

Increasing the cascading of wood materials from buildings: design implications

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Background

Wood based materials represent a reliable way of storing carbon above ground.

<https://woodfromfinland.fi/products/>

Background

The increased use of wood in buildings can help store sequestered atmospheric carbon...

<https://www.archdaily.com/933091/kajstaden-tall-timber-building-of-moller-architects>

Background

...but could also generate a trade-off affecting
biomass availability, etc.

<https://www.gettyimages.in/photos/forest/>

Background



Wood accounts for 36% of the construction and demolition waste in Finland.

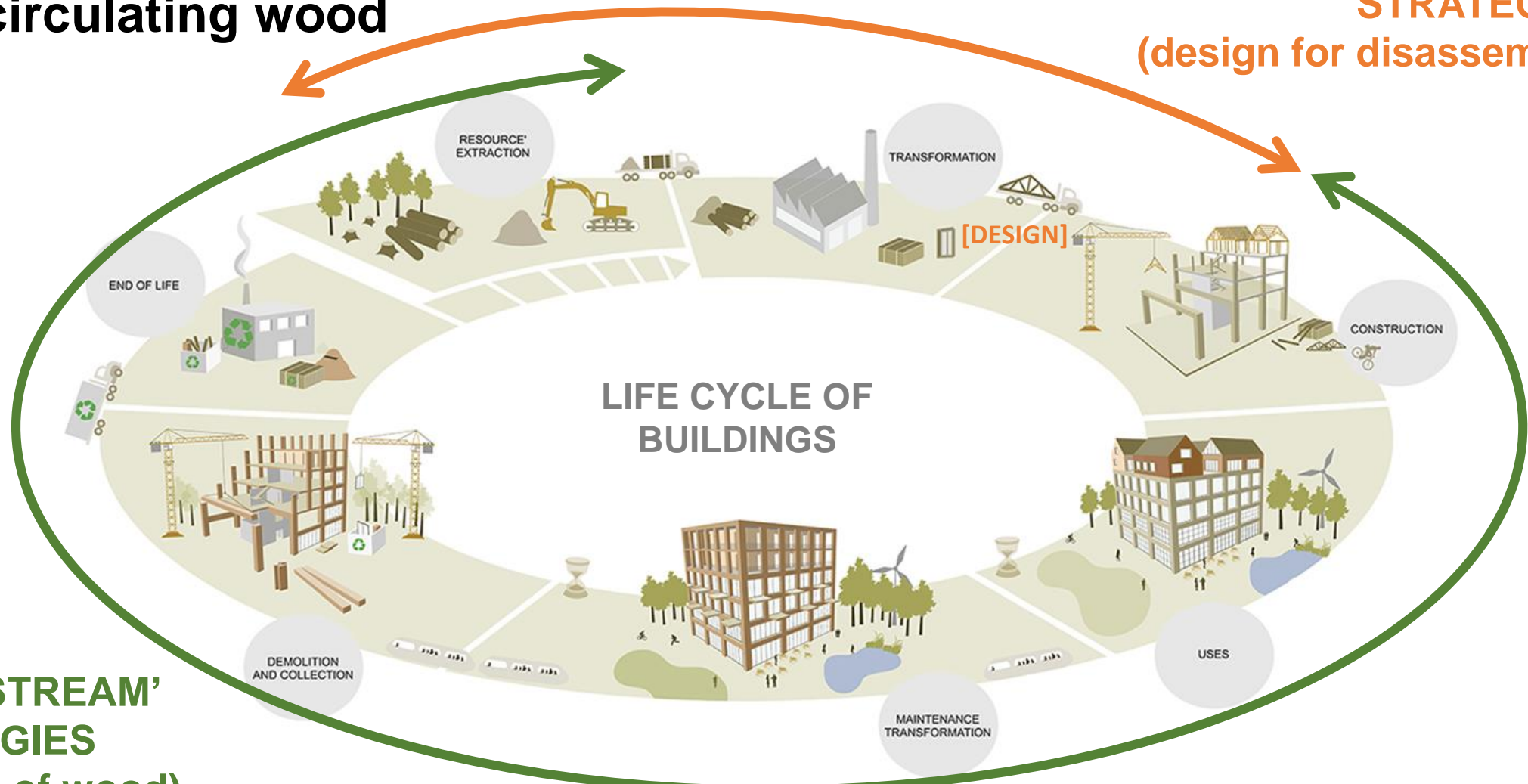
Background



The design of reusable wood elements can help reduce pressure on primary resources.

Recirculating wood

'UPSTREAM' STRATEGIES
(design for disassembly)

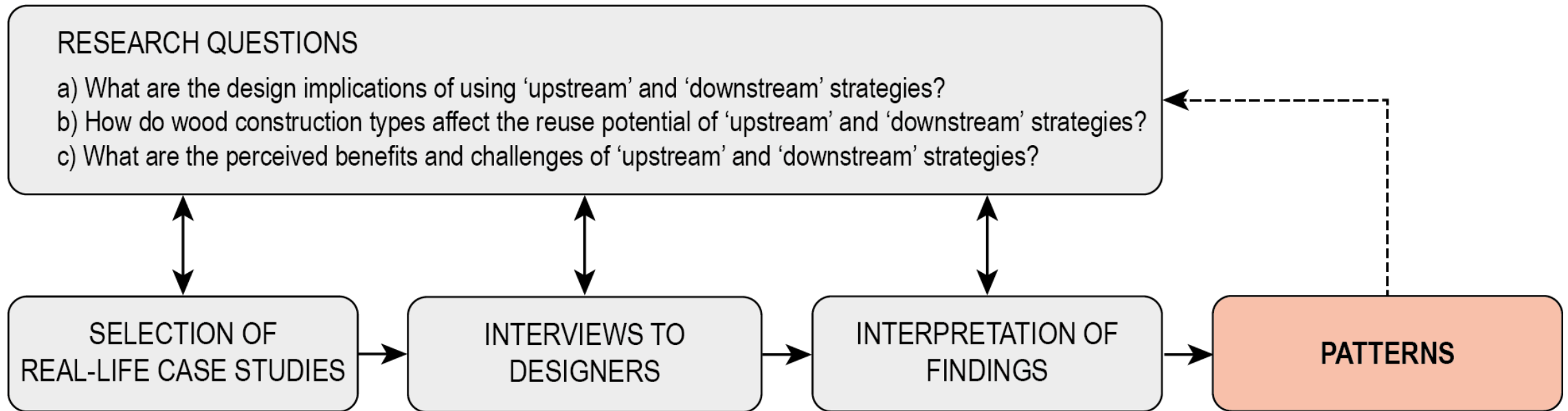


'DOWNSTREAM' STRATEGIES
(salvage of wood)

<http://smartlivinglab.ch>

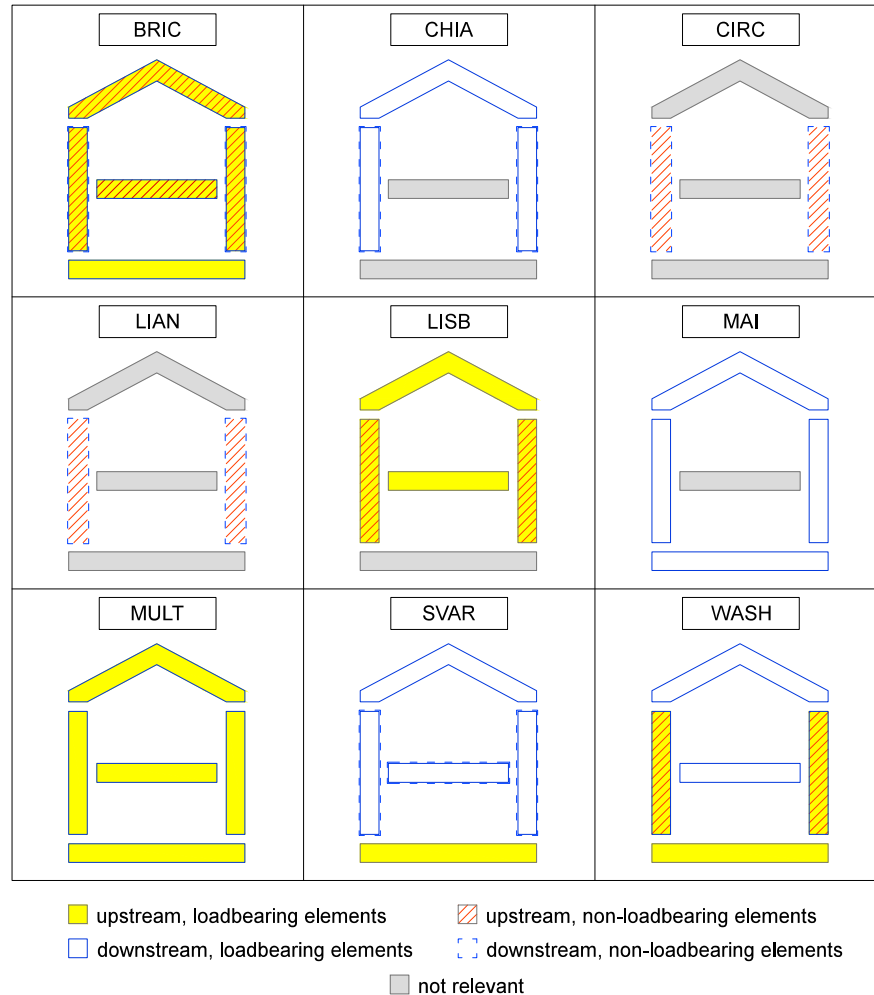
Research approach

The study adopted a qualitative approach with a focus on designers' experience.



Source of the figure: Piccardo, C. & Hughes, M. (2022). Design strategies to increase the reuse of wood materials in buildings: Lessons from architectural practice, *Journal of Cleaner Production*, Vol. 368, 133083. doi: <https://doi.org/10.1016/j.jclepro.2022.133083>

Case studies



- 6 residential buildings, 2 cultural buildings, and 1 office building
- 3 different construction types: platform frame, post&beam, solid timber (CLT)
- 6 different countries in Europe

Source of the figure: Piccardo, C. & Hughes, M. (2022). Design strategies to increase the reuse of wood materials in buildings: Lessons from architectural practice, *Journal of Cleaner Production*, Vol. 368, 133083. doi: <https://doi.org/10.1016/j.jclepro.2022.133083>

‘Upstream’ strategies: patterns

Joint configuration

- Reversible joints → customized fastenings
- Durable joints → standard fastenings



Samples of wood waste.

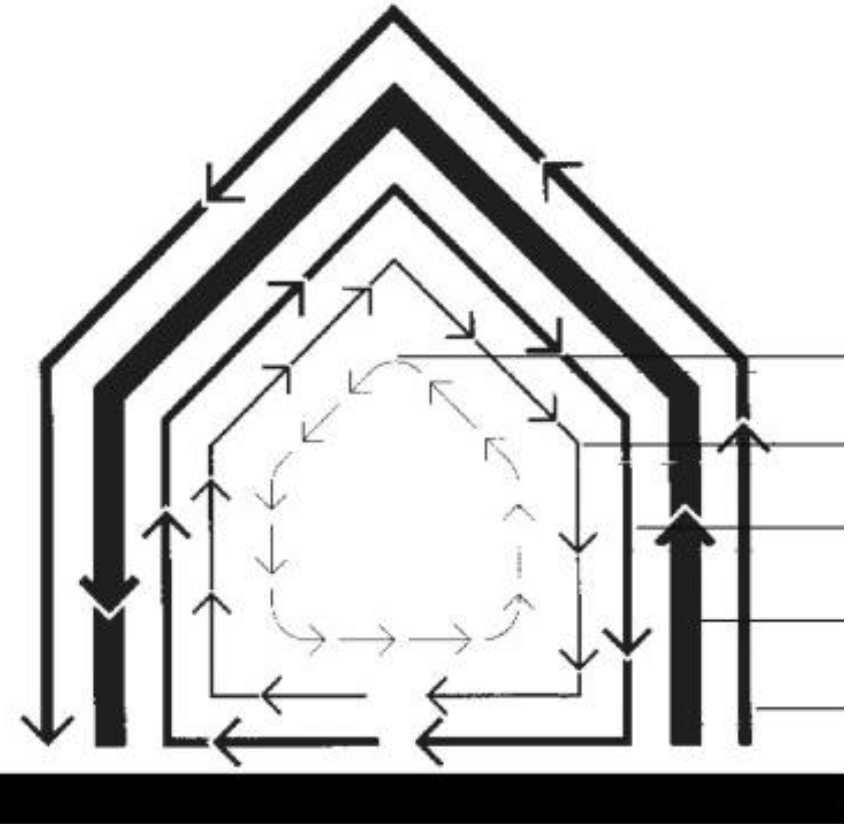
'Upstream' strategies: patterns

Joint configuration

- Reversible joints → customized fastenings
- Durable joints → standard fastenings

Relational dependency

- Separation of parts and sub-parts
- Independent building services



Durmisevic, E. (2010). Green Design and Assembly of Buildings and Systems: Design for Disassembly a Key to Life Cycle Design of Buildings and Building Products. VDM Verlag Dr. Müller Aktiengesellschaft & Co. KG, Saarbrücken (Germany).

‘Upstream’ strategies: patterns

Joint configuration

- Reversible joints → customized fastenings
- Durable joints → standard fastenings

Relational dependency

- Separation of parts and sub-parts
- Independent building services

Level of prefabrication

- Highly-prefabricated structure
- Modular design



'Upstream' strategies

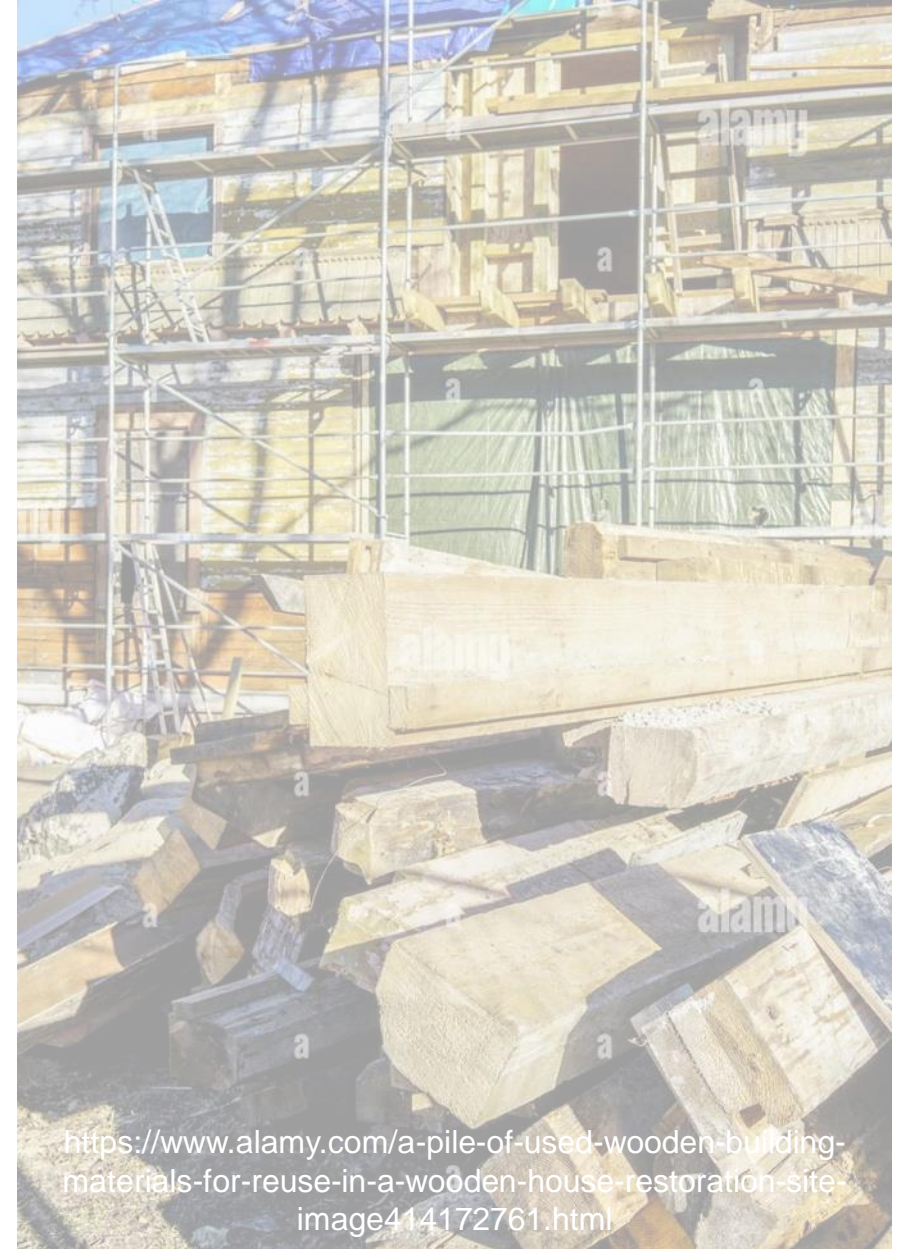
	Loadbearing elements				
	Post&beam		Platform frame	Solid timber	
	BRIC	LISB	BRIC	MAI	MULT
<i>Joint configuration</i>					
Reversible joints		x		x	x
Durable joints	x			x	
<i>Relational dependency</i>					
Separation of parts and sub-parts	x			x	
Independent building services	x	x	x	x	
<i>Level of prefabrication</i>					
Highly-prefabricated structure			x	x	x
3D modular design				x	

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'Downstream' strategies: patterns

Recovery of salvaged wood

- Loadbearing or non-loadbearing elements
- Single elements or components (e.g. windows)



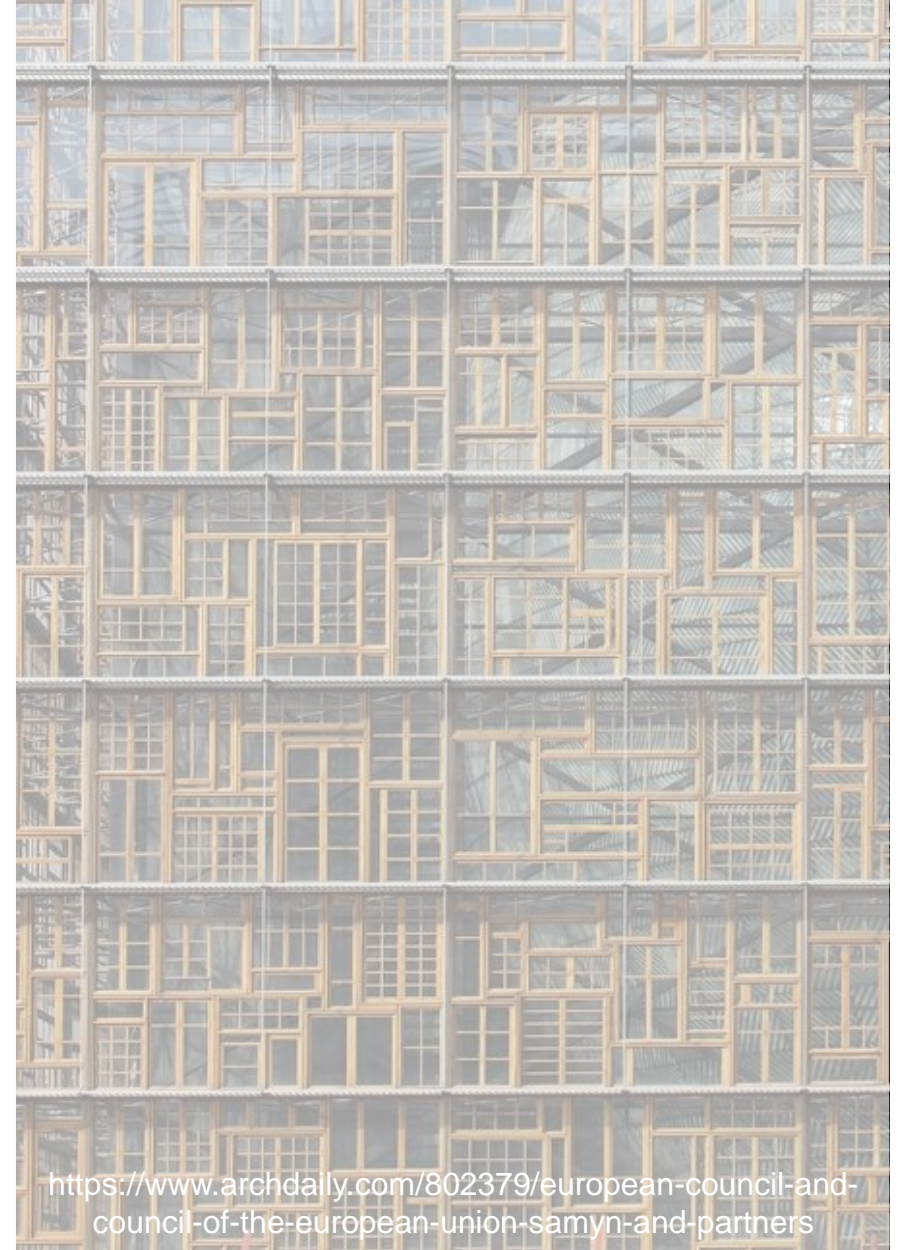
'Downstream' strategies: patterns

Recovery of salvaged wood

- Loadbearing or non-loadbearing elements
- Single elements or components (e.g. windows)

Adaptable building layout

- During the design phase
- According to an iterative design process.



<https://www.archdaily.com/802379/european-council-and-council-of-the-european-union-samyn-and-partners>

'Downstream' strategies

	Loadbearing elements				Non-loadbearing elements		
	Platform frame			Solid timber	CHIA	CIRC	LIAN
	BRIC	SVAR	WASH	MAI			
Recovery of salvaged wood	x	x	x	x	x	x	x
Adaptable building layout		x			x		x

Source of the table: Piccardo, C. & Hughes, M. (2022). Design strategies to increase the reuse of wood materials in buildings: Lessons from architectural practice, *Journal of Cleaner Production*, Vol. 368, 133083. doi: <https://doi.org/10.1016/j.jclepro.2022.133083>

Challenges

- Extra costs due to customized design and manufacturing of fastenings and uncertain cost benefits from the reuse of disassembled wood in future.
- Poor quality of salvaged wood (e.g. high moisture content of salvaged wood, the presence of metal residues, etc.).
- Increased construction time due to re-manufacturing operations of salvaged wood compared to new wood products.
- Difficulties to combine certain existing standards (related to e.g. energy efficiency and acoustic comfort) with ‘upstream’ and ‘downstream’ strategies in new buildings.

More information

Design strategies to increase the reuse of wood materials in buildings: Lessons from architectural practice

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ABSTRACT

The use of wood-based products might contribute to the mitigation of climate change and resource depletion in the building sector. However, the increasing demand for wood-based products might generate a trade-off affecting biomass availability, forest ecosystem services, and the climate change mitigation potential of forests. Therefore, it is important to couple the use of wood-based products with the adoption of circular economy strategies. Upstream strategies can facilitate the future reuse of wood elements in new buildings, whilst downstream strategies aim at the reuse of wood elements originating from demolished or disassembled buildings, in new buildings. The aim of this study was to identify patterns describing upstream and downstream strategies currently adopted in architectural practice. A sample of real-world case-study buildings was identified and the respective designers were interviewed. The interviews identified three patterns for upstream strategies, namely the reversibility of joints, independence of different building components and prefabrication, and two patterns for downstream strategies, namely the recovery of salvaged wood and adaptability of the building layout. Several challenges were also highlighted. The use of upstream and downstream strategies can increase the time (and costs) in the design and manufacturing phase. Downstream strategies can also be influenced by the quality of salvaged wood. Upstream strategies showed difficulties to comply with current building standards (e.g. acoustic standards). Finally, metrics and indicators are needed in order to measure the efficiency of wood recirculation in upstream and downstream strategies, as well as to support their implementation.

1. Introduction

The building sector is responsible for about 28% of global energy-related CO₂ emissions, rising to about 40% if CO₂ emissions from the manufacture of building materials are included (International Energy Agency/United Nations Environment Programme, 2018). Therefore, materials are key to mitigating the embodied emissions of buildings (Pomponi et al., 2020). Recently, there has been much speculation about the potential for wood products used in construction to help shift the building sector from a source of carbon emissions to a net sink. Several studies have highlighted that increasing the amount of wood-based building materials is one of the most important and effective ways of storing carbon above ground (Arehart et al., 2021). Furthermore, by increasing the use of wood buildings, more carbon-intensive and non-renewable materials are displaced (Amini et al., 2020). In these ways, the use of wood in construction might simultaneously contribute to both the mitigation of climate change, and reducing resource

depletion caused by construction activities. However, the increasing demand for wood-based products might also generate trade-offs, affecting biomass availability, forest ecosystem services, and the climate change mitigation potential of forests (Jonsson et al., 2021). Churkina et al. (2020) analyzed the carbon benefits of increasing wood buildings in urban areas by 2050, noting that to preserve forest sustainability it is important to couple the use of new wood-based products with the design of durable wood constructions and reusable wood elements. In this way, adopting measures that improve resource efficiency in wood buildings can not only help store sequestered atmospheric carbon effectively, but also help reduce pressure on primary resources.

The principal objective of the circular economy in this context is to reduce the consumption of primary material resources by adopting a holistic approach (Mair and Stern, 2017). The European Directive on waste (European Parliament and Council, 2018) encourages the recovery of all waste for material purposes, i.e. reuse and recycling, as a key way of reducing the use of primary resources. A Europe-wide study (Vis

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