



As frondosas autóctonas: A resiliencia do sector forestal?

28 y 29 de febreiro e 1 de marzo | UNED Lugo

Decarbonization and cascade use of hardwoods

Klaus Richter, TU München



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Structure

Options for decarbonization

- **Potential for wood based materials**
- **Case study Beech gluelam**
- **Conclusion decarbonization**

Options for cascading

- **Potential for wood based materials**

Conclusion cascading



Can mankind limit the global temperature increase to 1.5°C ... 2°C?

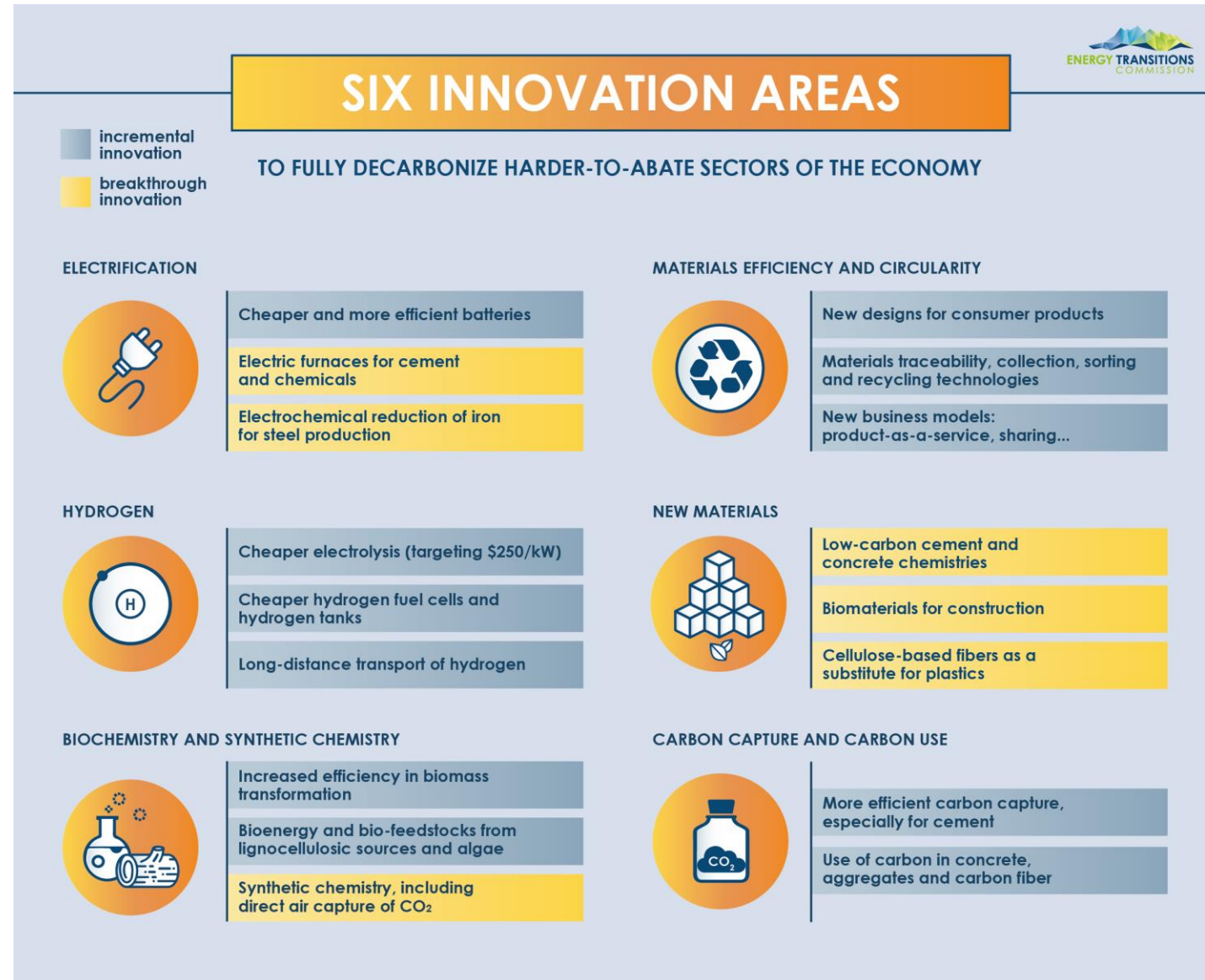
Required conditions

1. Ban fossile carbon sources by 2050
2. Expansion/creation of managed carbon sinks (e.g. carbon farming)
3. Protection of natural carbon sinks (forests, wetlands, coastal ecosystems, etc.)

DECARBONIZATION
DEFOSSILIZATION

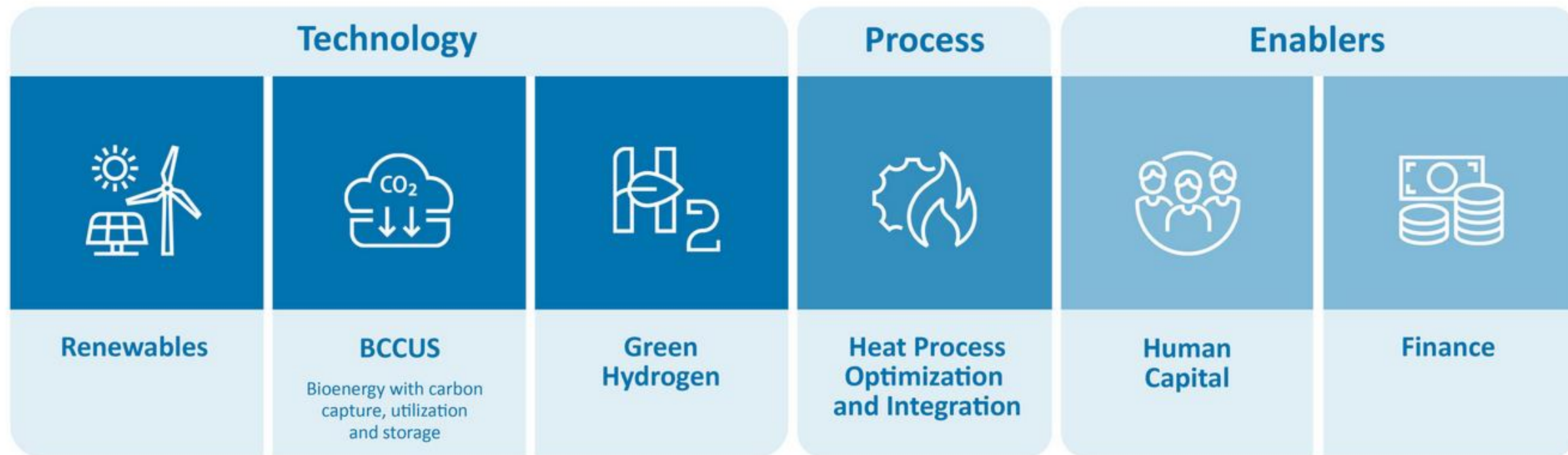


Decarbonization innovation areas



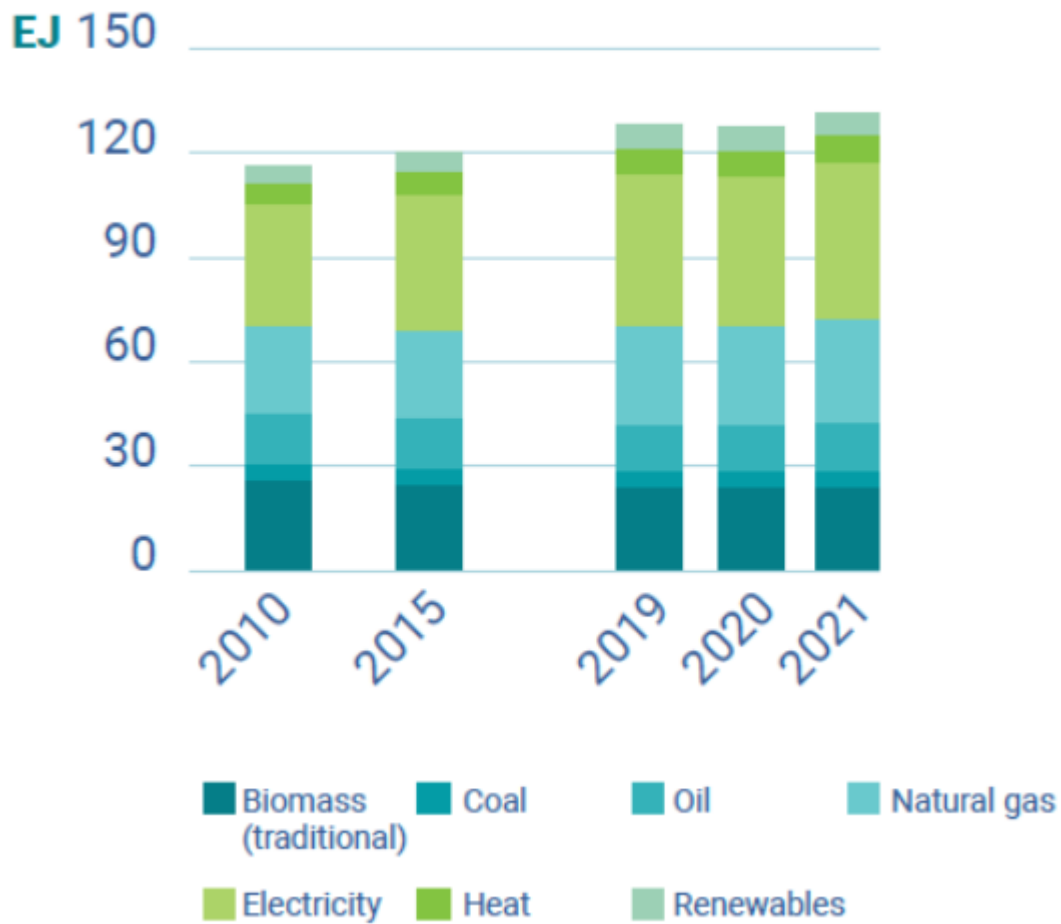


Decarbonization focus areas

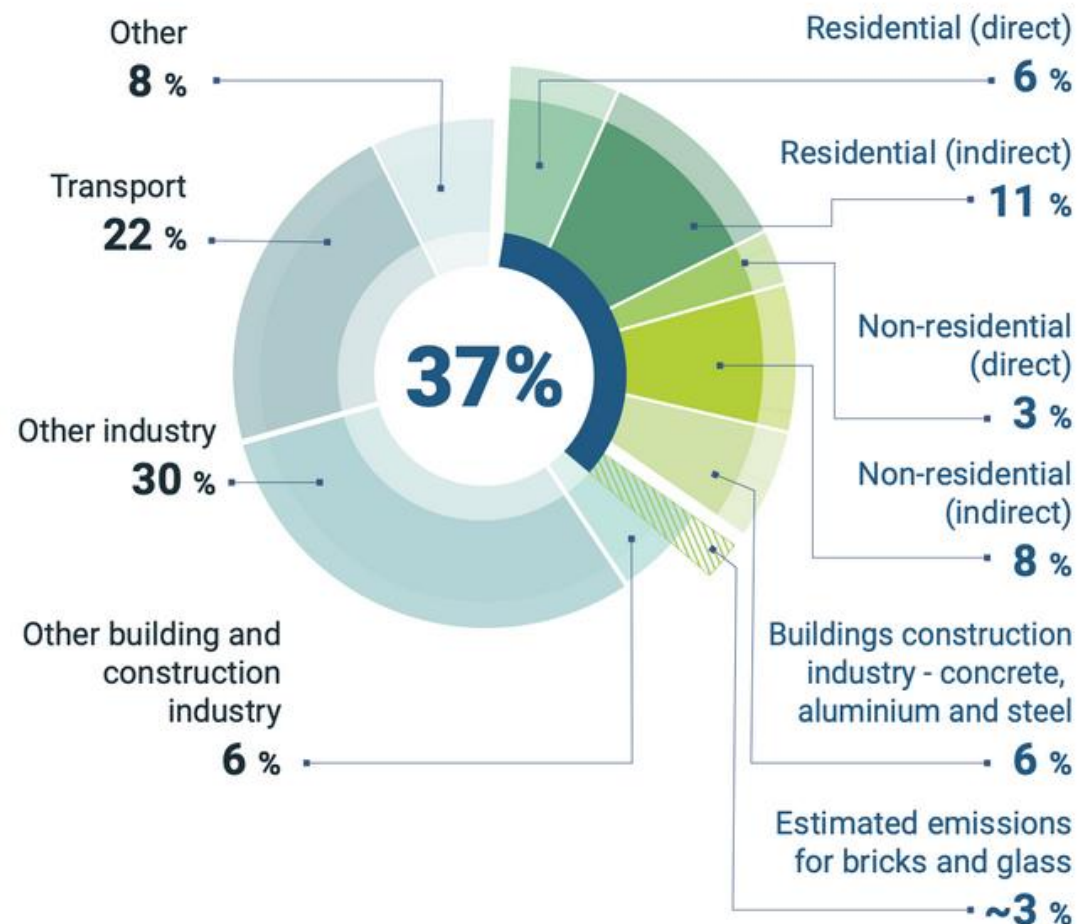




Energy consumption in buildings by fuel 2010-2021

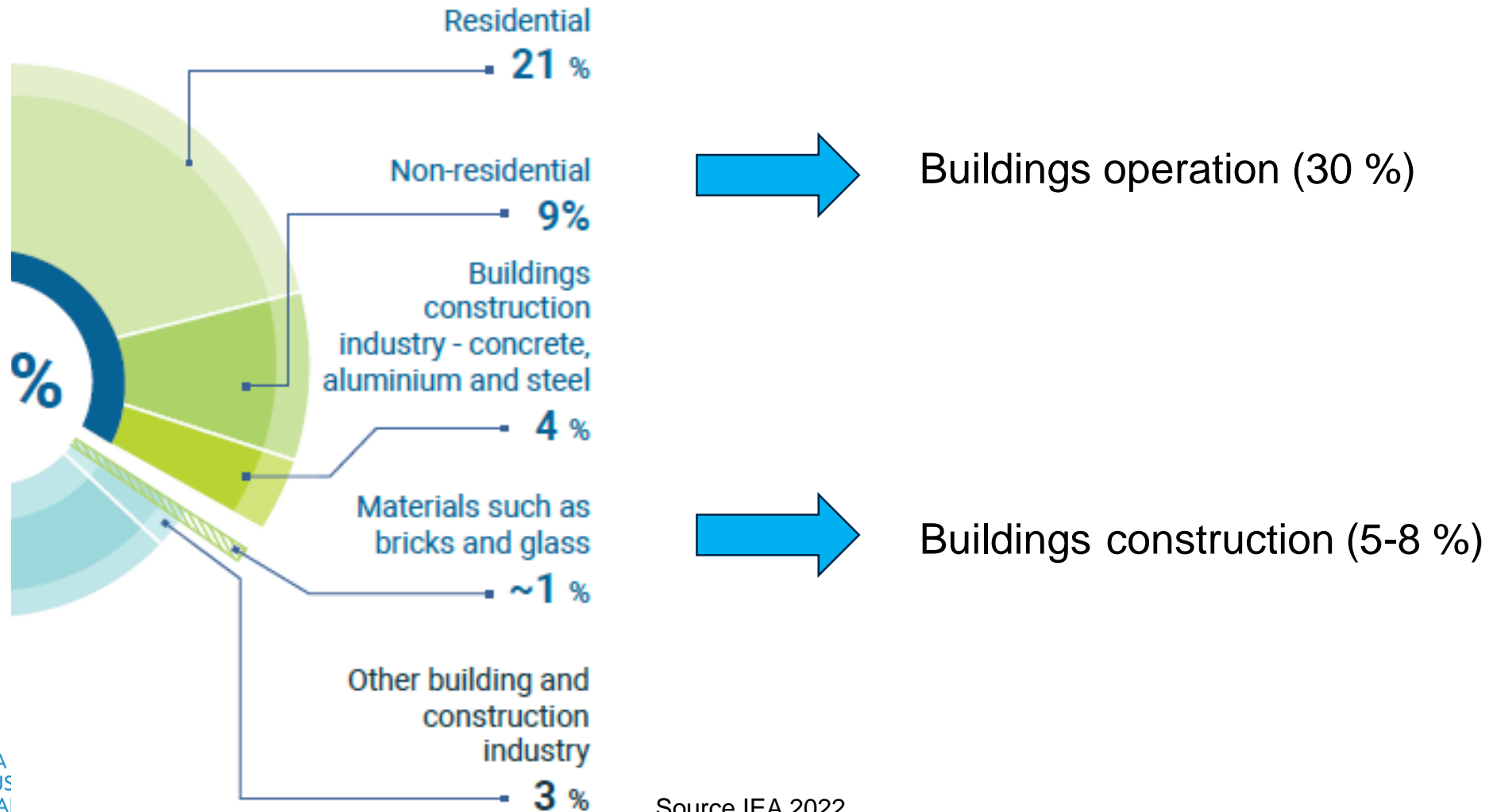


Global share of buildings and construction operational and process CO2 emissions, 2021





Buildings operation vs. Buildings construction



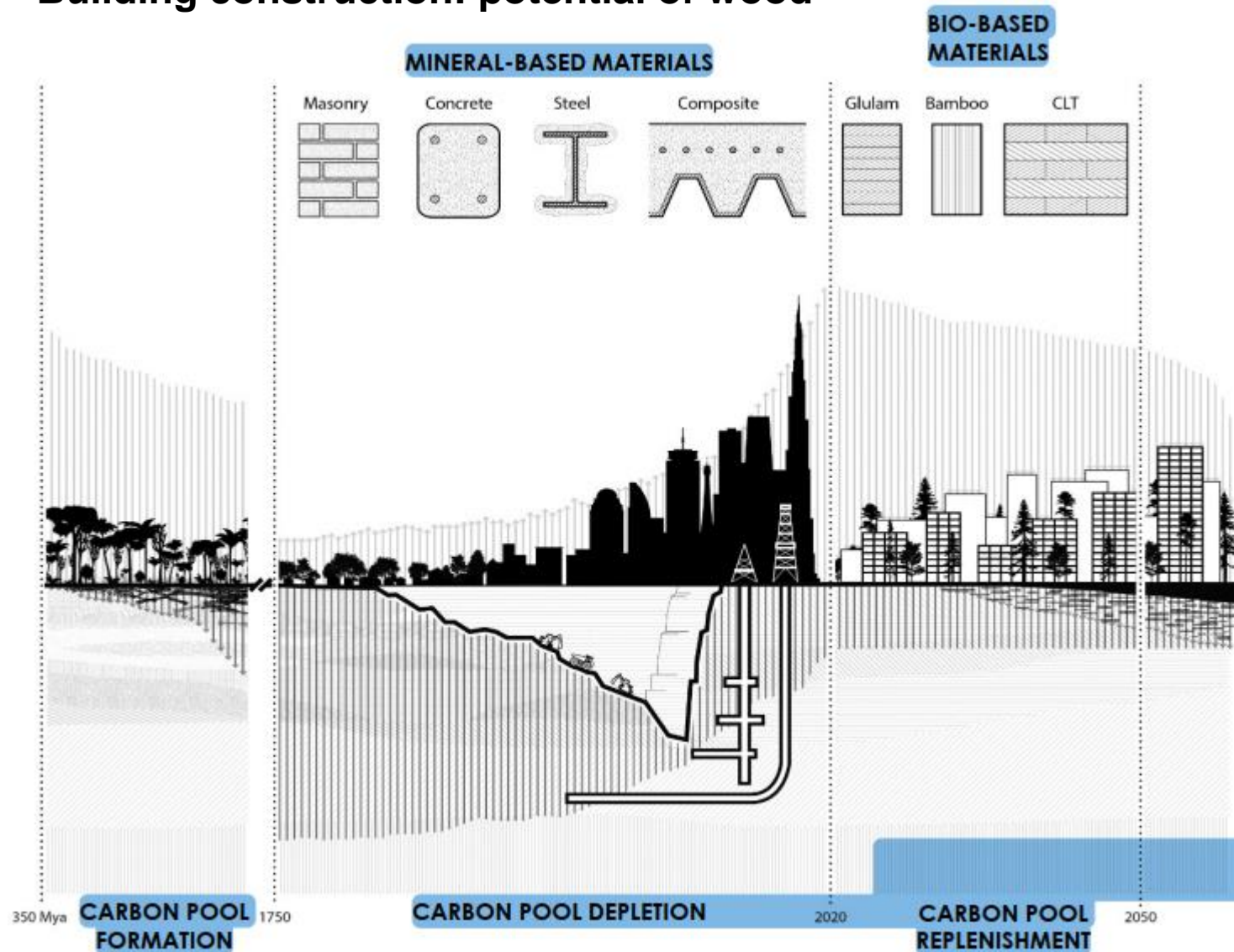


The forest – building carbon pump



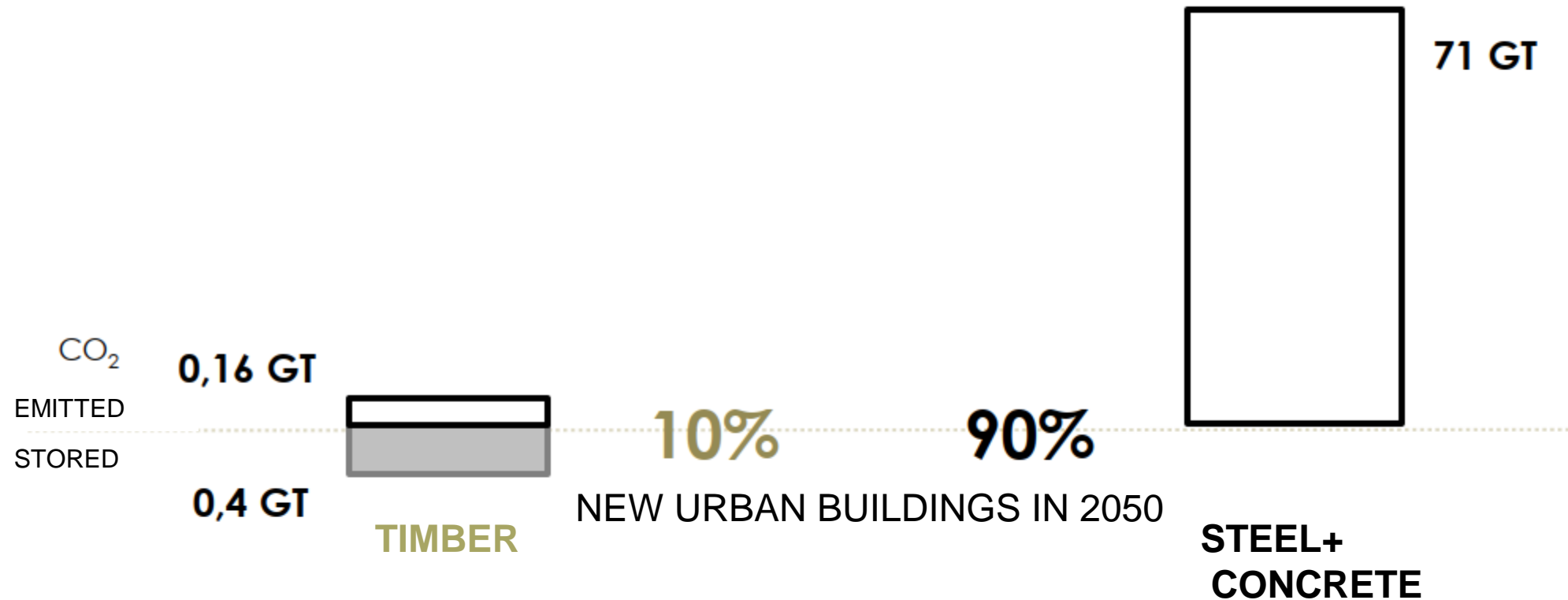


Building construction: potential of wood

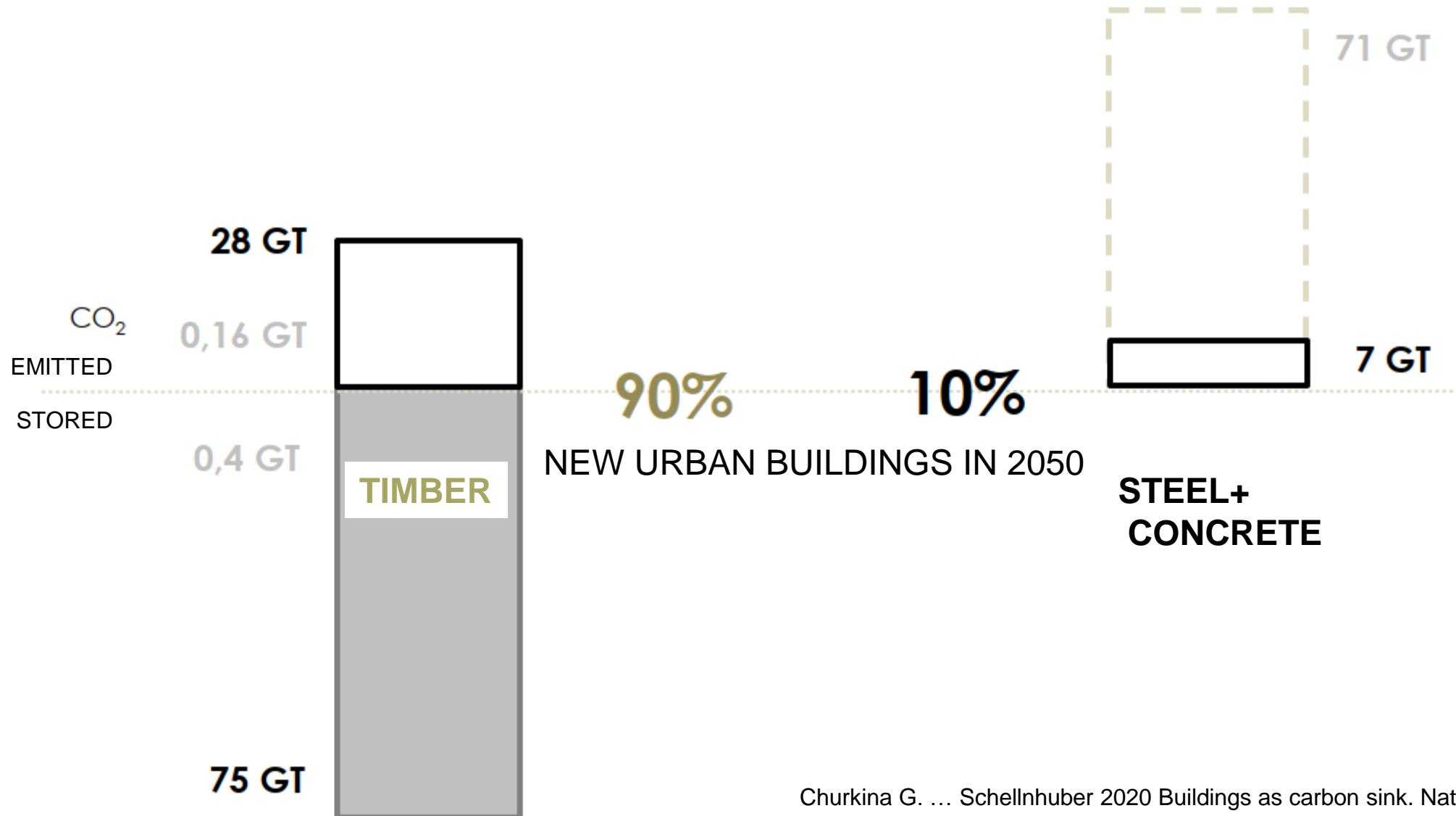


- Contribution to lower or nearly zero emissions in the building sector; requires easy and rapid scalability
- Retaining sustainable forestry and biodiversity
- Circular wood products
- New and improved wood processing techniques and new wood products
- Hybrid materials

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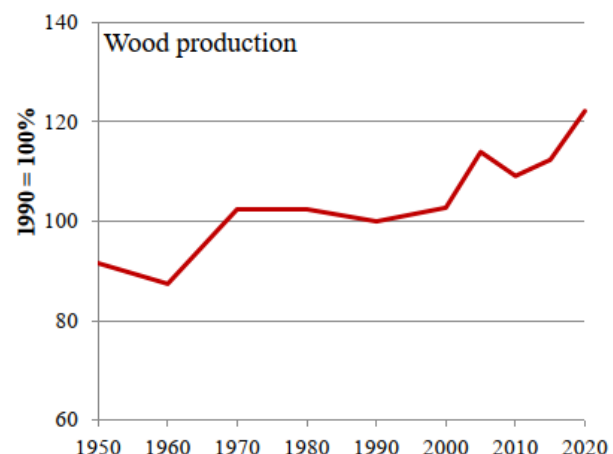
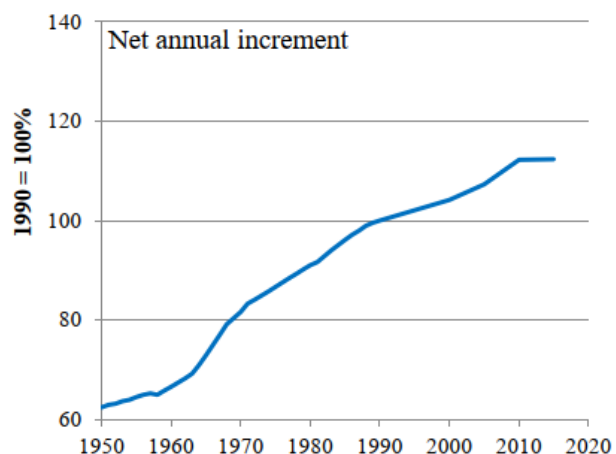
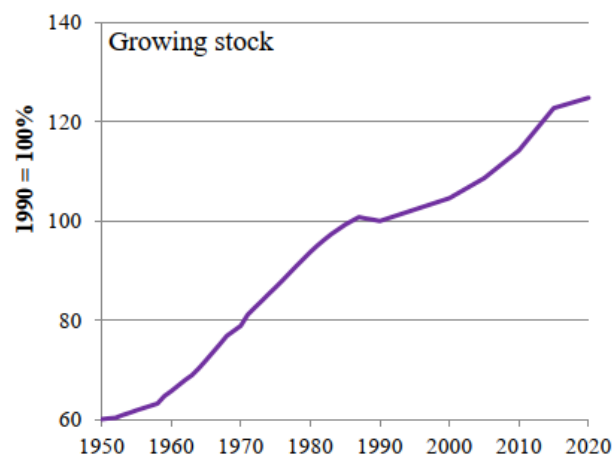
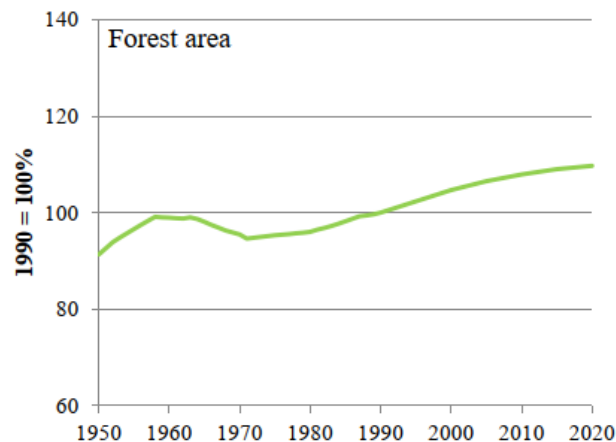
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Where shall the timber come from?

Development of EU forest resources



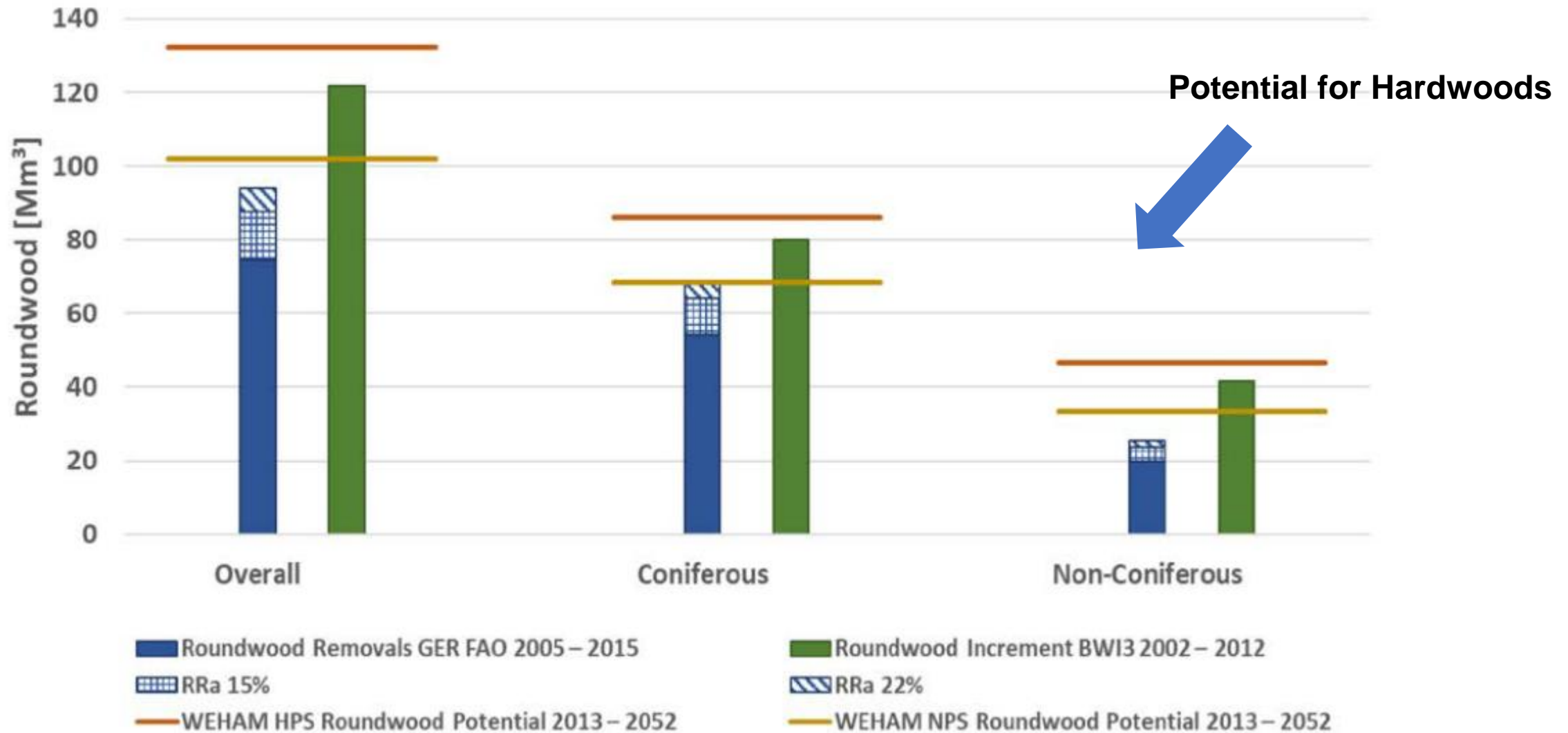
- Forest resources expanded significantly over the past 70 years
- Since 1950 steep increase in growing stock, annual increment and wood production can be observed.
- Changes since 1990 in EU + UK:
 - Forest area: +10%
 - Growing stock: +49%
 - Net annual increment: +24%
 - Wood production: +41%

*Long term trends in the graphs are only shown for 21 EU Member States (16 for net annual increment) due historic data availability.

Source: Forest Europe, 2021; Kuusela, 1994; Gold, 2003; Gold, 2006; FAOSTAT, 2022.



Average forest growth utilization in Germany





Hardwood properties (I)

- Woodiness: often high
- Cross section: often non-circular
- Growth habit: often curved
- Branches: often large with strong overhangs
- Root growth: often pronounced
- Assortments: often very variable



Foto: Ralf Rosin



Hardwood properties (II)

- Many native species
- High variation in properties within and among wood species
- Complex wood structure
 - Many different cell types
 - Smaller fiber length
 - Weak spots more often large and irregularly distributed
 - High, individual color variability
 - Wide range of different ingredients

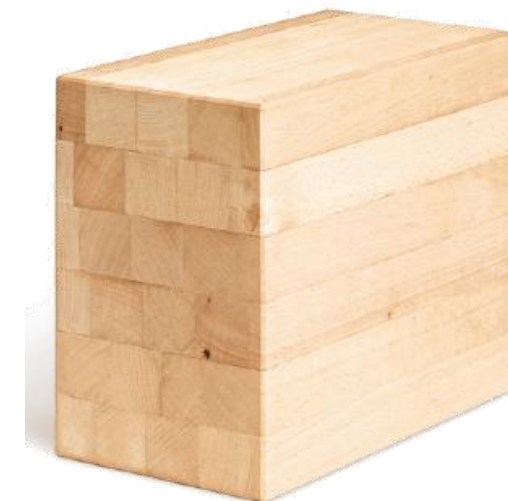


Hardwood properties (III)

- (often) High strength, stiffness and bulk density
- Lower content of VOCs
- Partially higher swelling and shrinkage behavior
- High variability of natural durability
- Low correlation of wood properties with visible or so far measurable wood characteristics



Engineered wood products



Fotos: Ralf Rosin

Foto: Fagus Suisse

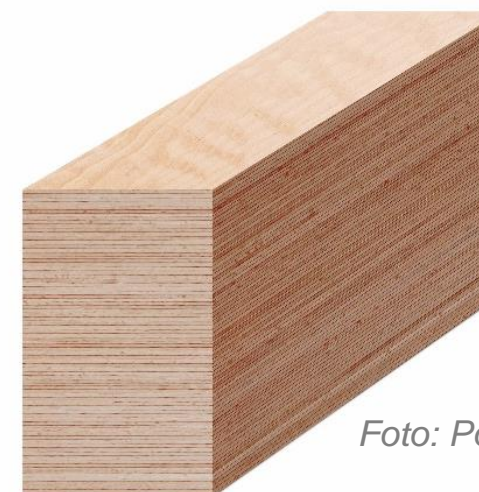


Foto: Pollmeier Massivholz

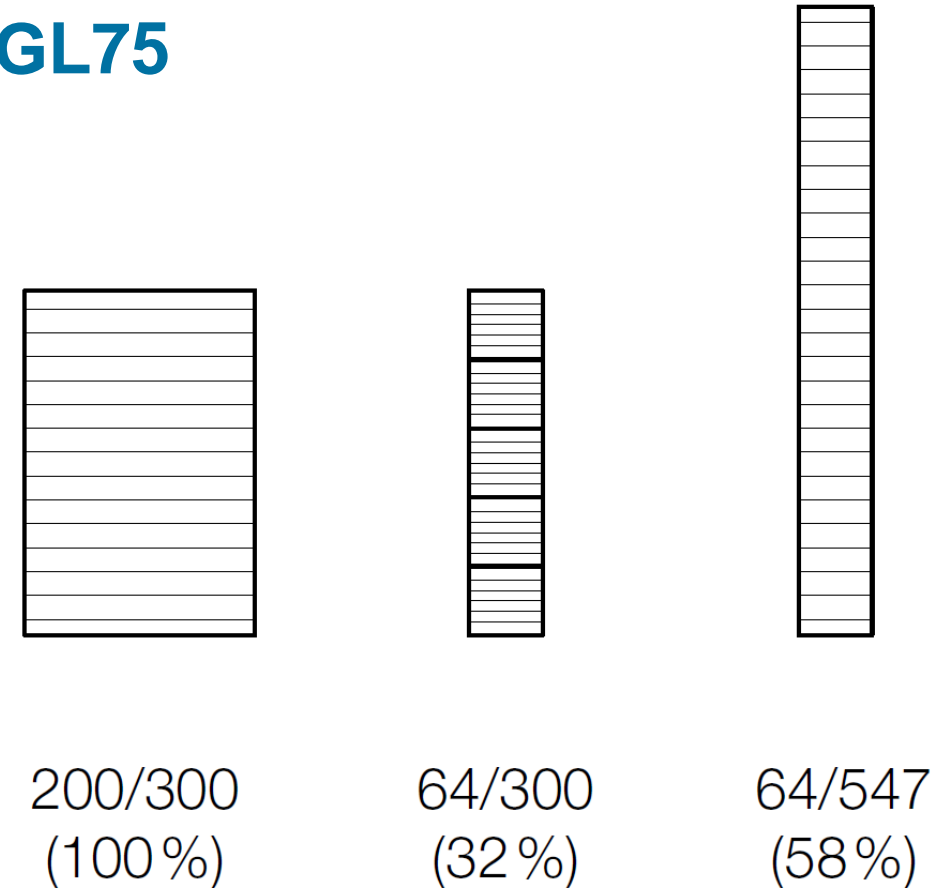


Performance of hardwood building products

GLT Spruce GL24h vs. GLT of LVL Beech GL75

When ... becomes decisive, the potential for material savings ...

- **Stiffness** → comparatively low
- **Bending strength** → realistic
- **Shear strength** → considerably
- **Compressive/tensile strength perp** → considerably
- **Compressive/tensile strength long** → enormous





Panel formed building products



Foto: www.hhh.at



Foto: Stefan Torno



Foto: Ralf Rosin

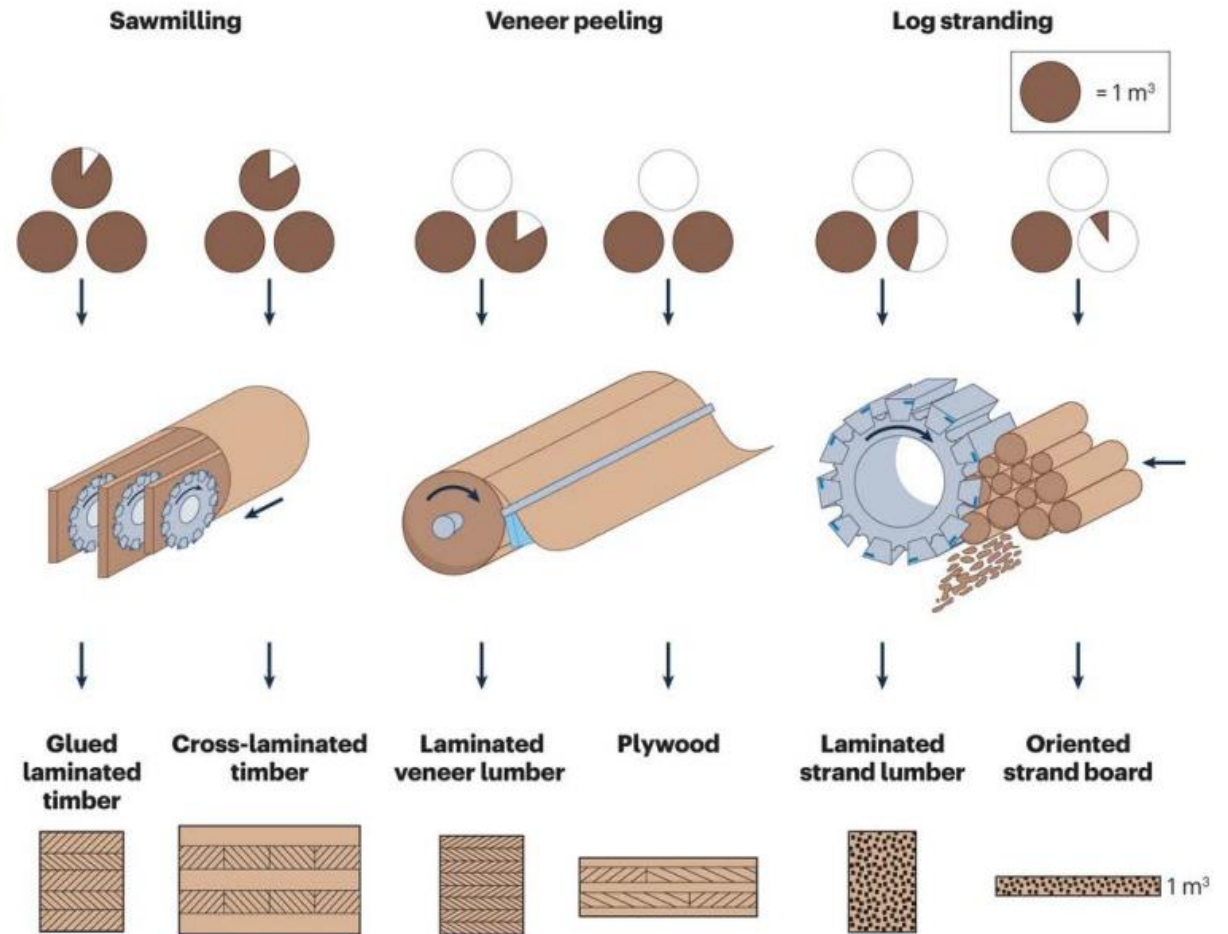


A plea for the efficient use of wood in construction

Maximilian Pramreiter, Tobias Nanning, Lukas Malzl & Johannes Konnerth

The transition to climate-friendly cities has led to a renaissance of wood as a renewable building material. To prevent severe raw material shortages in the future, the material-first utilization of wood in long-living, resource-efficient engineered wood products and constructions will be key.

Resource demand of established engineered wood products.





Estimated amount of round wood (without bark) required to produce 1 m³ of glued laminated timber, cross-laminated timber, laminated veneer lumber, plywood, laminated strand lumber or oriented strand board.




Applications with potential Technology

- **Roundwood / „higher qualities“**

→ EWP 

→ Building products non-load bearing: windows, exterior doors, parquet, flooring, Solid wood panels 
Exterior building: Decking 

- **Industrial roundwood / „minor qualities“**

→ Wood based (isolation) panels 

→ Packaging products 



→ Biorefinery 



Applications with potential Decarbonization

- **Roundwood / „higher qualities“**

- EWP 

- Building products non-load bearing: windows, exterior doors, parquet, flooring, Solid wood panels 
Exterior building: Decking 

- **Industrial roundwood / „minor qualities“**

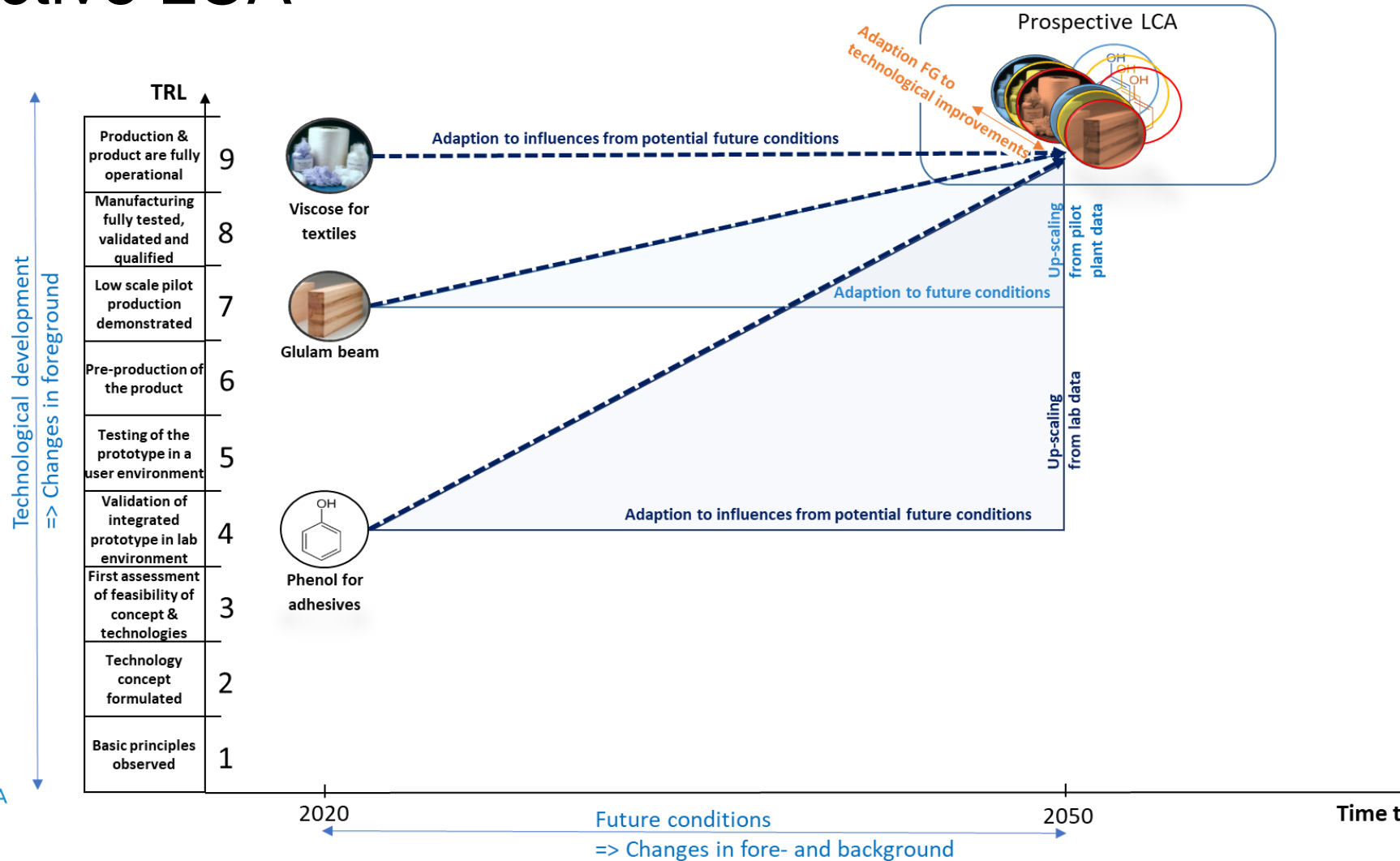
- Wood based (isolation) panels 

- Packaging products 

- Biorefinery 



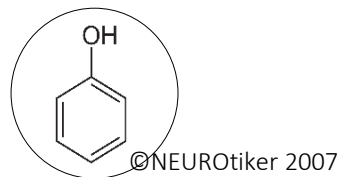
Prospective LCA





Case studies

Case study 1
Lignin-based adhesive



Case study 2
Glulam beam

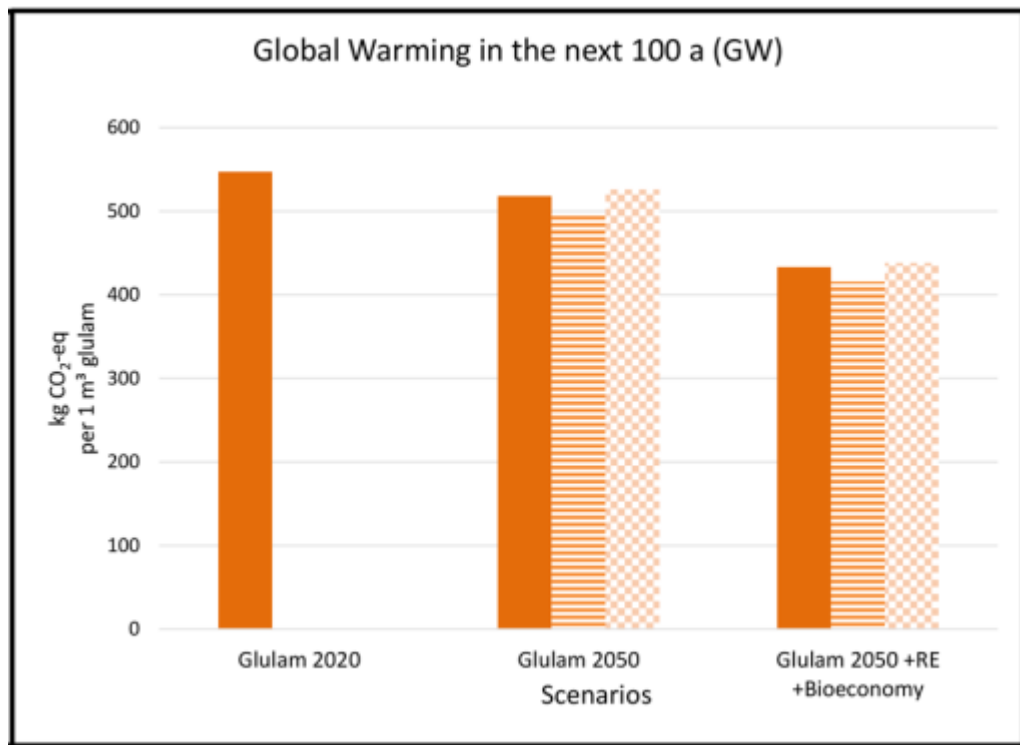


Case study 3
Viscose fibers



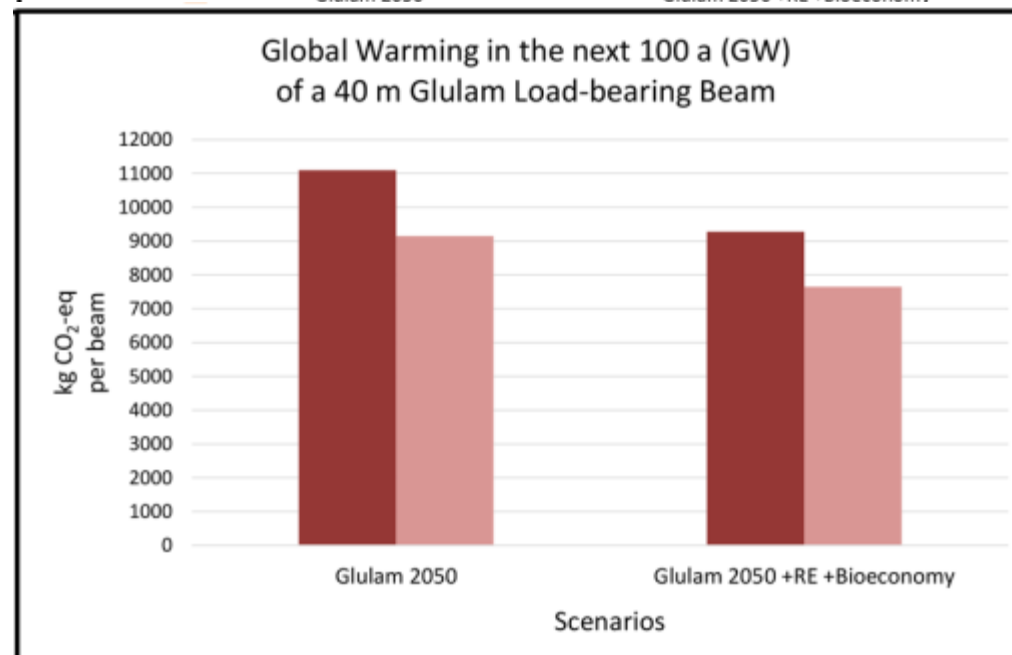
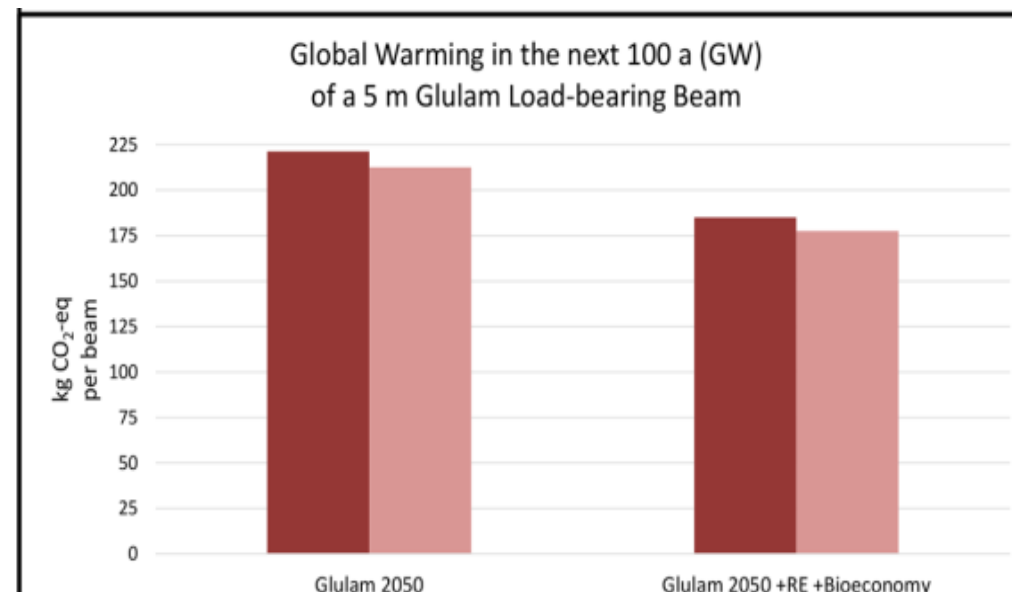
Wooden component	Purified lignin	Solid wood	Cellulose fibers
Production paths	Pulping: 2-3 Valorization: 3 Adhesive production: 3	Glulam production via high pressure pressing	Pulping: 2-3 Viscose production: 1
Production status in Germany	Two products available on the market but no production in Germany	Case studies with first applications e.g. building of Bavarian State Institute of Forestry, no regular production	1 production site of Bavaria, no pulp production
Declared unit	1 kg of adhesive	1 m ³ of glulam	1 kg of viscose fiber
Functional unit	-	<ul style="list-style-type: none"> 5 m glulam beam of low beech assortments holding constant roof pressure of 1 N/mm for 50 years 40 m glulam beam of high beech assortments holding constant roof pressure of 1 N/mm for 50 years 	-

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Sensitivity analysis legend:

- Base line
- Allocation factor min
- Sawnwood input max
- Dimensioning today
- Innovative dimensioning





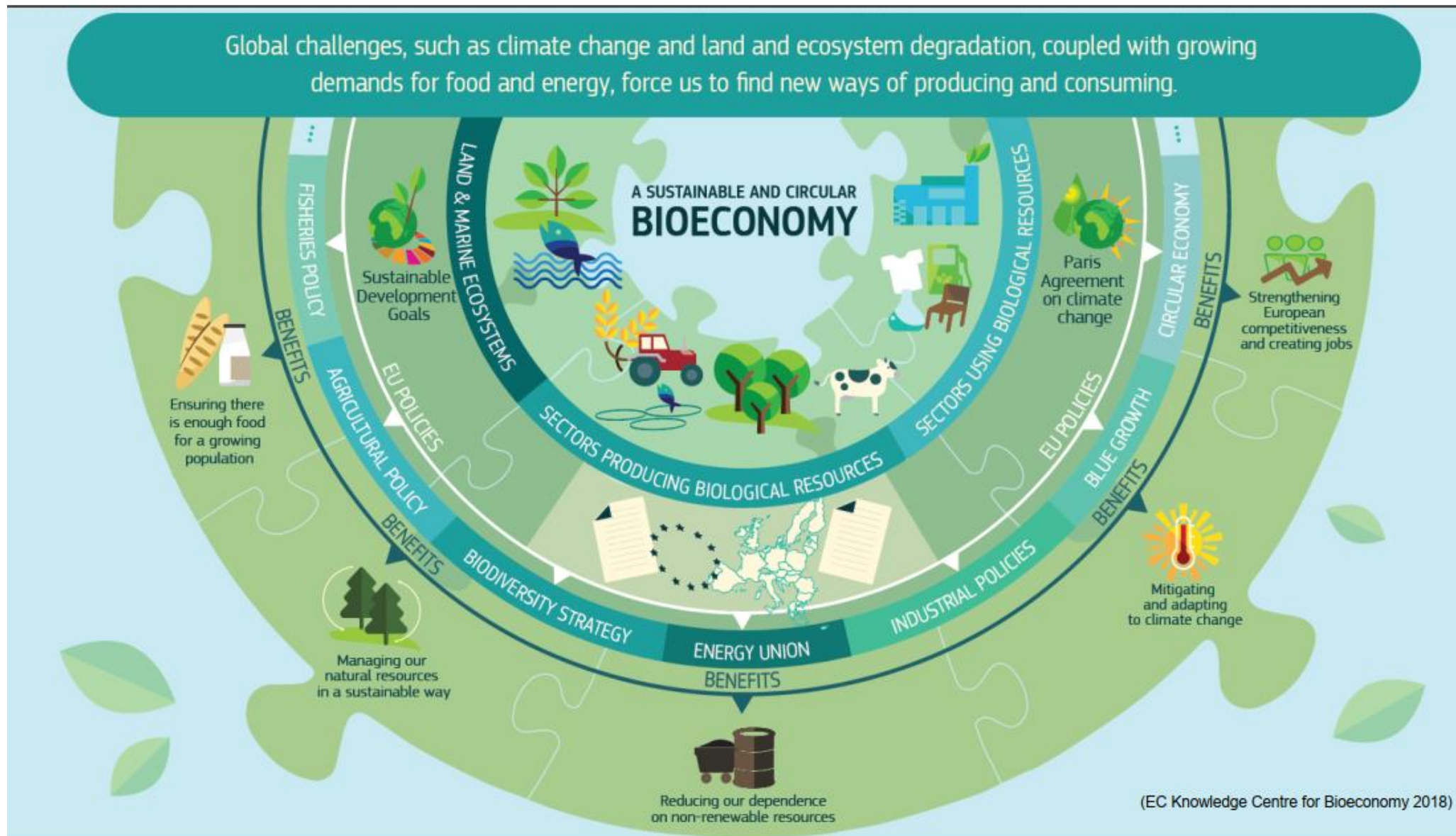
Conclusion decarbonization

- Future scenarios for 2050 predict reduced environmental impacts for hardwood building products, implying an overall improvement and positive options for decarbonisation.
- The greatest reduction of an environmental impact, however is through the rapid growth of the RE share in the electricity mix coupled with the amendment of standards to allow smaller crosscuts of hardwood glulam.
- This rapid growth in the RE share will also affect (reduce) the substitution potential wood currently has in comparison with “competing” materials. Several studies have shown that climate mitigation by energy and material substitution of wood products has an expiry date, see e.g. Brunet-Navarro et al 2021, <https://doi.org/10.1016/j.jclepro.2021.127026>).
- The necessary technical adaptation of the process lines as well as the building codes needs to be realised in due time in order to allow a hardwood based decarbonization strategy .

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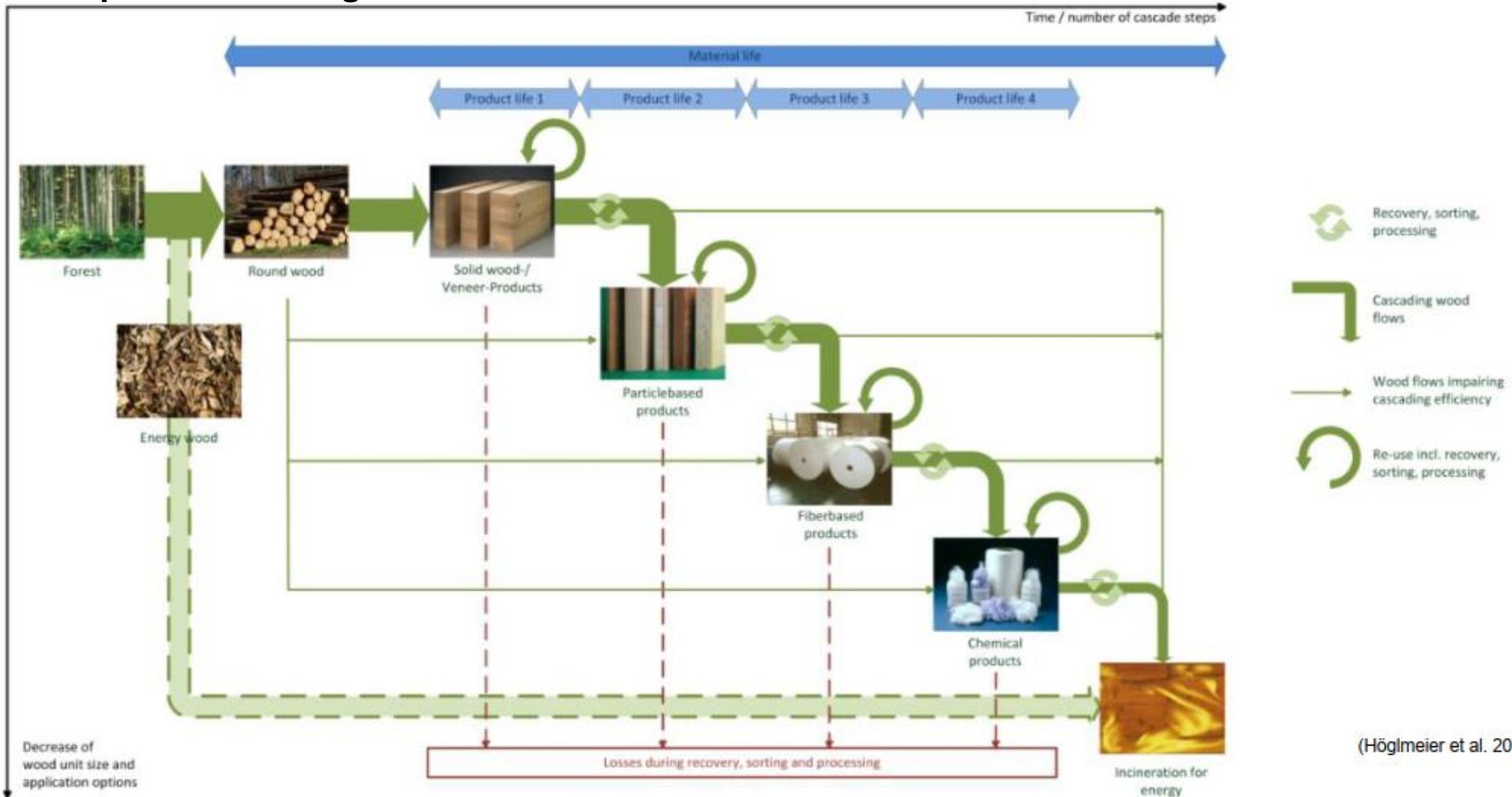
Options for cascading



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Principle of cascading in the forest and wood industries





Wood cascading: expectations and barriers

Resource efficiency

Independence from supply chains

Scarcity of raw materials

Value creation potential

Positive environmental effects

Carbon storage

Security of supply (quantity, quality)

Technical implementation

Minor material properties

Contamination

Unclear customer acceptance

Legal restrictions

Lack of overall assessment



Building products made of recovered (soft)wood

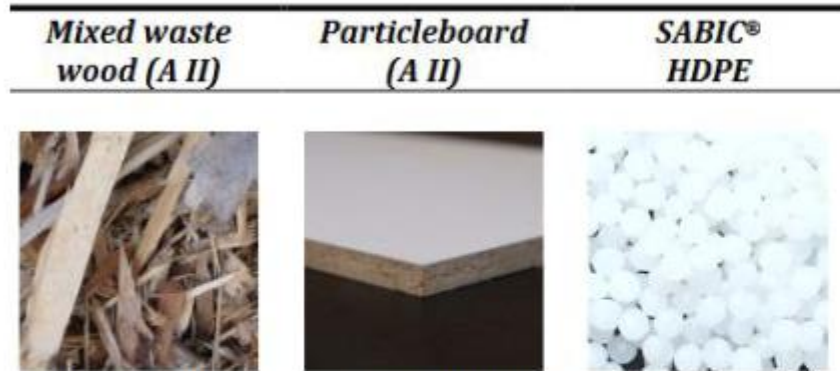


Yield

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Recovered wood for Particle- and Fiberboards, and Biorefineries



(Sommerhuber 2016, Post-consumer wood in WPC)



(Fraunhofer ICT 2017, ReWoBioRef)



(www.ecorefibre.eu, EcoReFibre Project 2023)



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Holztafelbau – Status Quo

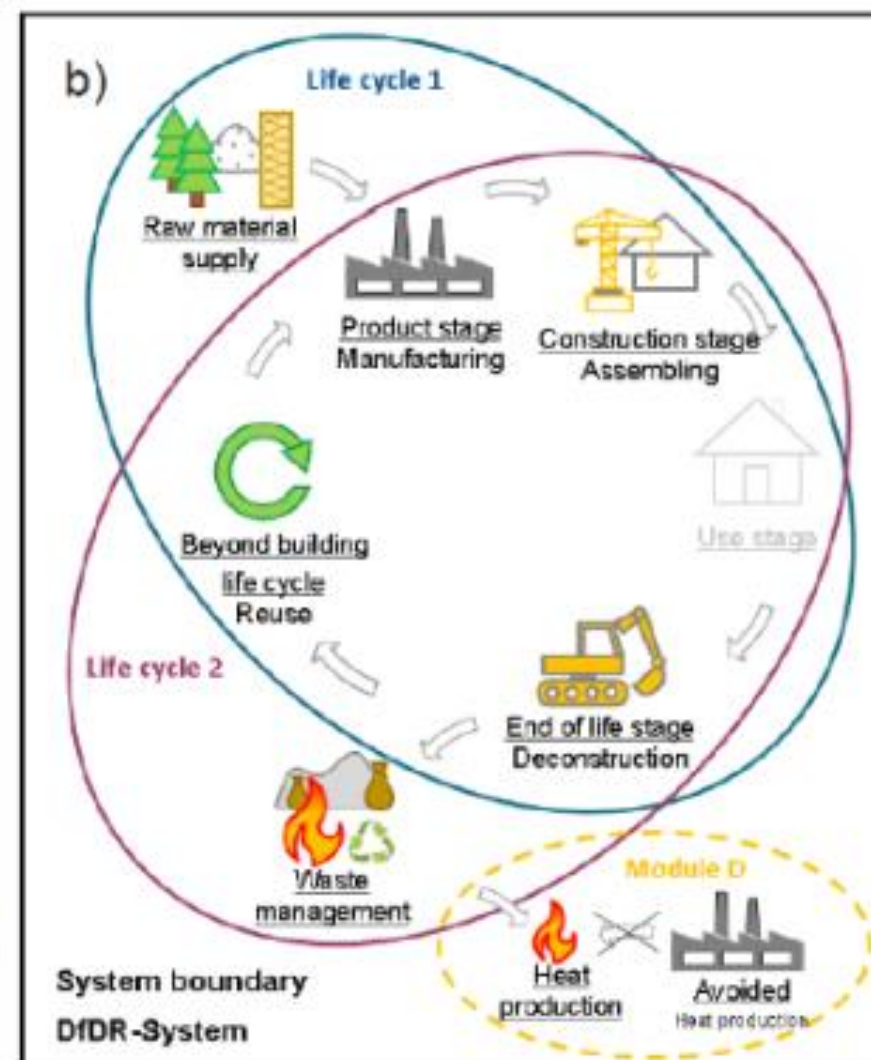
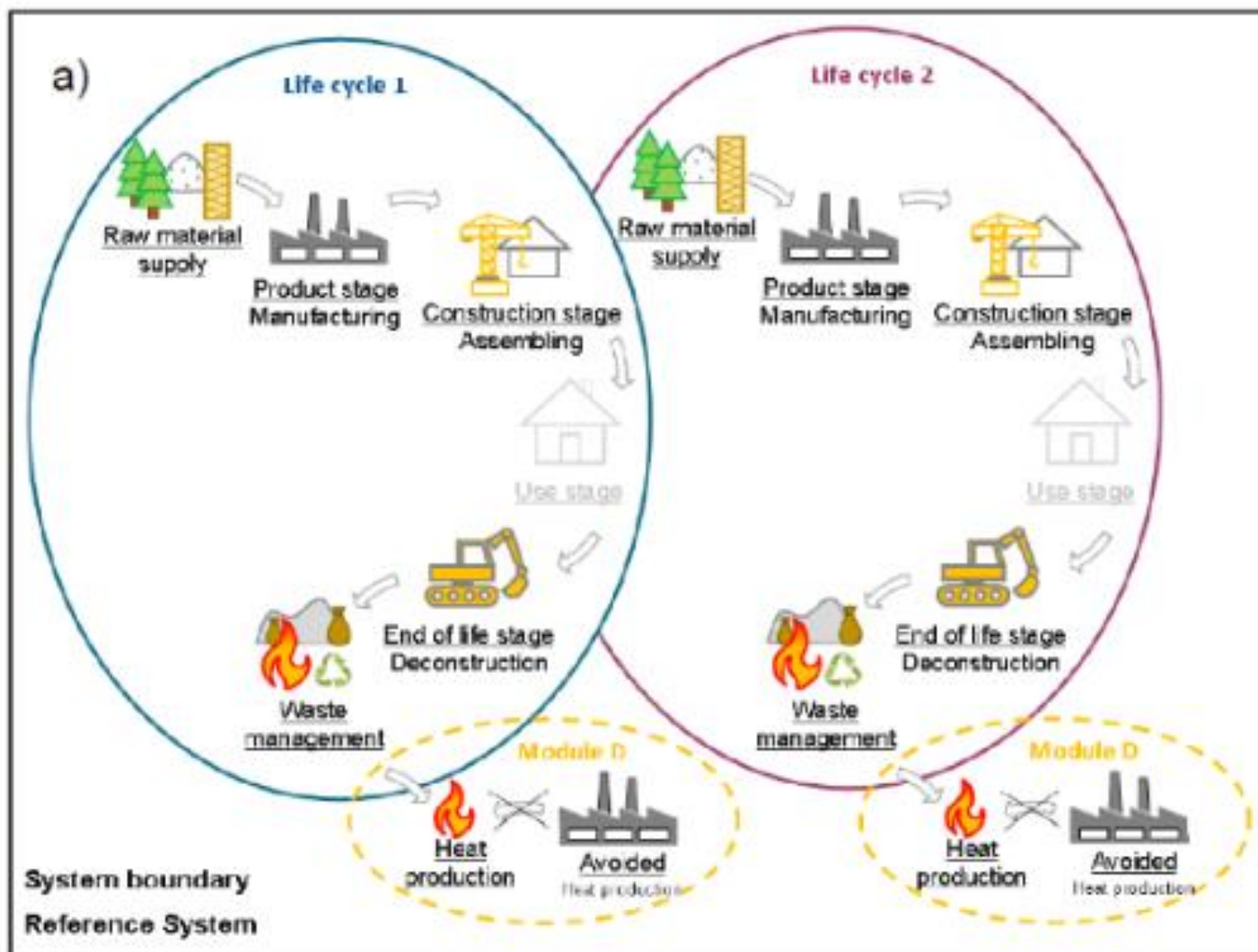


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Design for Disassembly and Reuse

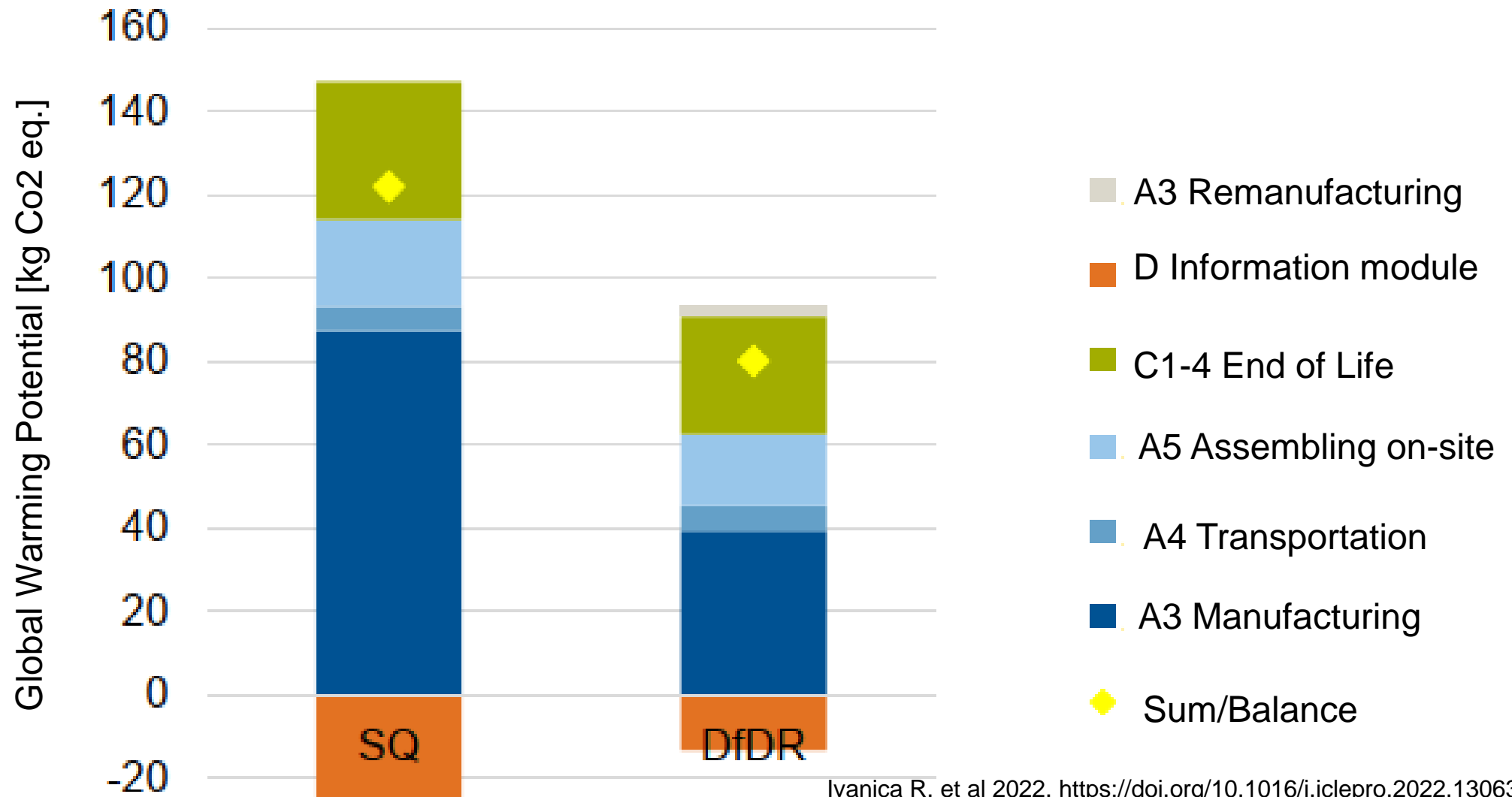
Reference system (Status Quo)



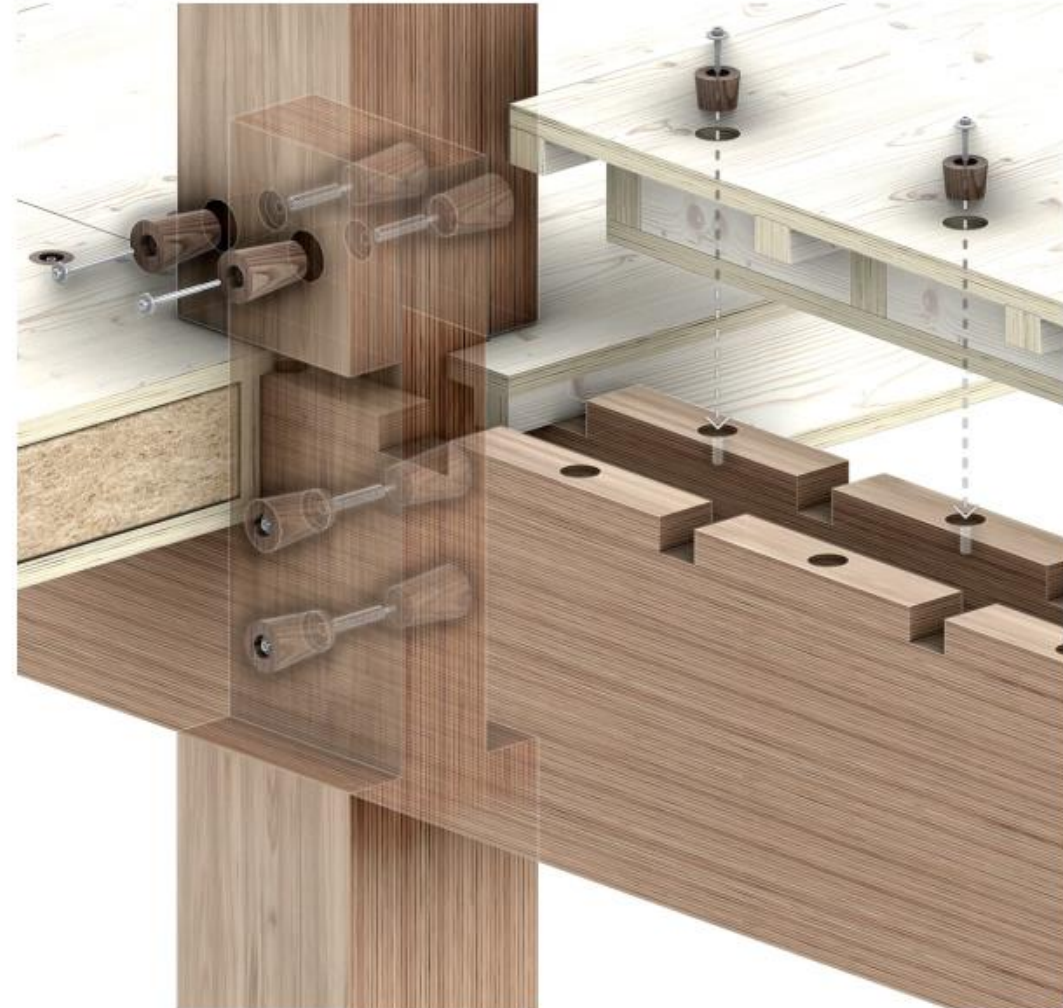
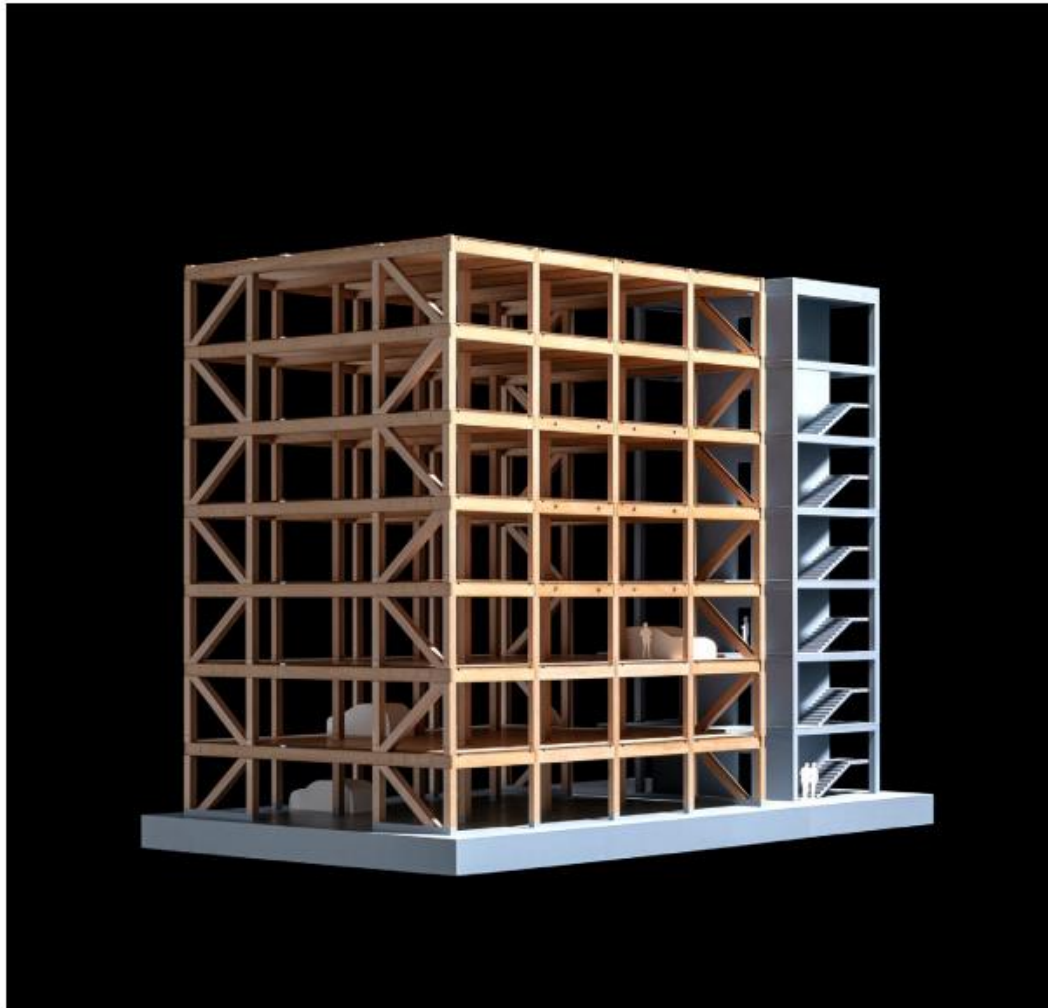
Design for recycling system



Design for Disassembly and Reuse: Global Warming effect



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Conclusion circularity

- Today's recover and recycling rate of the wood building industry is rather low (<10%).
- In current and ongoing case studies positive values of wood circularity are shown and all future strategies on wood potentials in the bioeconomy are relying on circularity effects, in order to match the demand for wood based material with the planetary boundaries.
- So far no specific studies comparing the circularity potential of softwood and hardwoods are realized. However, due to the specific wood properties of hardwoods there is a higher potential for hardwoods to be used in biorefinery processes.



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