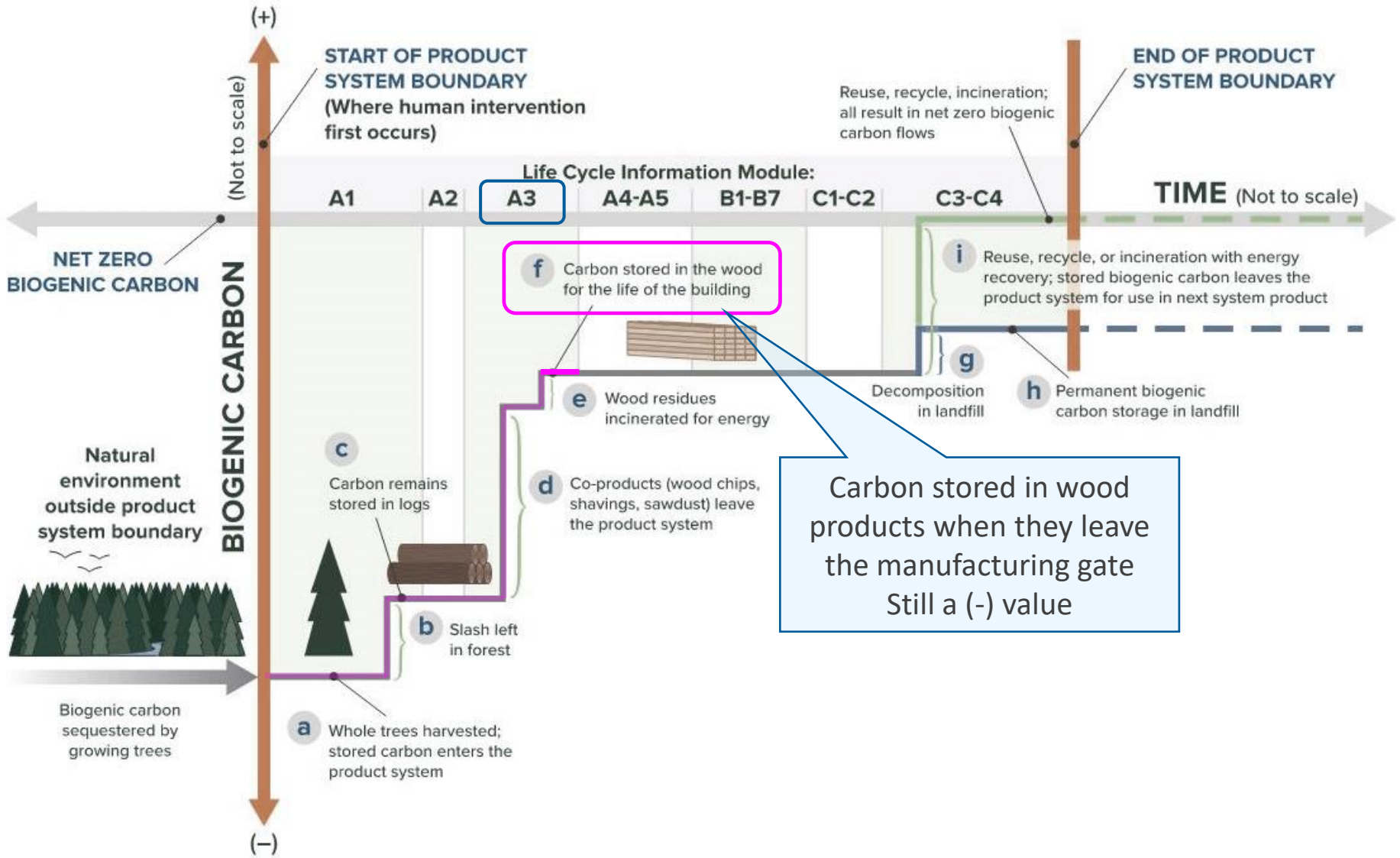
Carbon leaves the product system in the form of **co-products**
Counted as (+) export
(but not a direct emission to the atmosphere)

BIOGENIC CARBON FLOWS



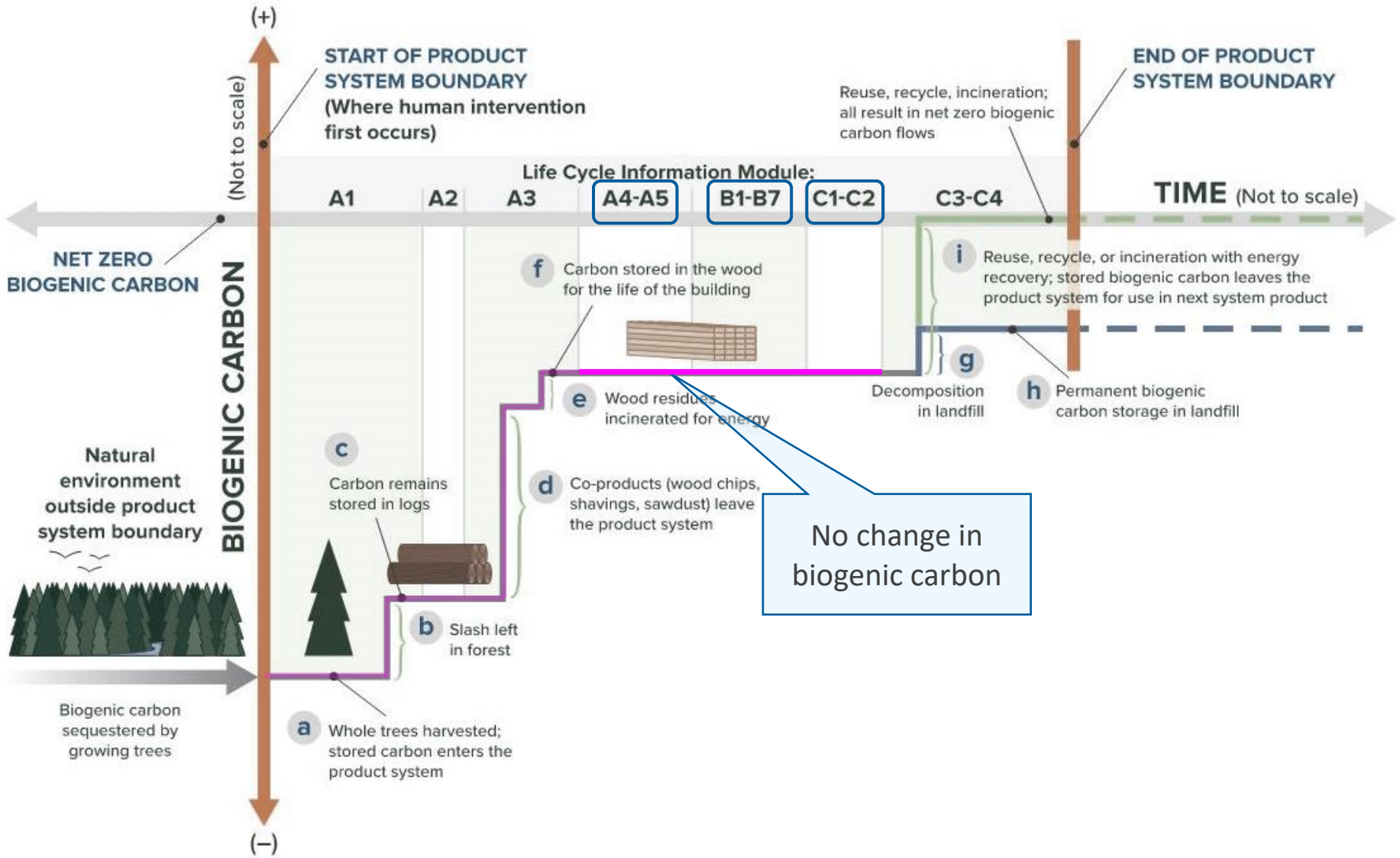
Carbon leaves the product system in the form of **wood residues incinerated for energy**
Counted as (+) emission
(but still carbon neutral)

BIOGENIC CARBON FLOWS



Carbon stored in wood products when they leave the manufacturing gate
Still a (-) value

BIOGENIC CARBON FLOWS



End-of-Life Fates for Wood Products

1. **Landfill**
2. **Incineration (for energy recovery)**
3. **Recycle**
4. **Direct Reuse**

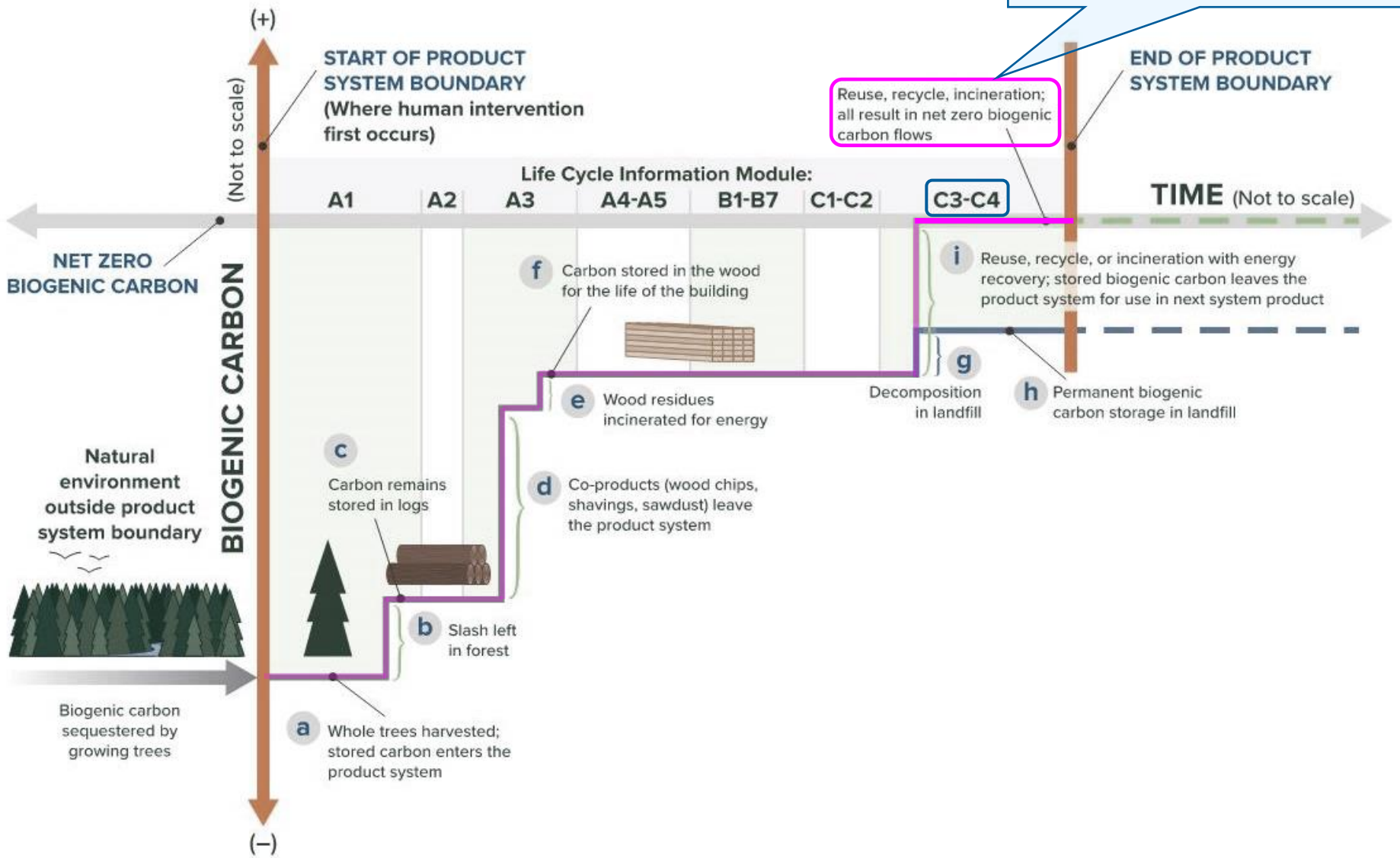
End-of-Life Fates for Wood Products

1. Landfill
2. **Incineration (for energy recovery)**
3. **Recycle**
4. **Direct Reuse**

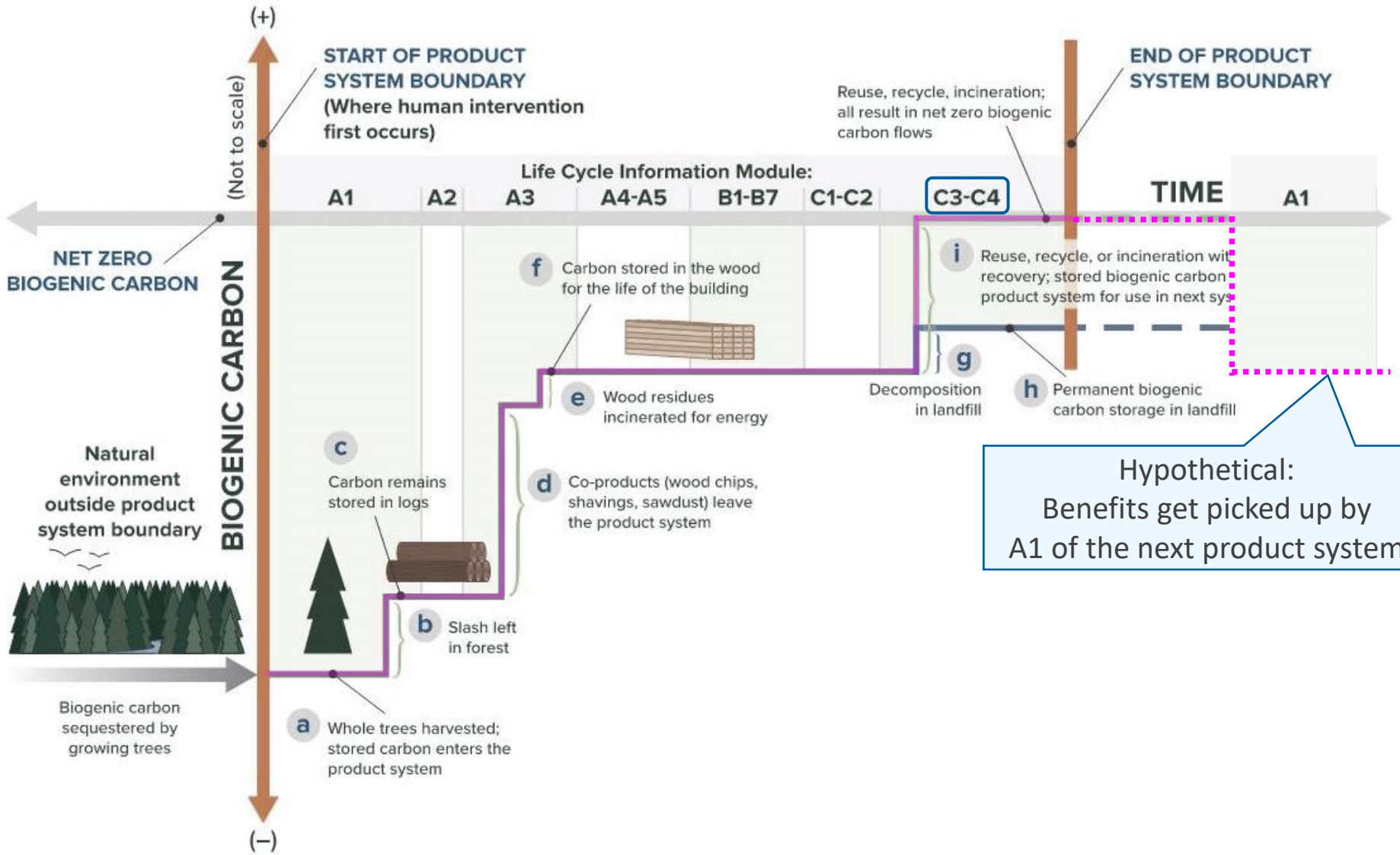
All biogenic carbon **leaves** the product system as an ***export / emission*** (+1).

BIOGENIC CARBON FLOWS

In all three cases, **net biogenic carbon flows are zero**.



BIOGENIC CARBON FLOWS



End-of-Life Fates for Wood Products

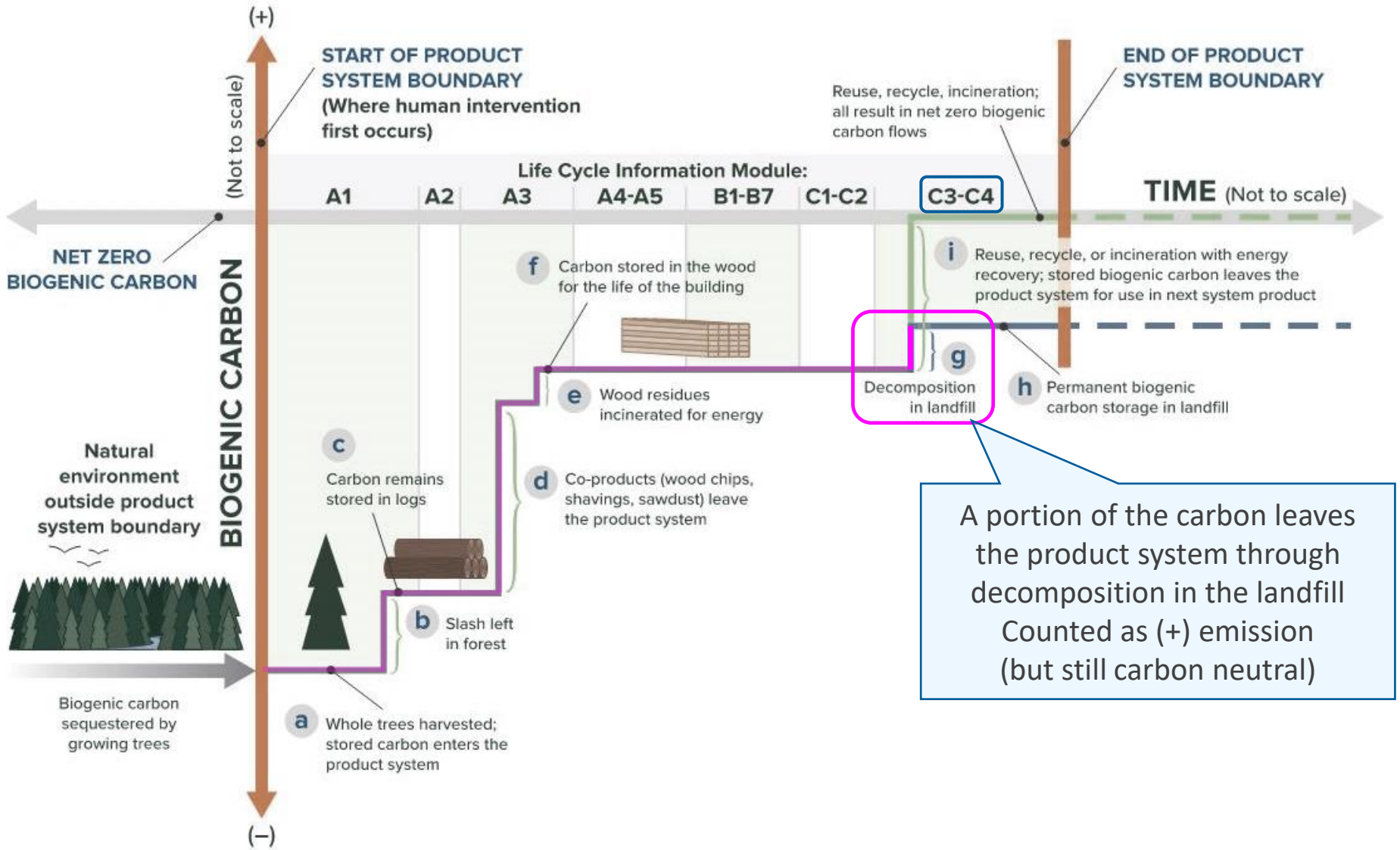
1. **Landfill**
2. Incineration (for energy recovery)
3. Recycle
4. Direct Reuse

Landfill operations
- Most does <u>not</u> decay
- Decay releases landfill gases
  - Emitted directly to atmosphere, or
  - Landfill gas capture for energy recovery

Does <u>not</u> include benefits of using recovered energy

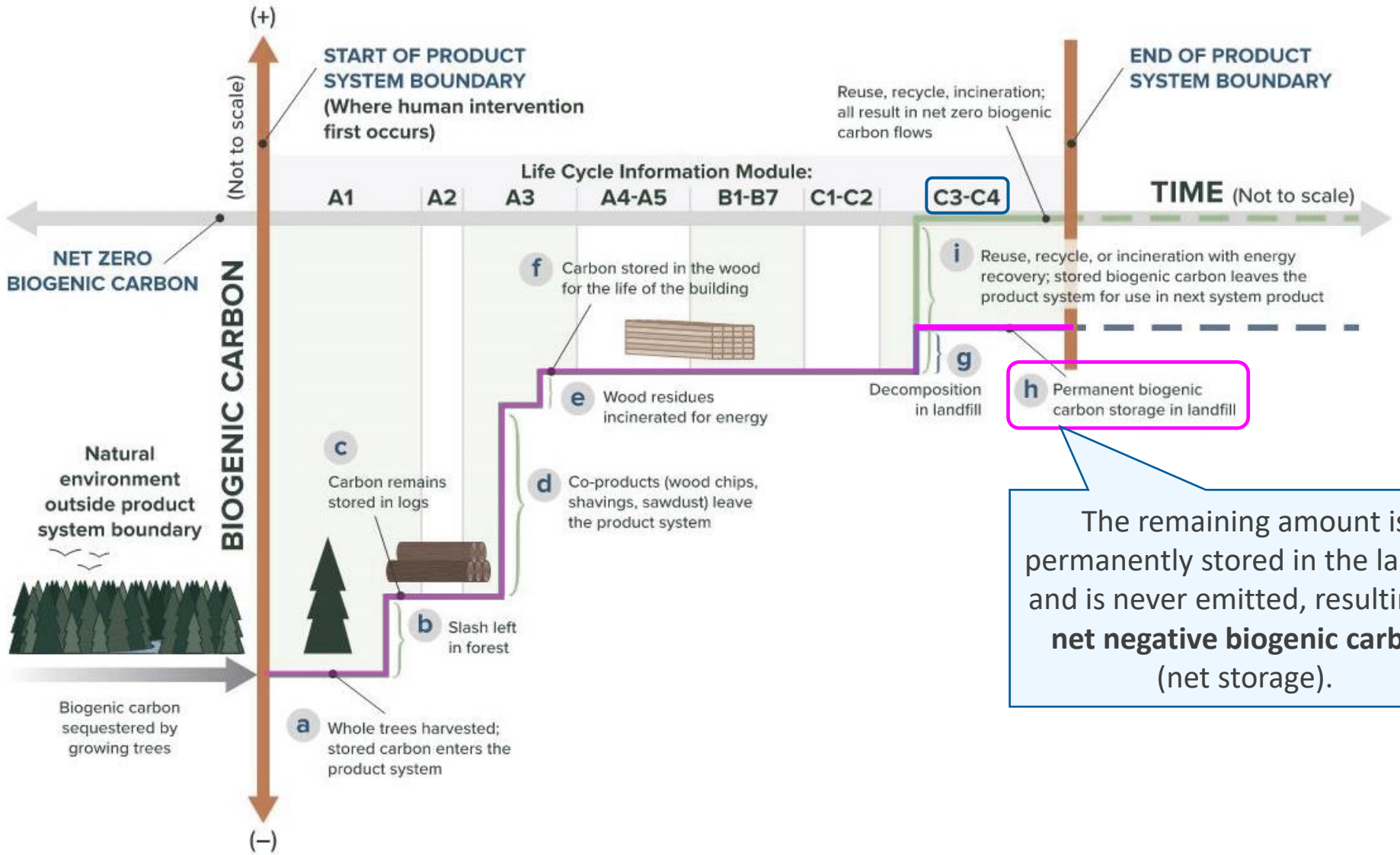
Most biogenic carbon is **<u>permanently stored</u>** in the landfill. The rest is released through decay as an ***emission*** (+1).

BIOGENIC CARBON FLOWS



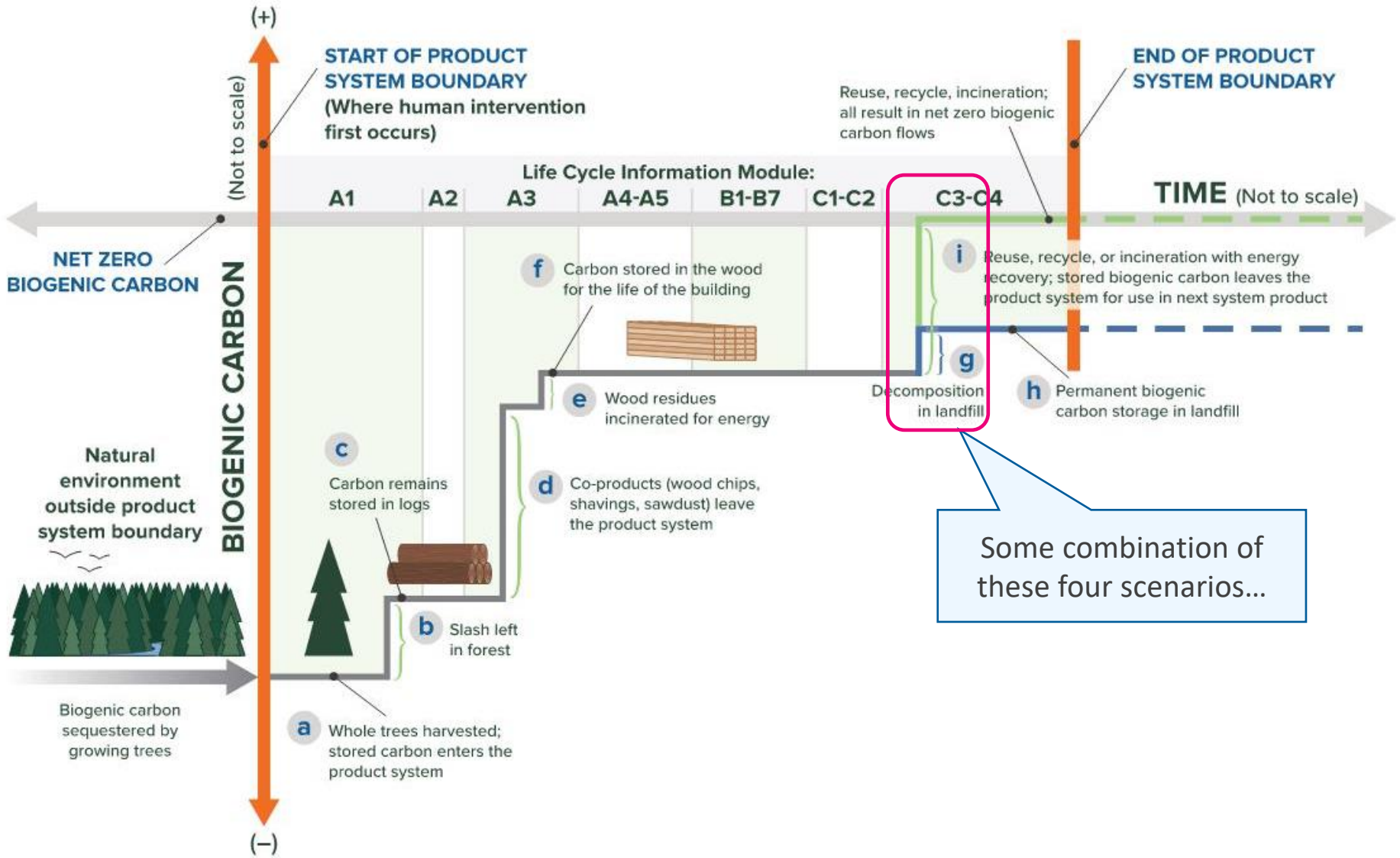
A portion of the carbon leaves the product system through decomposition in the landfill
Counted as (+) emission
(but still carbon neutral)

BIOGENIC CARBON FLOWS



The remaining amount is permanently stored in the landfill and is never emitted, resulting in **net negative biogenic carbon** (net storage).

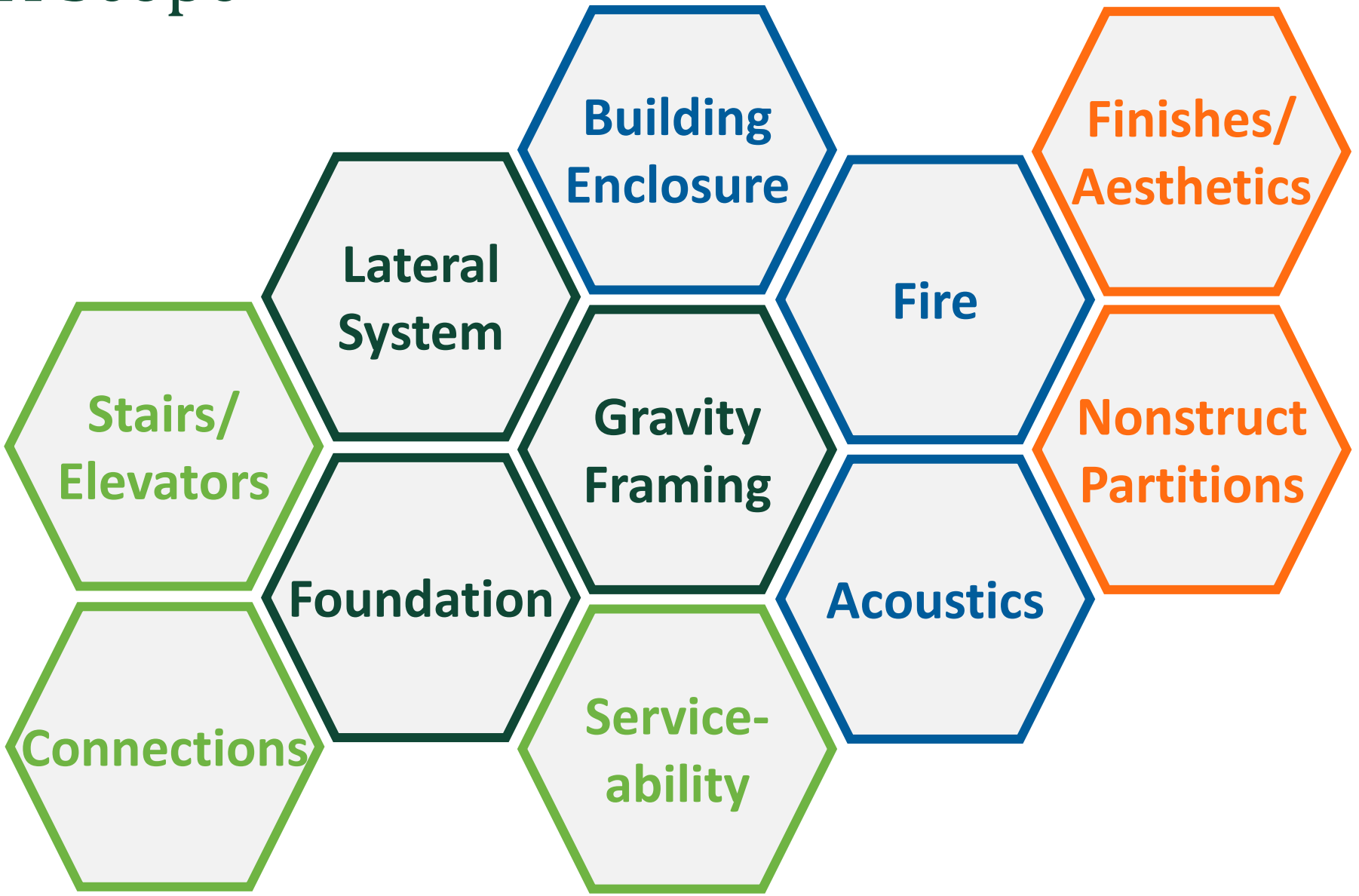
BIOGENIC CARBON FLOWS



Some combination of these four scenarios…

How to Compare Structures

WBLCA Scope


Building Enclosure
Finishes/ Aesthetics
Lateral System
Fire
Stairs/ Elevators
Gravity Framing
Nonstruct Partitions
Foundation
Acoustics
Connections
Service-ability

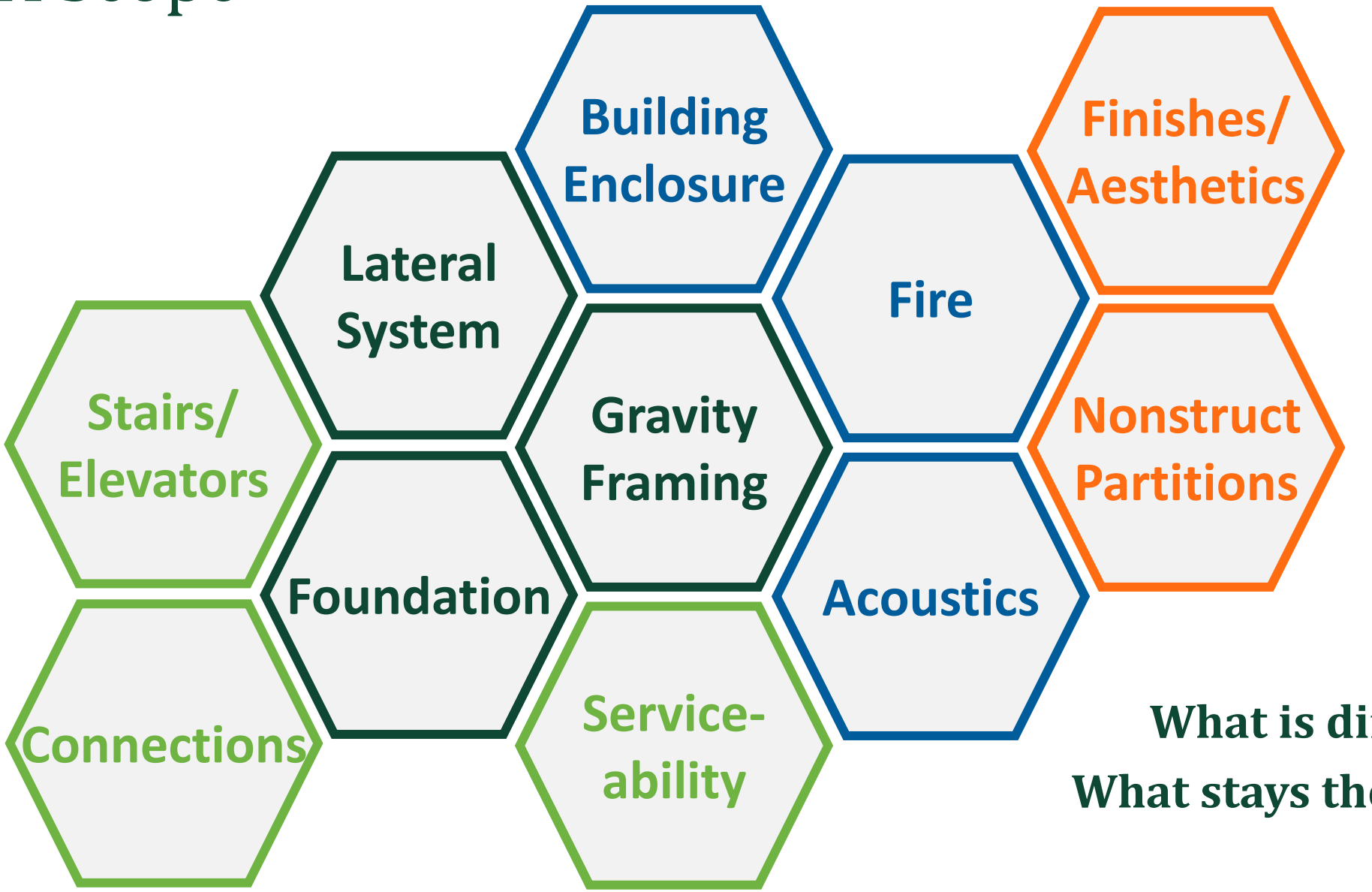
Comparative WBLCA

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

requires

Functional Equivalency

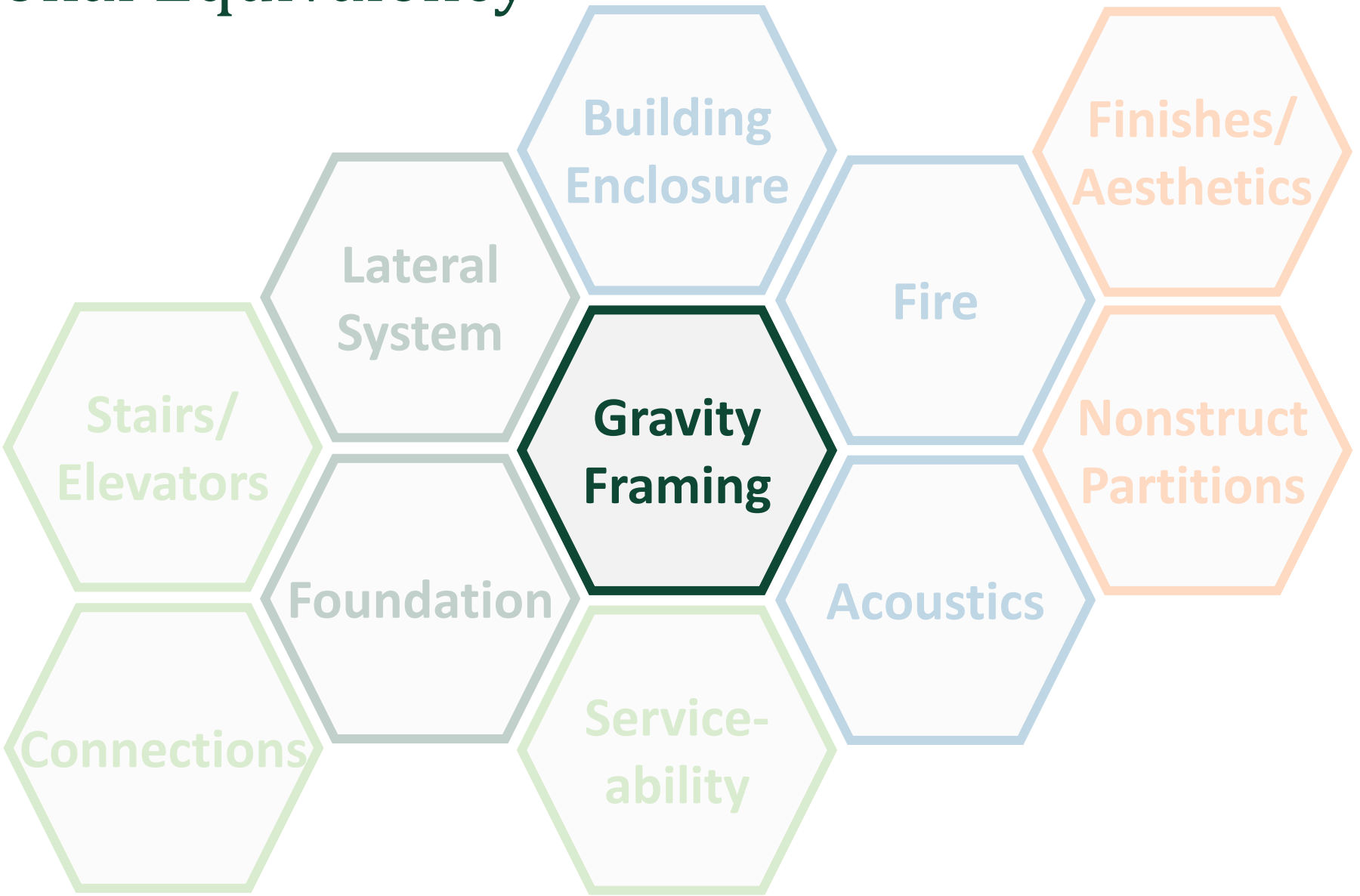
WBLCA Scope



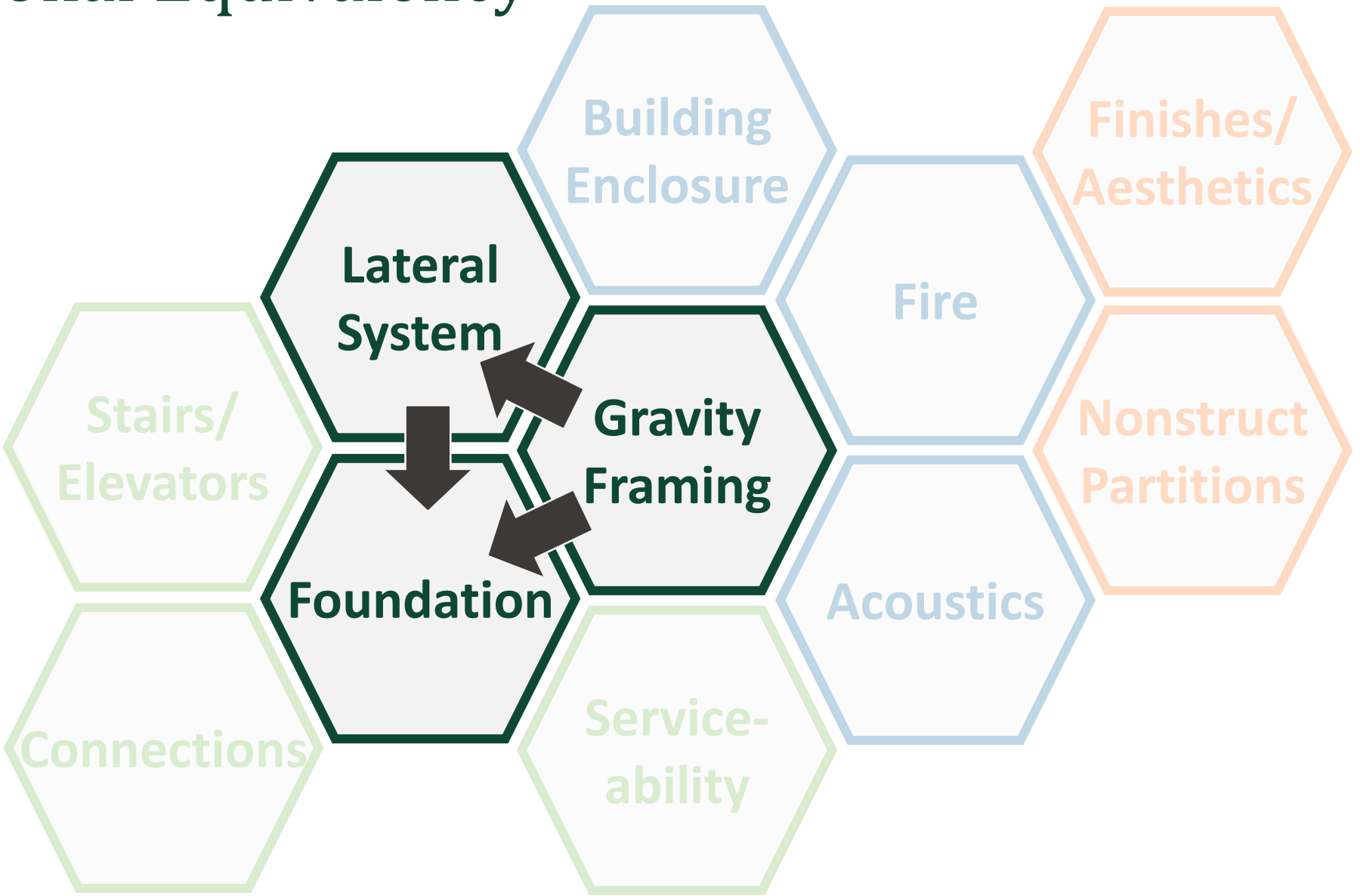
What is different?

What stays the same?

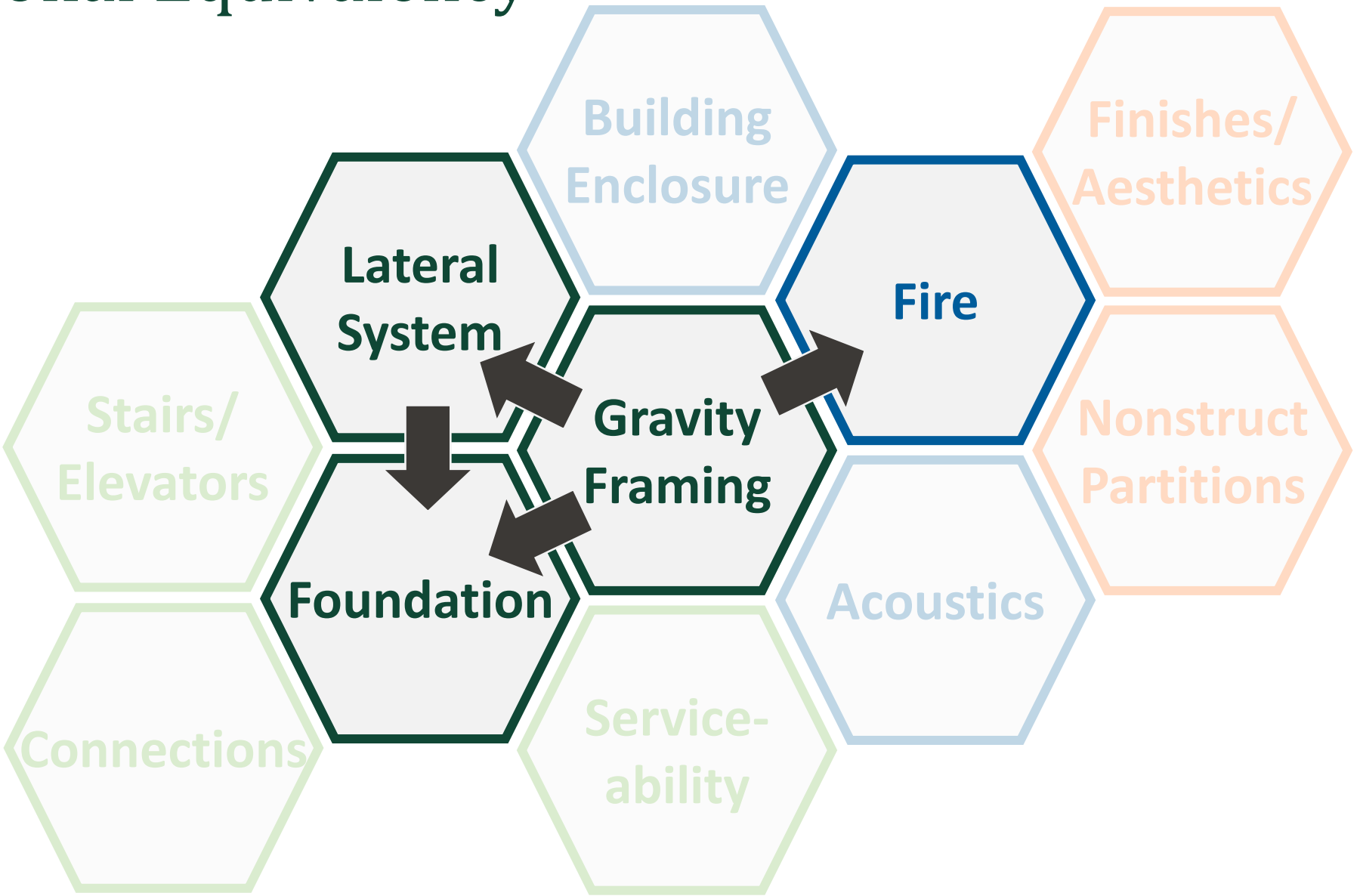
Functional Equivalency



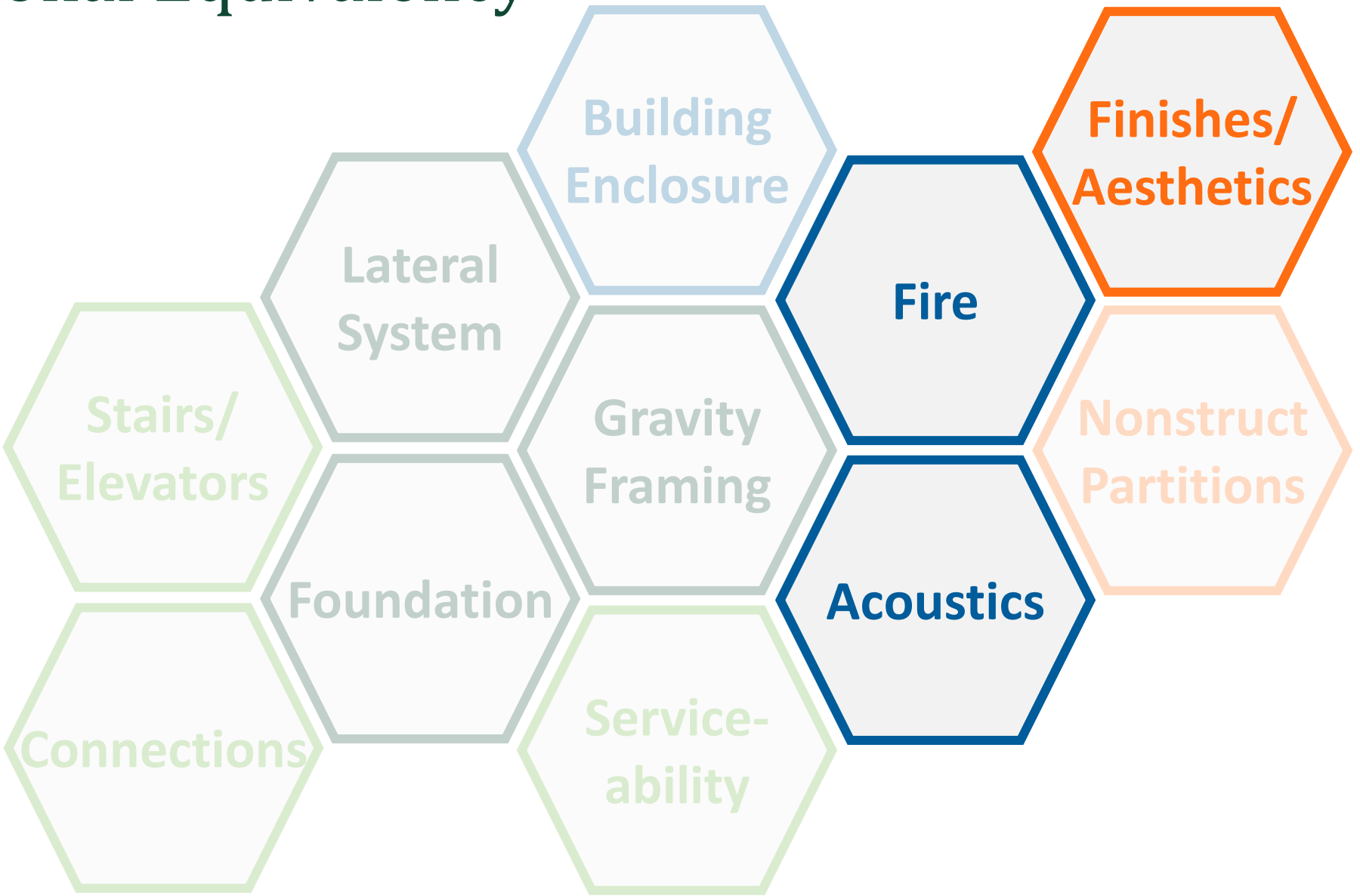
Functional Equivalency



Functional Equivalency



Functional Equivalency

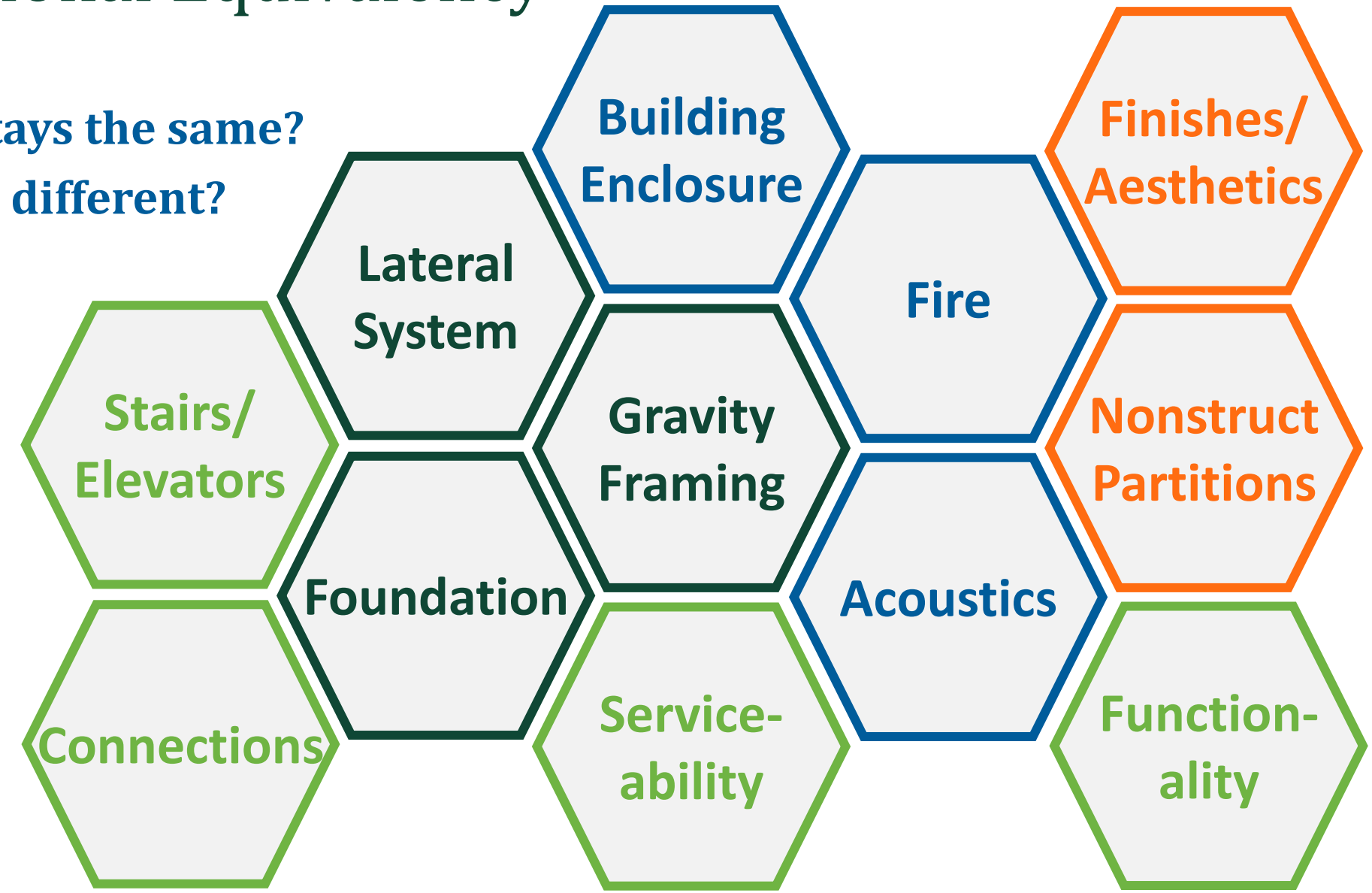


Functional Equivalency

Functional Equivalency

What stays the same?

What is different?



Resources from WoodWorks

Ashley Cagle, PE, SE
Erin Kinder, PE, SE, LEED AP
WoodWorks – Wood Products Council

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 WBLCAs 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 WBLCAs 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 framework)* and 14044 *(Requirements and guidelines)*. ISO 14040 Section 4.2.1 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.

Image: Monte French Design Studio

11 E Lenox / Boston, MA
Monte French Design Studio; H+O Structural Engineering

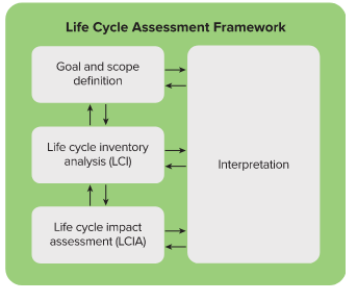


FIGURE 1: Stages of an LCA, adapted from

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.

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

TABLE 1:

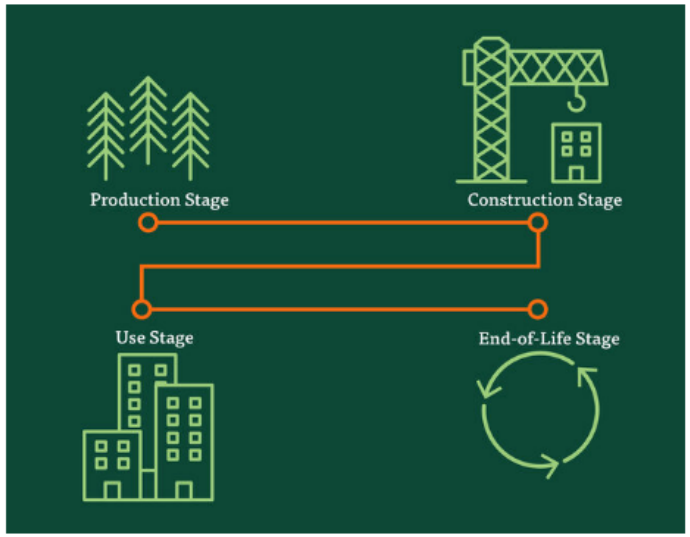
Goal Components	Notes
Intended application (What)	
Reason for study (Why)	
Intended audience (Who)	
Will results be made public?	

Photo: DPR Office, SmithGroup, photo Chad Davies

Resources from WoodWorks

Use these Resources to Inform Your Building Material Choices

Practical guidance on whole building life cycle assessment, biogenic carbon, carbon storage, environmental product declarations, and more.



Expert Tips

Introduction to Whole Building Life Cycle Assessment: The Basics

Life cycle assessment (LCA) is used to quantify environmental impacts over the lifetime of a product or system, from initial extraction of raw materials through manufacture, distribution, use, and final disposal.

View Resource

- When to Include Biogenic Carbon in an LCA — Expert Tips
- How to Include Biogenic Carbon in an LCA — Expert Tips
- Biogenic Carbon Accounting in WBLCA Tools — Expert Tips
- Calculating the Carbon Stored in Wood Products — Expert Tips
- What Net Zero Means in the Building Construction Industry — Expert Tips

View all Sustainability resources

Scan to view

Photo: DPR Office, SmithGroup, photo Chad Davies

QUESTIONS?

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