(Waste) Wood

Xan Browne / Aalto University / 16.11.2021

Royal Danish Academy

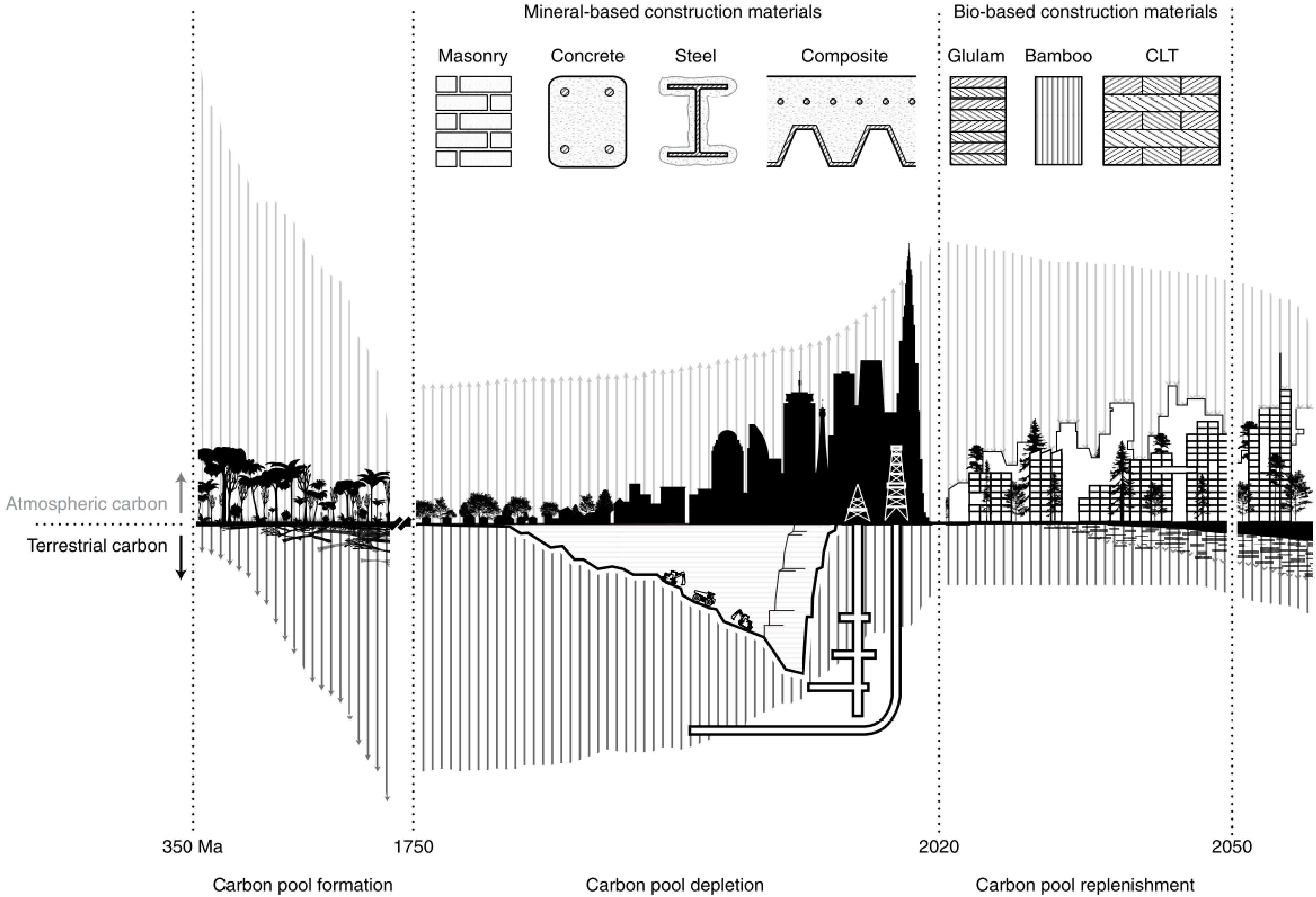
Lendager

Wood

The Nordic Project

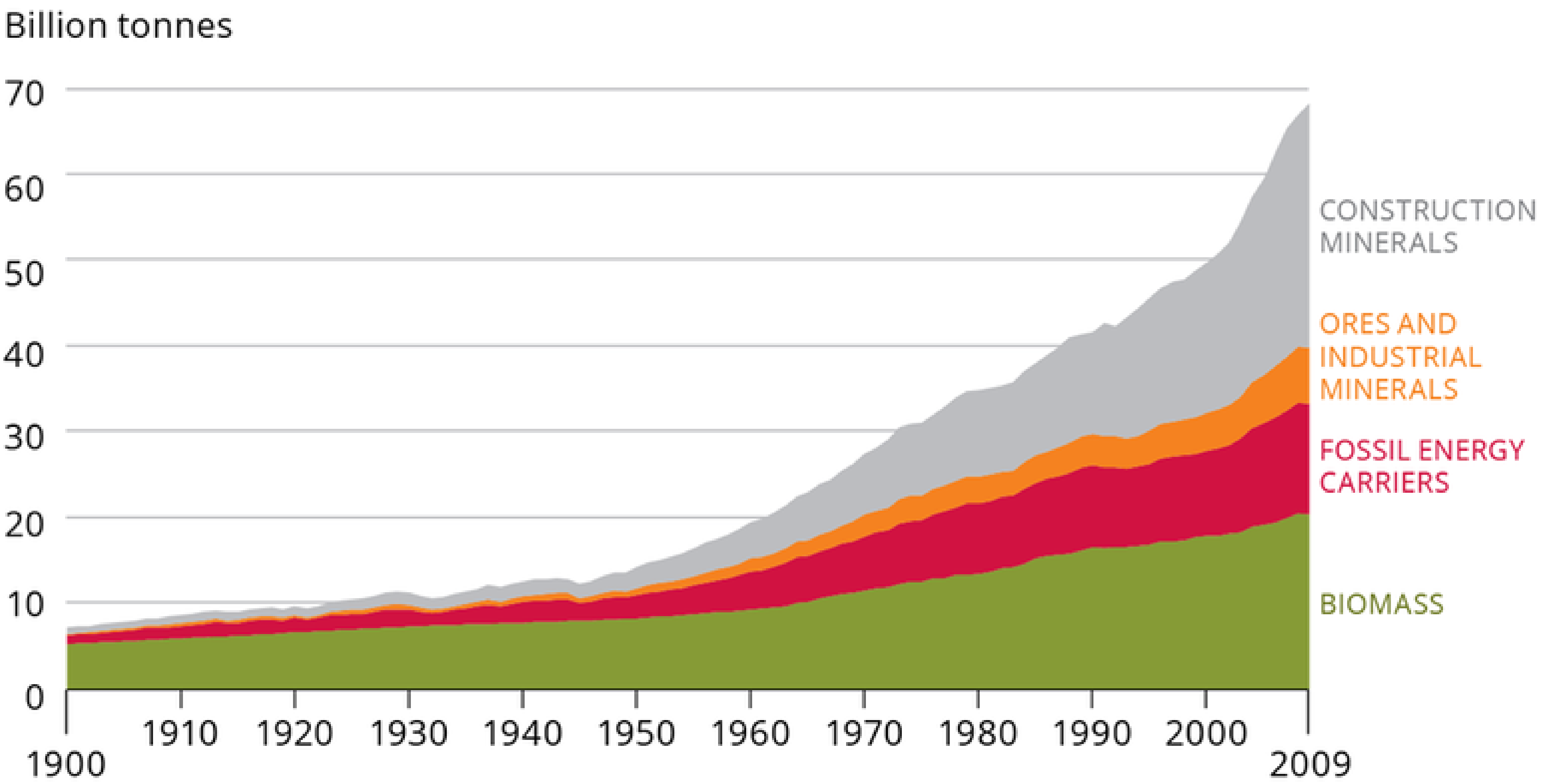
Architecture and (Waste) Wood Agency

Wood



Churkina, G., Organschi, A., Reyer, C., Ruff, A., Vinke, K., & Liu, Z. et al. (2020). Buildings as a global carbon sink. Nature Sustainability, 3(4), 269-276. doi: 10.1038/s41893-019-0462-4

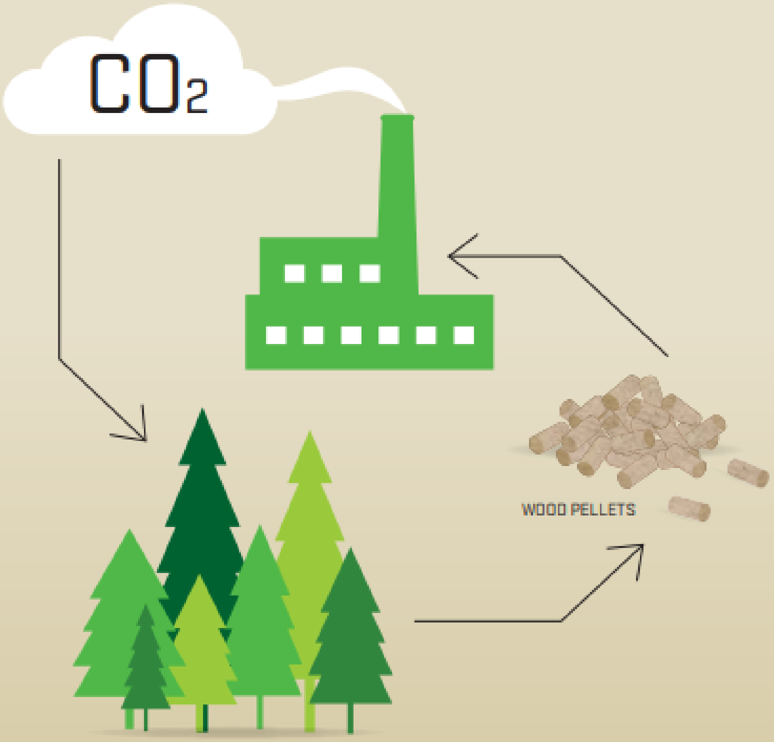
Global total material use by resource type



https://www.eea.europa.eu/soer/data-and-maps/figures/global-total-material-use-by

BIOMASS IS CLIMATE-FRIENDLY

Cycle of burning and reforestation



By replanting the forest it will absorb the carbon dioxide emitted by burning the wood pellets and wood chips

As is the case for other kinds of fuels, carbon dioxide is emitted from production and transport of wood pellets and chips.

By replacing coal and natural gas with sustainable wood pellets and wood chips carbon dioxide emissions can be reduced by approx. 90%. And this includes emissions from production and transport.[1]

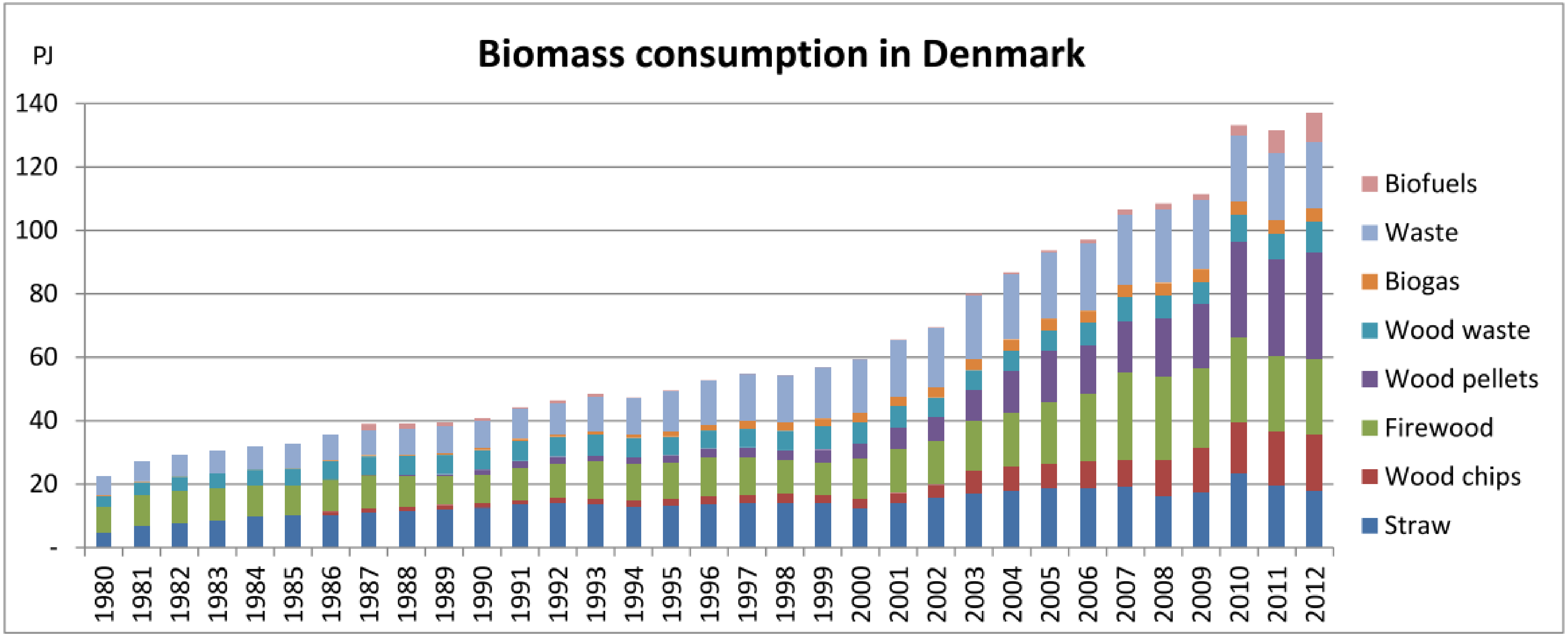
Shipping generates the lowest level of CO_2 emission.

Denmark has many docks ideally located at the largest CHP plants. Thus, imported biomass can easily be shipped to Denmark.

[1] SOURCE: EU-COMMISSION, 2010: "ACCOMPANYING DOCUMENT TO THE REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT ON SUSTAINABILITY REQUIREMENTS FOR THE USE OF SOLID AND GASEOUS BIOMASS SOURCES IN ELECTRICITY, HEATING AND COOLING".

https://www.danskenergi.dk/sites/danskenergi.dk/files/media/dokumenter/2017-09/BiomassForEnergy.pdf

Biomass Consumption in Denmark



https://backend.orbit.dtu.dk/ws/portalfiles/portal/97912187/Experiences_with_biomass_in_Denmark.pdf

GCR
GLOBAL CONSTRUCTION REVIEW

News

New French public buildings must be made 50% from wood

GCR Staff
07.02.20

The government of France is set to require that all new public buildings must be made at least 50% from wood or other sustainable materials from 2022 as it pushes for sustainable urban development.

The local government in Paris had already pledged a greater use of natural materials such as wood, straw and hemp, and any buildings higher than eight storeys built for the 2024 Paris Olympics must be made entirely of timber.

"If it is possible for the Olympics, it should be possible for ordinary buildings," said Julien Denormandie, minister for cities and housing, on 5 February. "I am imposing on all public bodies that manage development to construct their buildings with material that is at least 50% wood or other bio-sourced material."

Boligminister: "Det er klart, vi skal bygge mere i træ"

INTERVIEW: Boligministeren ser et stort potentiale i byggeri med træ. Udfordringen ligger i byggeriets årelange opfattelse af tegl som et overlegent materiale og forældede bygningsreglementer. Den vil han nu gøre op med.

Foto: Arthur J. Cammelbeeck/Altinget

Maria Neergaard Lorentsen Journalist

Boligmassen er en af de tungeste områder inden for klimaforurening. Ifølge EU-Kommissionen står byggesektoren alene for 40-50 procent af det globale ressourceforbrug.

"Byggeriet spiller en kæmpestor rolle i forhold til at nå vores klimamål. En del af det handler om materialerne, der bygges med, og som skal være mere klimavenlige," siger Boligminister (S) Kaare Dybvad.

nature sustainability

PERSPECTIVE

https://doi.org/10.1038/s41893-019-0462-4

Buildings as a global carbon sink

Galina Churkina[1,2]*, Alan Organschi[3,4], Christopher P. O. Reyer[2], Andrew Ruff[3], Kira Vinke[2], Zhu Liu[5], Barbara K. Reck[1], T. E. Graedel[1] and Hans Joachim Schellnhuber[2]

The anticipated growth and urbanization of the global population over the next several decades will create a vast demand for the construction of new housing, commercial buildings and accompanying infrastructure. The production of cement, steel and other building materials associated with this wave of construction will become a major source of greenhouse gas emissions. Might it be possible to transform this potential threat to the global climate system into a powerful means to mitigate climate change? To answer this provocative question, we explore the potential of mid-rise urban buildings designed with engineered timber to provide long-term storage of carbon and to avoid the carbon-intensive production of mineral-based construction materials.

During the Carboniferous period, giant fern-like woody plants grew in vast swamps spread across the Earth's surface. As successions of these plants grew and then toppled, they accumulated as an increasingly dense mat of fallen plant matter. Some studies have suggested that this material resisted decay because microbes that would decompose dead wood were not yet present[1], while others have argued that a combination of climate and tectonics buried the dead wood and prevented its decomposition[2]. Over millions of years, geological pressures and temperatures transformed that accretion of organic matter into fossil fuel deposits (Fig. 1, left panel). Since the advent of the industrial revolution in the mid-nineteenth century, these deposits have been continuously extracted and burned to fuel the industrialization required to meet the demands for products and infrastructure of a burgeoning population, leading to substantial increases in atmospheric concentrations of carbon dioxide (CO_2) (Fig. 1, middle panel).

High atmospheric CO_2 concentrations, longer growing seasons, warmer temperatures, forest regrowth and increasing nitrogen mineralization have been identified as the main drivers of current increases in the productivity of vegetation globally[3–5]. In recent decades, the world's forests have served as a net sink of carbon (1.1 ± 0.8 GtC yr^{-1}) with living tree biomass accumulating most of it[6]. While local[7] and global[8] studies suggest that climate change will likely enhance forest growth in the future, it remains unclear how long CO_2 fertilization effects, especially in nitrogen-limited forests, will persist[9] and continue mitigating climate change. Enhanced carbon sequestration in forests may be reinforced, counteracted or even offset by concurrent changes in surface albedo, land-surface roughness, emissions of biogenic volatile organic compounds, transpiration and sensible heat flux[10]. Moreover, storing carbon in forests over the long term becomes less reliable because of the changing dynamics of forest disturbances such as fire, wind and insect outbreaks, which are closely linked to climate change[11,12] and can decrease forest growth and storage of carbon in forests[13]. For example, droughts and frequent heat waves have been shown to reduce forest productivity and net carbon uptake[14,15].

The organic deposits of modern forests will not accumulate in large quantities underground as in the Carboniferous period, nor replenish the underground carbon pool naturally because soil microorganisms, plant species and Earth's climate have inevitably evolved. Furthermore, current rates of fossil fuels combustion have far exceeded carbon sequestration rates in forests creating the need for national governments to submit reduction targets for CO_2 emissions to the United Nations Framework Convention on Climate Change (UNFCCC) as part of their obligations under the Paris Agreement[16]. However, even if all governments were to achieve their commitments, anthropogenic CO_2 emissions would exceed the carbon budget range associated with the agreement[17]. The mitigation pathways presented by the Intergovernmental Panel on Climate Change (IPCC)[18] try to account for this dilemma by introducing large-scale carbon extraction schemes, mainly based on bioenergy with carbon capture and storage, which are supposed to reconcile the budget. These schemes convert biomass to heat, electricity, or liquid or gas fuels and couple that activity with storing the CO_2 on land or in the ocean. Such an approach poses socio–economic risks[19] and threats to natural ecosystems[20,21].

Barring global-scale disasters of natural and human-caused origin, the coming decades will be characterized by demographic and economic growth in many parts of our planet. This will result in accelerated urbanization—UN projections foresee 2.3 billion new urban dwellers by 2050[22]—and entails the production of an enormous volume of housing and infrastructure. We propose to exploit this projected demand for urban buildings as a means to mitigate climate change. By employing bio-based materials, technologies and construction assemblies with high carbon storage capacity and low embodied carbon emissions, we can create a durable, human-made global carbon pool while simultaneously reducing CO_2 emissions associated with building sector activities (Fig. 1, right panel). Embodied energy or carbon emissions refer to energy or emissions associated with building construction, including extracting, transporting and manufacturing materials.

The problem

A recent study concluded that if the global population increases to 9.3 billion by 2050[23], then the emissions from the development of new infrastructure could claim 35–60% of a remaining carbon budget[24] based on limiting a global temperature increase to 2 °C. Further reductions in the energy demands and associated greenhouse gas emissions associated with the manufacture of mineral-based construction materials will be challenging, as these industries have already optimized their production processes. Future improvements in energy efficiency

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LETTER

Cities as carbon sinks—classification of wooden buildings

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Keywords: CO_2 capture, carbon storage, green buildings, LEED

Supplementary material for this article is available online

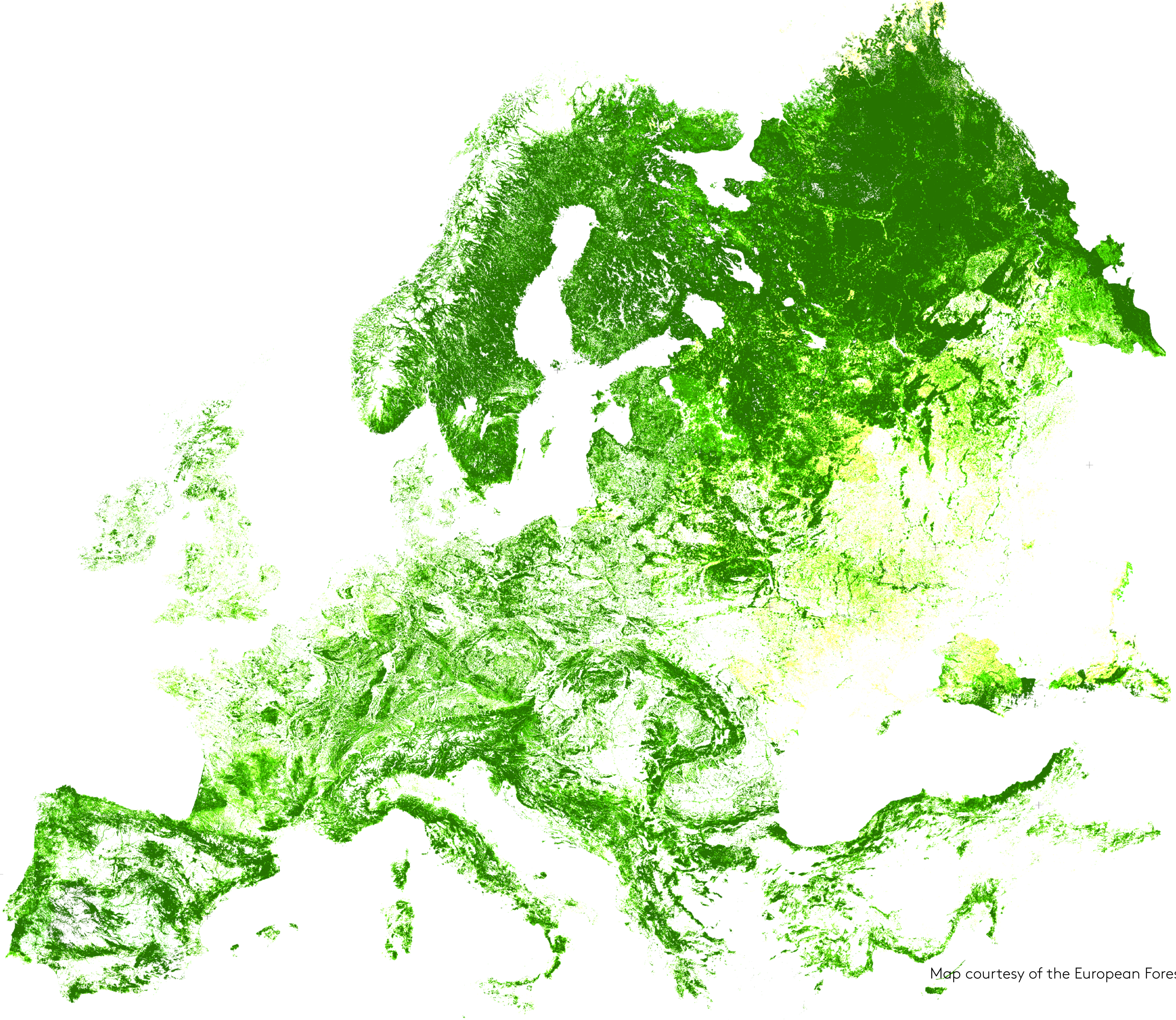
Abstract

Although buildings produce a third of greenhouse gas emissions, it has been suggested that they might be one of the most cost-effective climate change mitigation solutions. Among building materials, wood not only produces fewer emissions according to life-cycle assessment but can also store carbon. This study aims to estimate the carbon storage potential of new European buildings between 2020 and 2040. While studies on this issue exist, they mainly present rough estimations or are based on a small number of case studies. To ensure a reliable estimation, 50 different case buildings were selected and reviewed. The carbon storage per m^2 of each case building was calculated and three types of wooden buildings were identified based on their carbon storage capacity. Finally, four European construction scenarios were generated based on the percentage of buildings constructed from wood and the type of wooden buildings. The annual captured CO_2 varied between 1 and 55 Mt, which is equivalent to between 1% and 47% of CO_2 emissions from the cement industry in Europe. This study finds that the carbon storage capacity of buildings is not significantly influenced by the type of building, the type of wood or the size of the building but rather by the number and the volume of wooden elements used in the structural and non-structural components of the building. It is recommended that policymakers aiming for carbon-neutral construction focus on the number of wooden elements in buildings rather than more general indicators, such as the amount of wood construction, or even detailed indirect indicators, such as building type, wood type or building size. A practical scenario is proposed for use by European decision-makers, and the role of wood in green building certification is discussed.

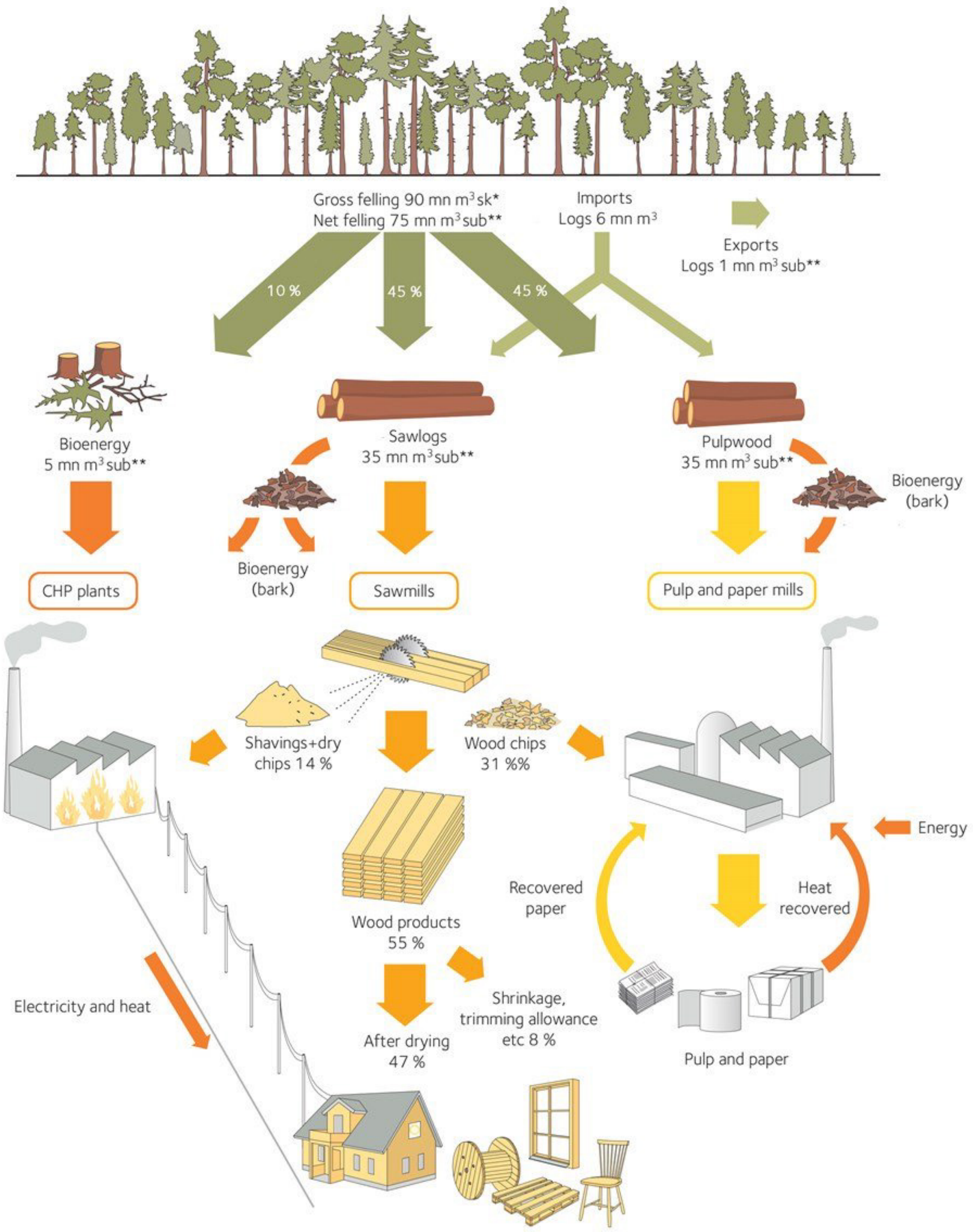
1. Introduction

Currently, the construction of new buildings is a significant source of emissions. These are caused by the processing, manufacturing, and transportation of building materials. Concrete and steel productions in particular are responsible for a large share of global emissions [1]. However, it is possible to transform this source of emissions into a tool to mitigate climate change [2]. Combined with sustainable forestry, wood construction could increase the carbon sinks of cities beside forests. Buildings can provide long-term carbon storage, especially if they are located in urban areas where there is a growing demand for real estate; and thus, old wooden buildings do not become obsolete but are retrofitted instead of being demolished or left to decay, which is often the case in shrinking rural areas.

The focus of climate action in the building sector has traditionally been on the use phase of buildings, since energy consumption in this phase has dominated the life-cycle emissions of buildings [3–10]. This emphasis on the use stage has resulted in thicker insulation, improved thermal performance of windows, and more efficient heat recovery systems. However, these changes, along with the ongoing decarbonization of energy production, means that the emissions embodied in the building materials used to construct these new energy-efficient buildings play an increasing role in the total life-cycle emissions of buildings. For example, nearly zero-energy buildings have a pre-use impact that equals roughly 50% of their overall greenhouse gas (GHG) impact [11]. Several researchers have made similar observations when comparing zero-energy buildings to conventional buildings [12–18]. In the case



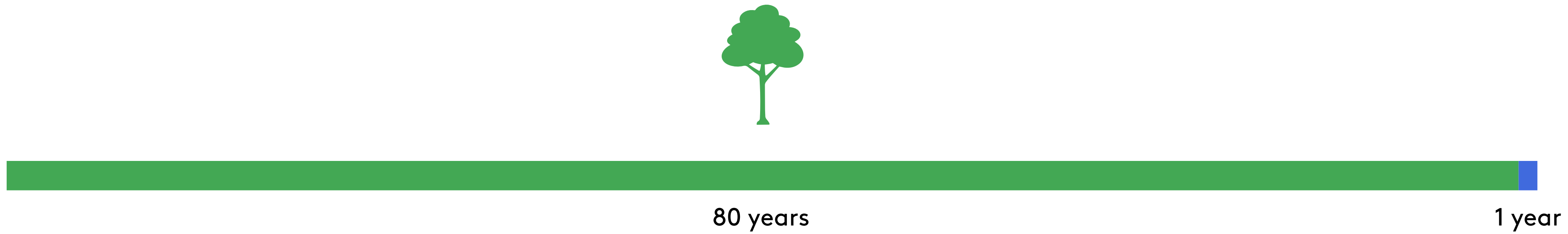
Map courtesy of the European Forest Institute

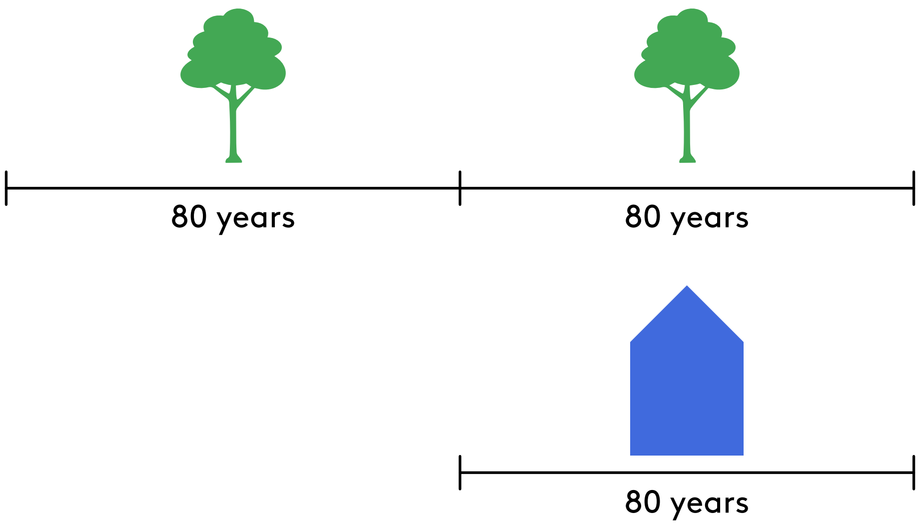


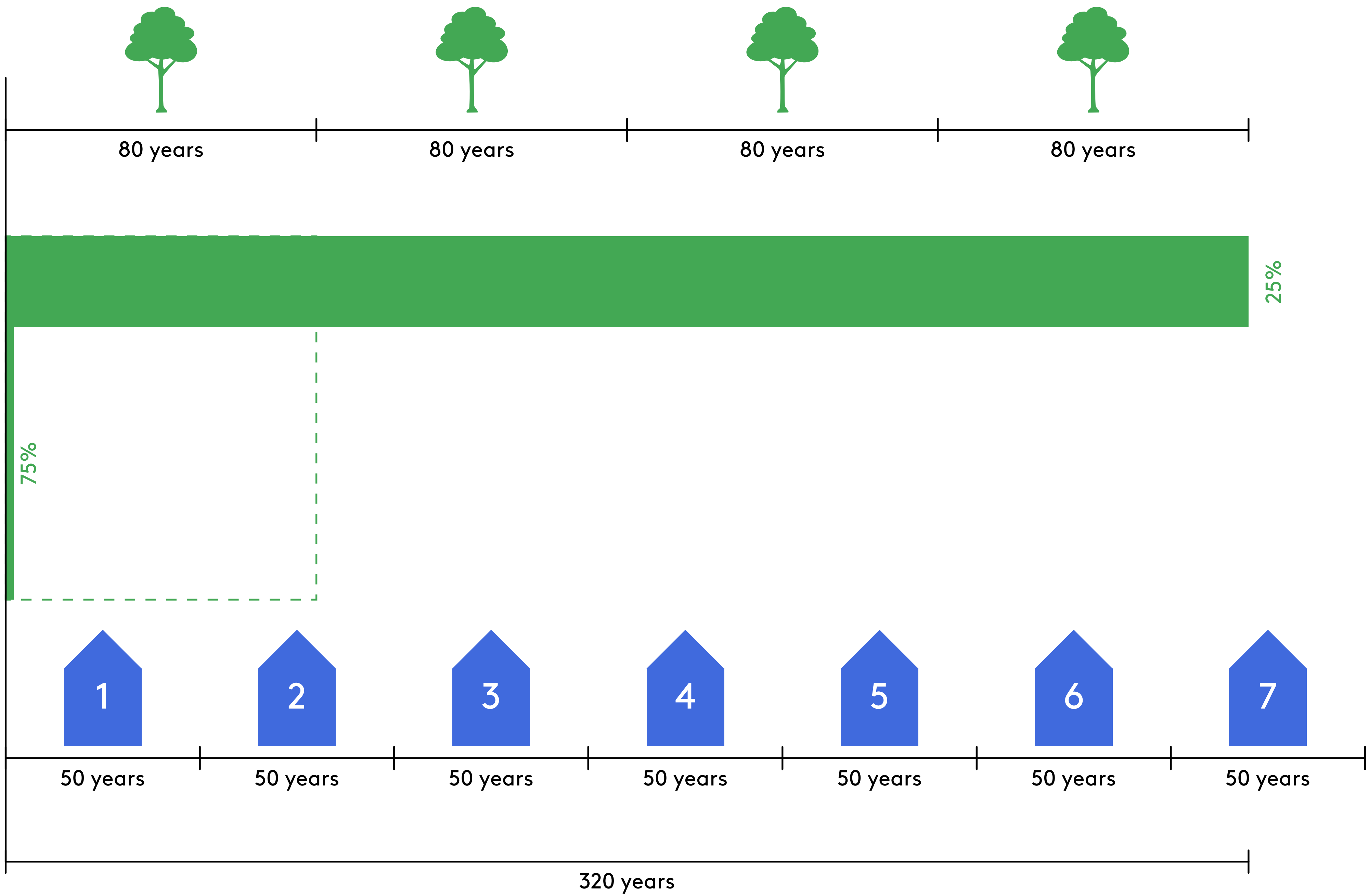
Swedish Wood- from log to plank. Accessed 03/09/21 at
https://www.swedishwood.com/wood-facts/about-wood/from-log-to-plank/

In Europe, 16Mt of construction and demolition wood waste is produced annually*

*Vis M., U. Mantau, B. Allen (Eds.) (2016) Study on the optimised cascading use of wood. No 394/PP/ENT/RCH/14/7689. Final report. Brussels 2016. 337 pages

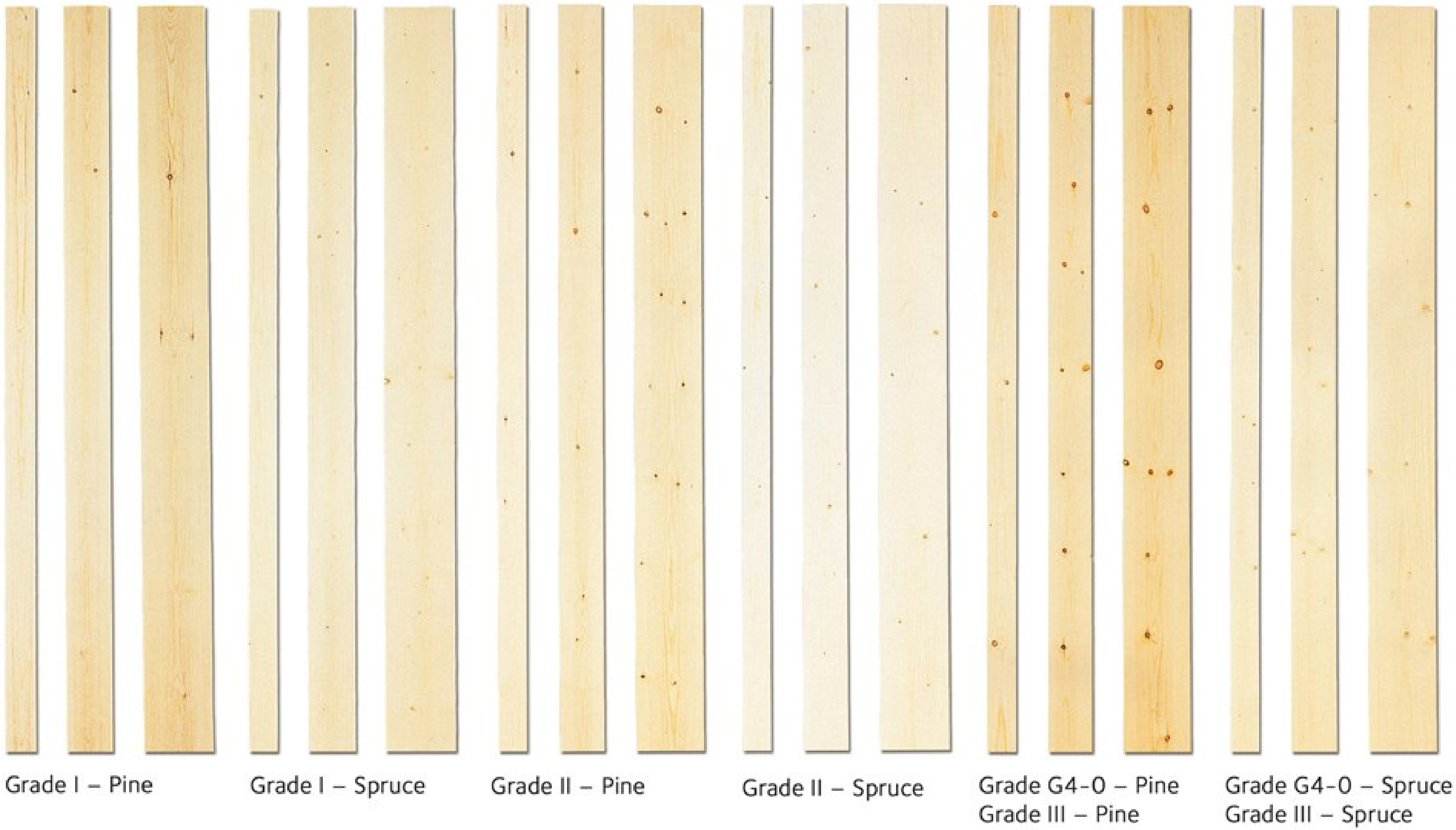

80 years
1 year


80 years
80 years
80 years

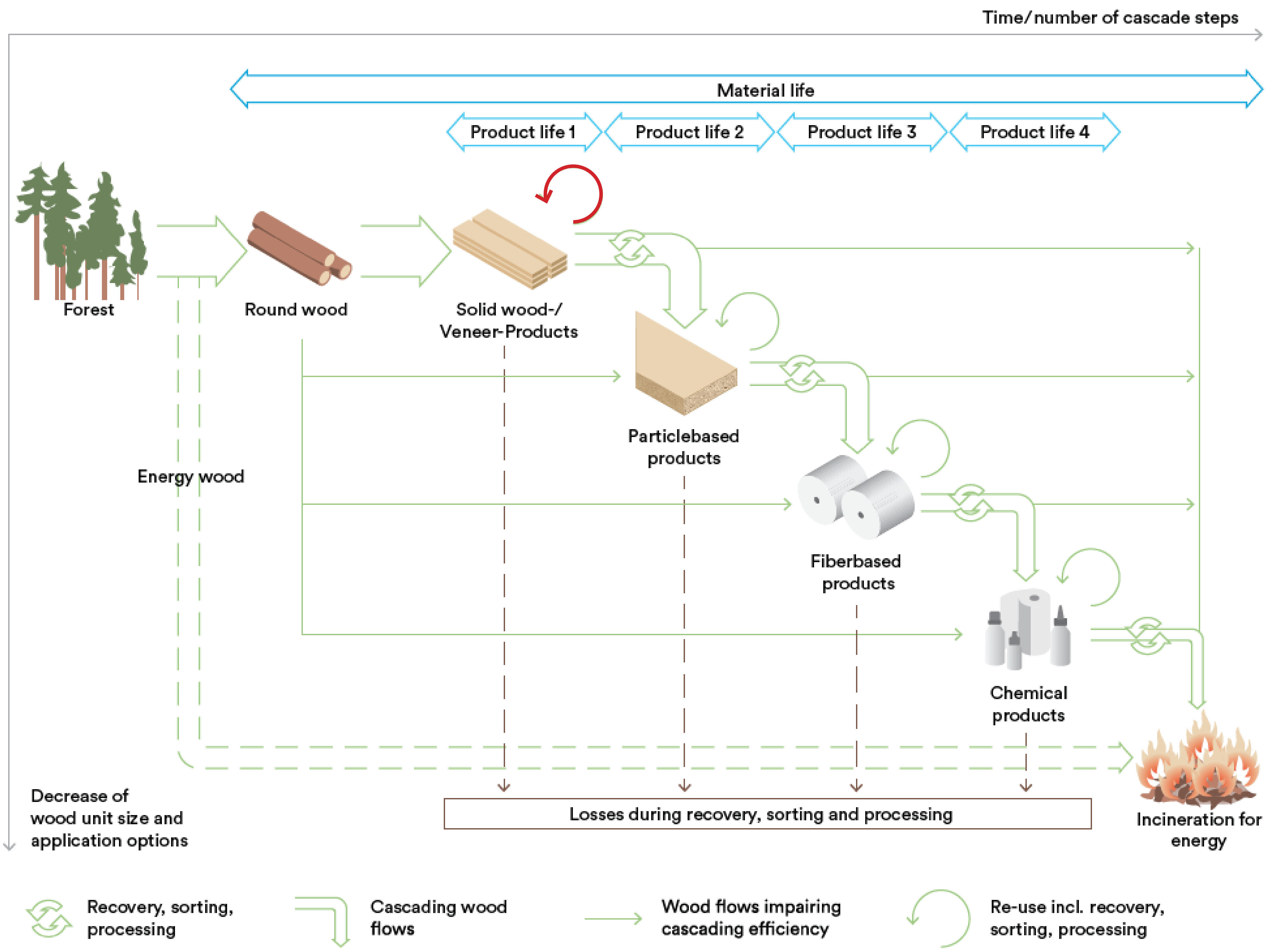


80 years
80 years
80 years
80 years
25%
75%
1
2
3
4
5
6
7
50 years
50 years
50 years
50 years
50 years
50 years
50 years
320 years

Appearance Grading



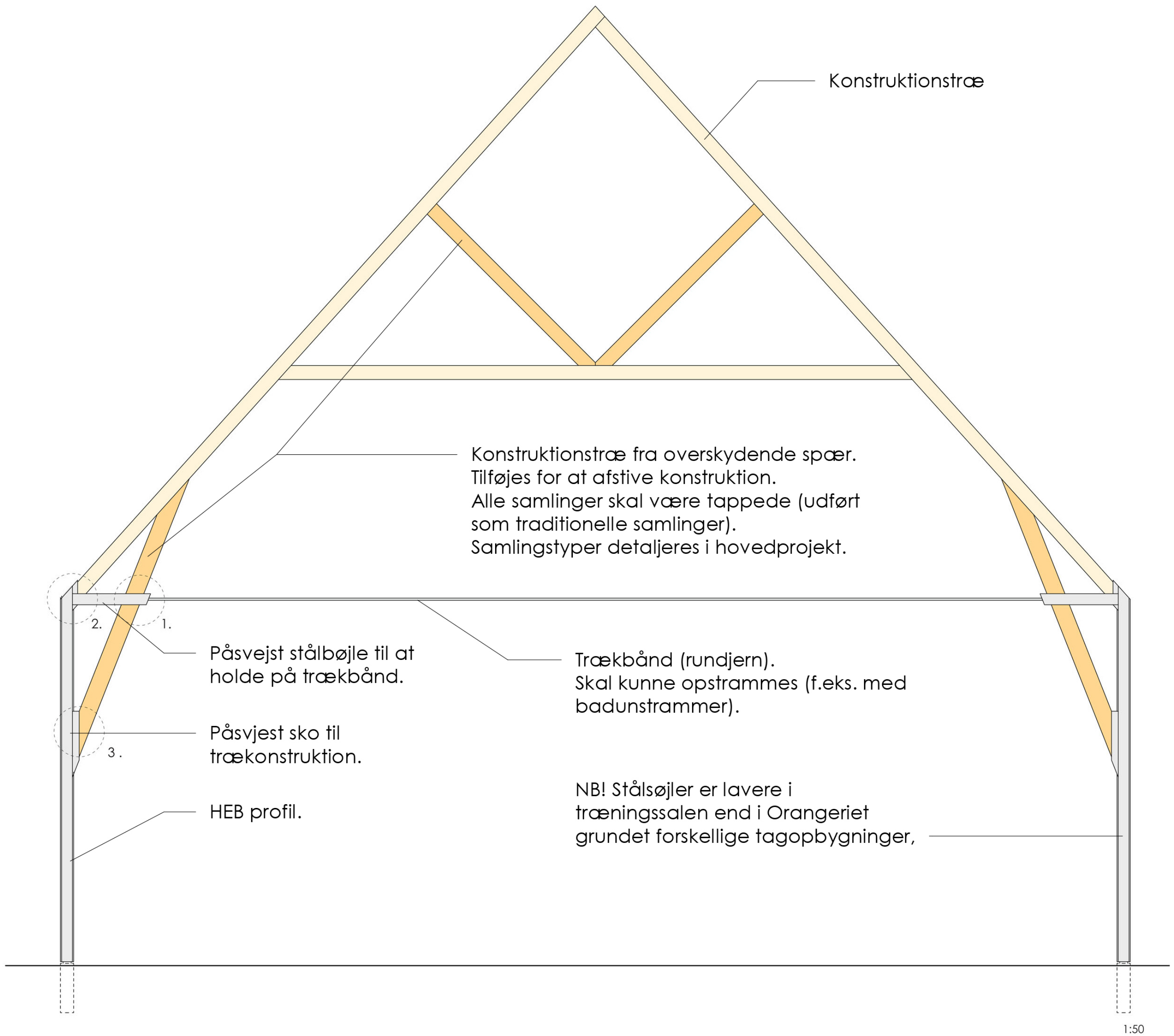
https://www.swedishwood.com/wood-facts/about-wood/wood-grades/

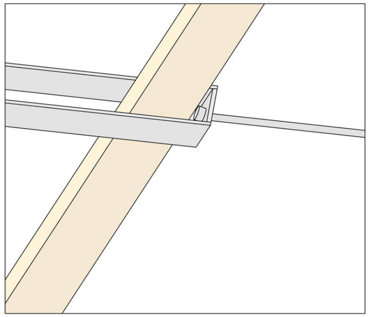


Biomass cascading. Höglmeier et al. 2015

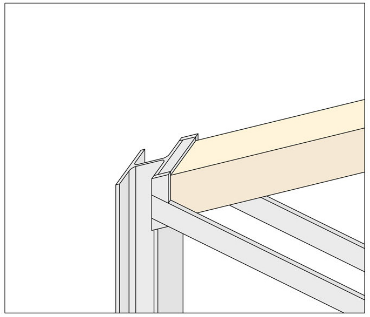
Gladsaxe Børnehuset, Lendager

Design Alterations

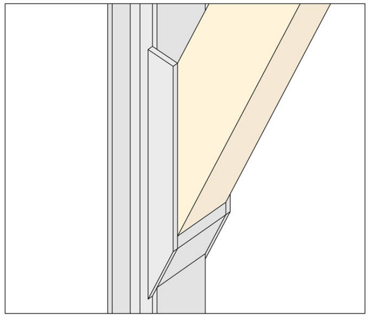




Principdetalje. 1.
Stålbøjle og trækbånd.

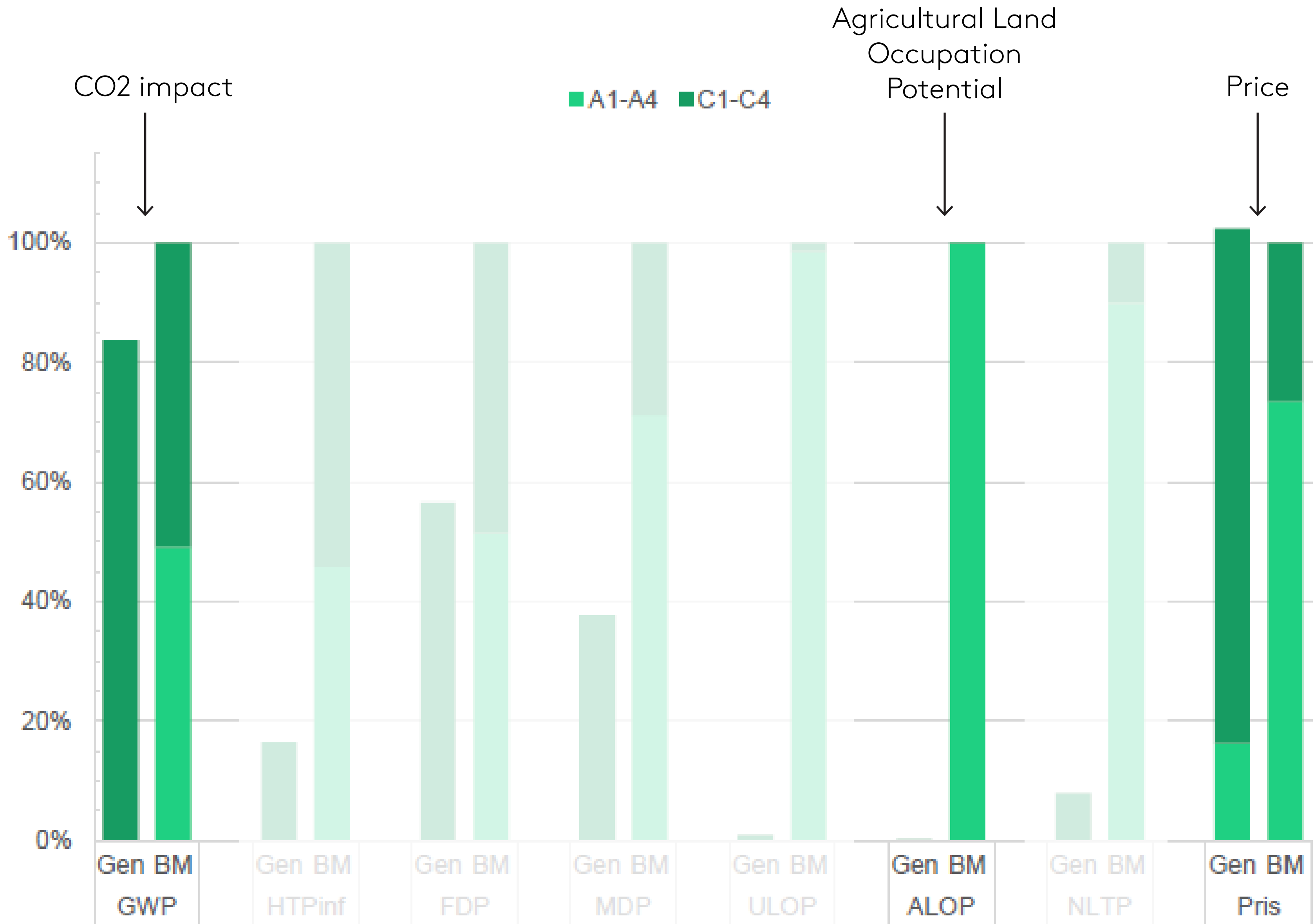


Principdetalje. 2.
HEB profil og stålbånd.



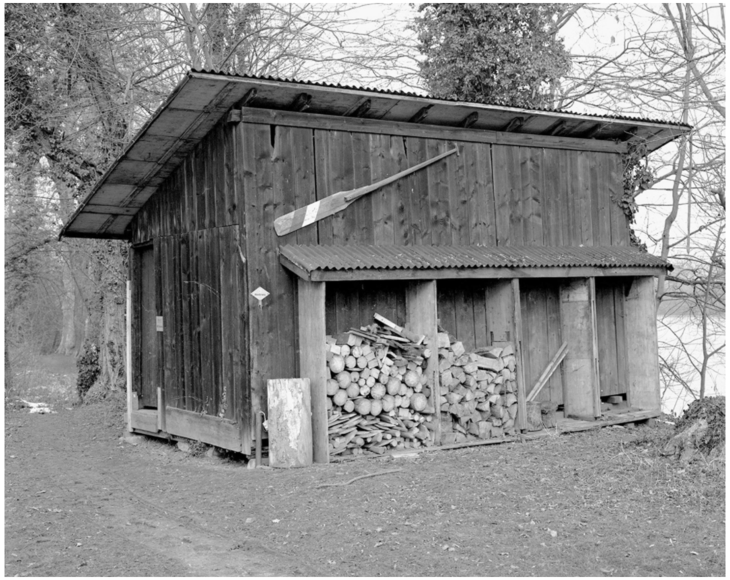
Principdetalje. 3.
Påsvejset sko omkring konstruktionstræ.

Impact Assessment



Based on the master thesis of Anders Ravn Stokbro from Denmarks Technical University

ShedBoatShed (mobile architecture number 2), Simon Starling



https://www.themoderninstitute.com/artists/simon-starling/works/shedboatshed-mobile-architecture-no-2-2005/88/

The Nordic Project

Nordic Timber Building Culture: a rich assortment of traditions and techniques

Stave Church, Norway

Image courtesy of: wikimedia.org

Typical vernacular house, Sweden

Image courtesy of: wikimedia.org

Half timbered house, Denmark

Image courtesy of: depositphotos.com

Timber covered market, Denmark

Image courtesy of: https://scandinaviantraveler.com/

Vernacular beam and column

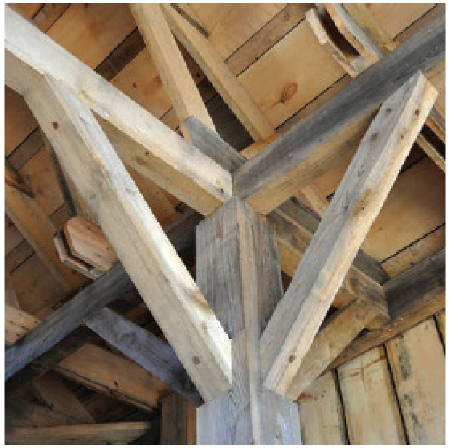


Image courtesy of: nordicforestresearch.org

Lantern Pavilion, Norway

Image courtesy of: archdaily.com

Brosenius construction, Sweden

Image courtesy of: solarhousehistory.com

Harbour buildings, Norway

Image courtesy of: globotreks.com

Waste Wood Streams and Types

Demolition waste

Image courtesy of davewomach.com

Glulam offcuts

Image courtesy of images.fordaq.com

High quality wood incorrectly

Image courtesy of maisondecour.files.wordpress.com

Cross laminated timber offcuts

Image courtesy of amstudio.com.au

Dismantled timber frames

Image courtesy of yr-architecture.com

Demolition waste

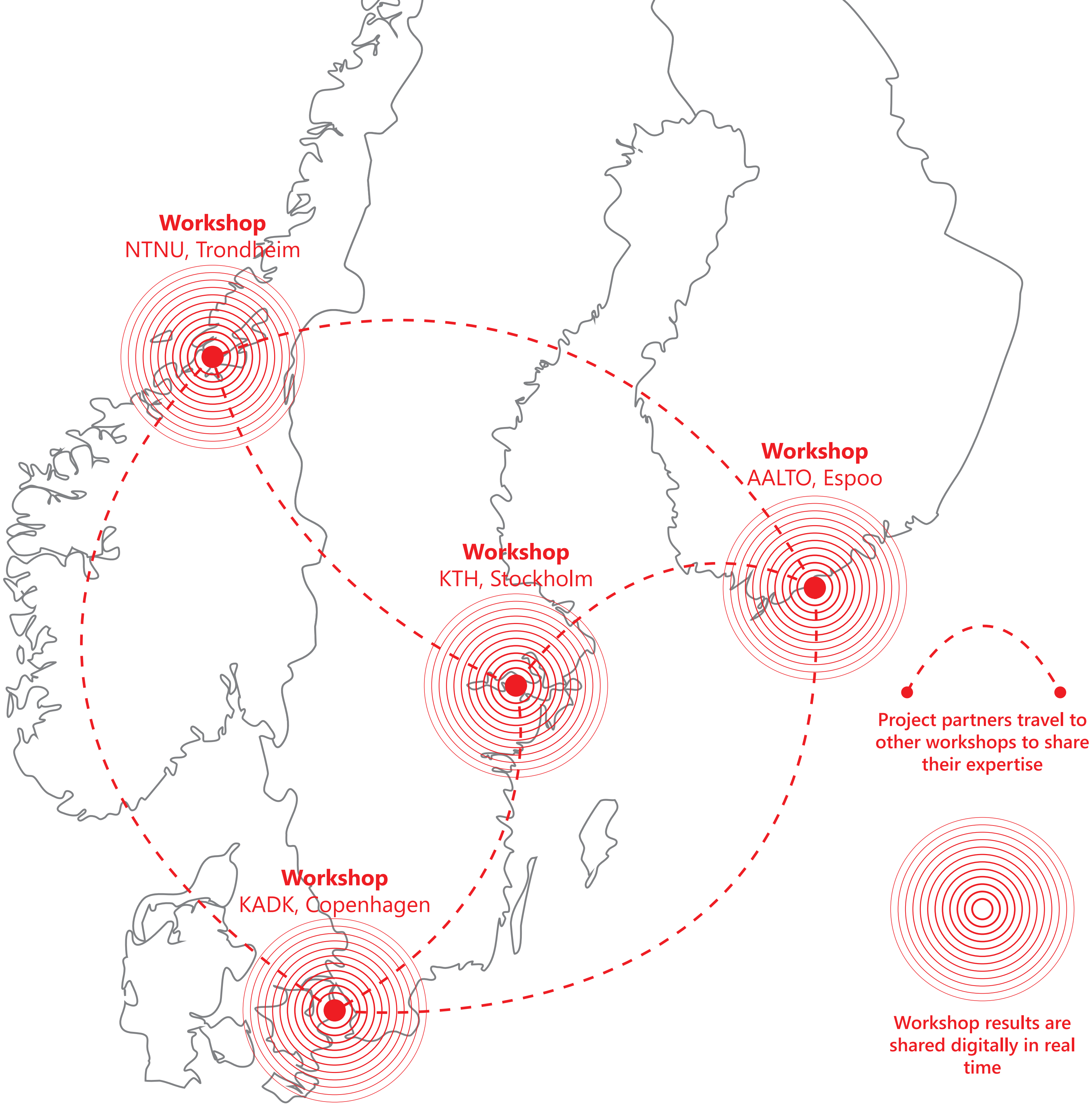
Image courtesy of timber-recycling.co.uk

General offcuts

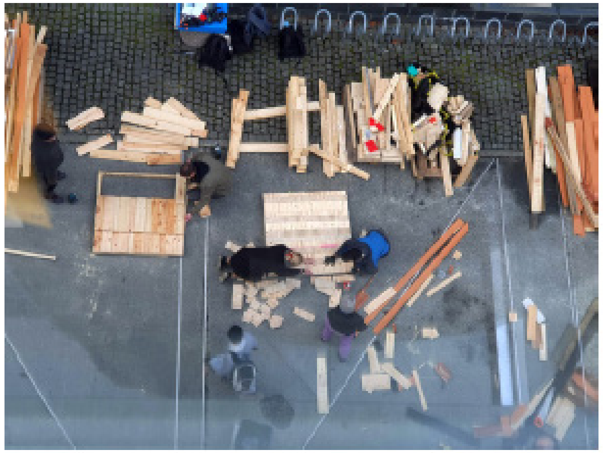
Image courtesy of manwithoutcountry.com

General waste timber

Image courtesy of mmm.com


Workshop
NTNU, Trondheim
Workshop
AALTO, Espoo
Workshop
KTH, Stockholm
Workshop
KADK, Copenhagen
Project partners travel to other workshops to share their expertise
Workshop results are shared digitally in real time

Workshop at NTNU, Trondheim- Lead by Pasi Aalto

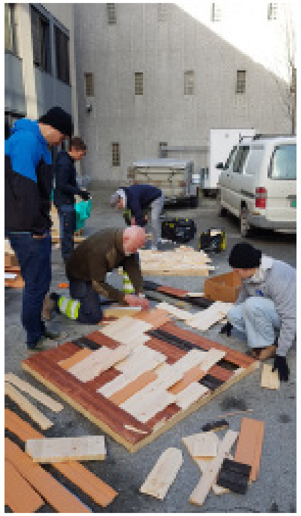


Berit Nilsen, Social Scientist

Pierre Bourdieu's three capitals
-Economic Capital
-Social Capital
-Cultural Capital

Hallvar Skogmo, Carpenter

Developing tongue and groove connections for short pieces



Marina Skanche, CE advisor

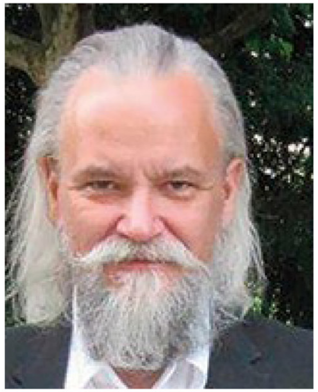
-Loopfront platform for registering information about waste materials locally





Workshop at The Royal Danish Academy, Copenhagen- Lead by Olga Popovic Larsen and Xan Browne

Magnus Wålinder
Professer @ KTH



Roberto Crocetti
Adjunct professer @ KTH

Göran Pohl
Professer @ HTW Saar


@nordicwastewoodforgood

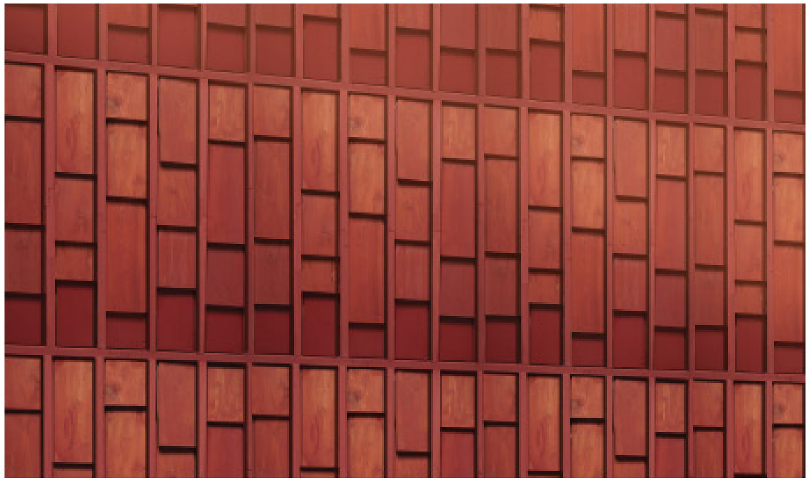


Figure 1/
Panel made from pine and accoya wood.

Figure 2/
Digital visual- istation.

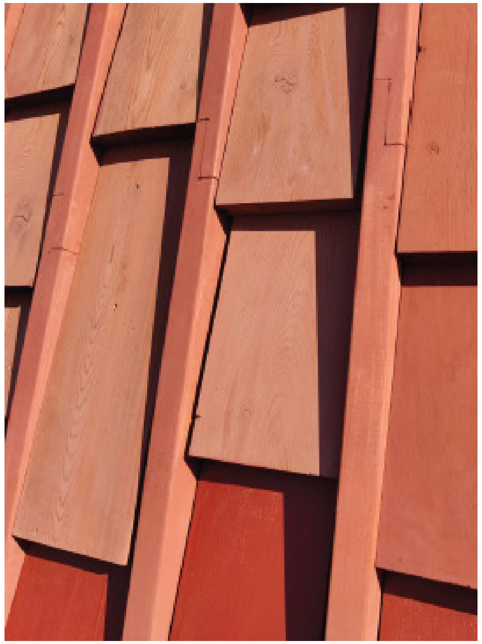


Figure 3/
Detail shot in sunlight.

Figure 4/
The pinewood used for the 'tiles'.

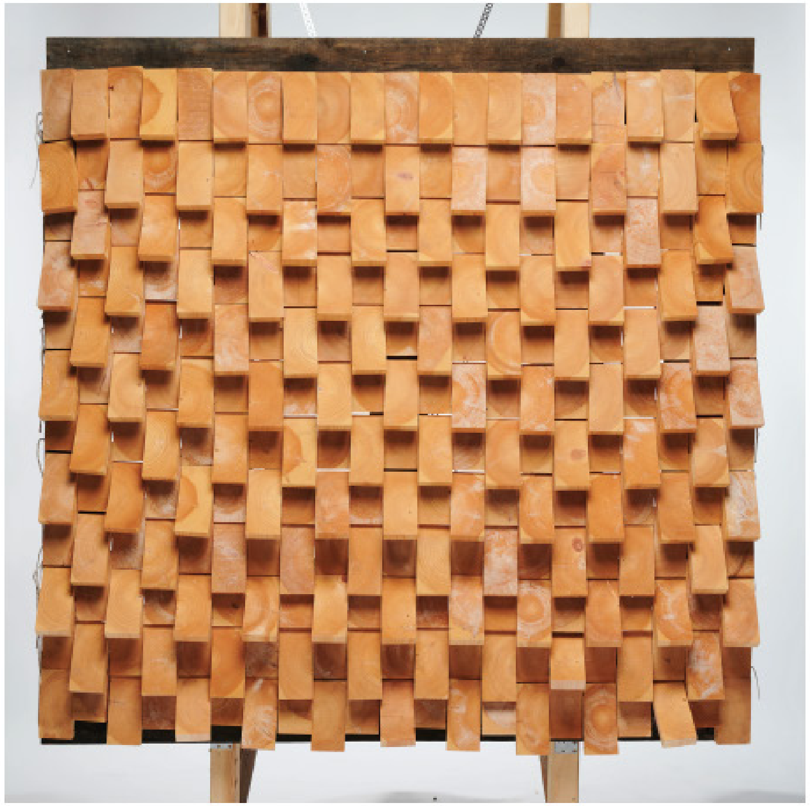
A NATURAL PAINT

This group decided to unify their waste wood with paint. Their point of depature was a red wooden warehouse in Copenhagen. The warehousehad differently sized boards, but the red colour tied the different widths together and gave the material a collective factor.

DRAWING ON TRADITION

The paint that the group used on the boards consisted of natural red pigments and a buttermilk glue. This type of glue, along with casein based glues have been used long before the invention of plastic binders. The paint on the bottom boards were enforced with a plastic based glue, as the bottom would recieve most weathering. This also created a dynamic between the two paints, as seen in figure 3.

The panel is a good example of how to balance biodegradable and non-biodegradable materials to maximize the qualities of both.v



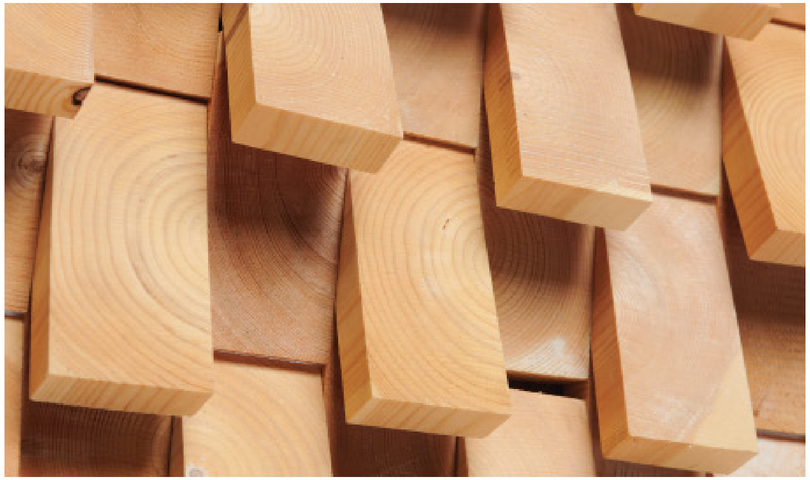


Figure 1/
Panel made from pine offcuts.

Figure 2/
Detail shot.

Figure 3/
Detail shot.

THREADED WOOD

This panel showcases an innovative way of joining many, smaller pieces of wood together. The small pine offcuts from danish window production have been tied together using a natural string, creating a textile-like effect.

At first glance the panel is like many of the others, a texture or structure, however this panel can move in both horisontal and vertical directions.

Application of this could be flexible partitions, where the panel is bent to form self-standing patterns and mounted on a support at certain points to keep upright.

Alternatively the panel could be bent outward and mounted on poles, to create shading or overhangs on facades.

Figure 1/
Panel made from reclaimed floorboards and accoya.

Figure 2/
Detail shot.

Figure 3/
Panel made from various offcuts.

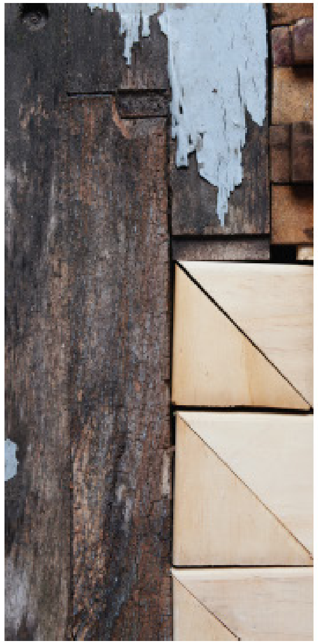
Figure 4/
Detail shot.

Figure 1/
Panel made from a reclaimed piece of wood and various offcuts.

Figure 2/
Detail shot.

Figure 3/
Detail shot.

Figure 4/
Detail shot.



PLUG AND PLAY

Searching for inspiration around Copenhagen, this group came upon an old piece of wood, possibly a door. The group decided to work with the idea of found or reclaimed wood and working filling in the gaps and crevaces found in the door.

ALL ABOUT OFFCUTS

Following the idea of found material, the group only used offcuts from other groups in the workshop. This resulted in a playful process where the group members sat around the fractured door and slowly came up with different shapes and structures based around what they had find. The process reulted in this expressive panel, which might not be easily scalable, however the process itself inspires a playful approach to creating a facade.

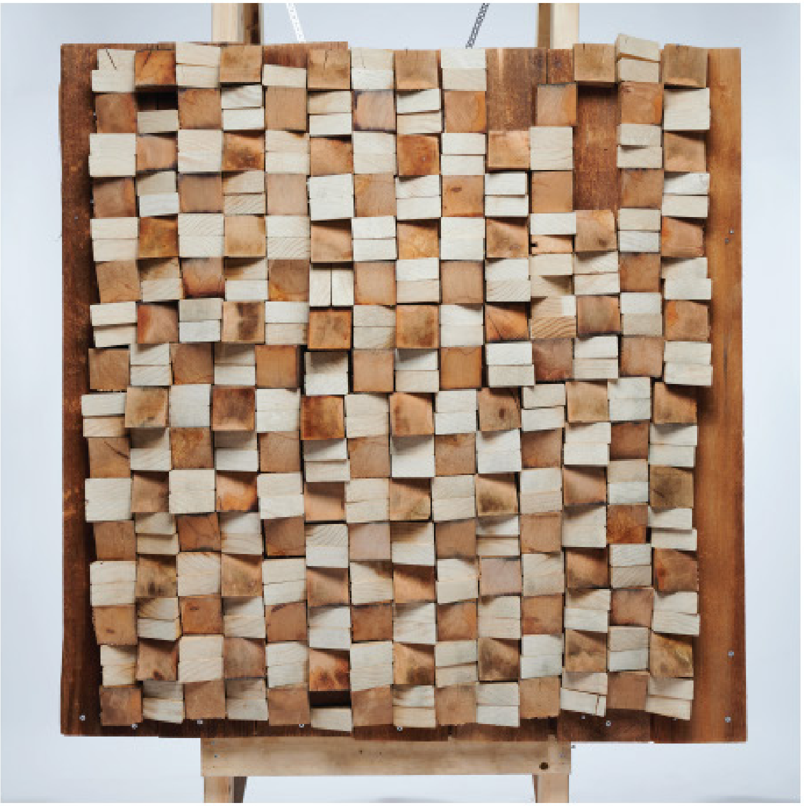


Figure 1/
Panel made from various offcuts.

Figure 2/
Detail shot.

Figure 3/
Panel made from reclaimed floorboards and accoya..

Figure 4/
Detail shot.

Figure 1/
Panel made from pine offcuts and reclaimed floor-boards.

Figure 2/
Detail shot.

Figure 3/
Panel, or insect hotel, made from various materials including accoya and reclaimed wood.

Figure 4/
Detail shot.

Figure 1/
Panel made from reclaimed floor-boards.

Figure 2/
Detail shot.

Figure 3-6/
How the panel opens up.

HOISTING

"Any architect dreams of hoisting something in their lifetime."
- Groupmember

This group was inspired by old warehouses with heavy wooden shudders and the way in which some fold onto themselves, rather than simply opening out.

What this allows for is a gradual opening process that also shades the opening. This application could work in spaces where direct sunlight can be an issue. This could be in offices, artist workshop or other places where UV damage could be an issue.

Furthermore, the incorporation of the shudder into the rest of the facade creates a seamless and coherent look both whilst open and closed. It makes the window feel incorporated rather than added to the facade.

Figure 1/
Panel made from reclaimed pine floorboards.

Figure 2/
Detail shot.

Figure 3/
Detail shot.

Figure 4/
Detail shot.

SELF SUPPORTED

Inspired by sheet pile walls and their corrugated structure, this group set out to create a self supported panel.

The panel consists of rows of joined cut up floorboards that then stack onto each other with no permanent fastening.

This makes it possible to dis-assemble and reassemble the panel. Applications for this could be at festivals or other places where a selfsupported wall needs to stand temporarily. With minor tweeks this structure could also be fastened at the ground, mak-ing it a fairly robust wall.

Visually the wall plays well with a common issue with reclaimed floorboards, being the inconsist-ency of finish. The group used white painted pieces to break up the pattern created by the struc-ture and in some places lined up the paint, which achieves a more wholistic and less random look.

Figure 1/
From the Copenhagen workshop

Figure 2/
From the Copenhagen workshop

Architecture and (Waste) Wood Agency

Cambio, Formafantasma

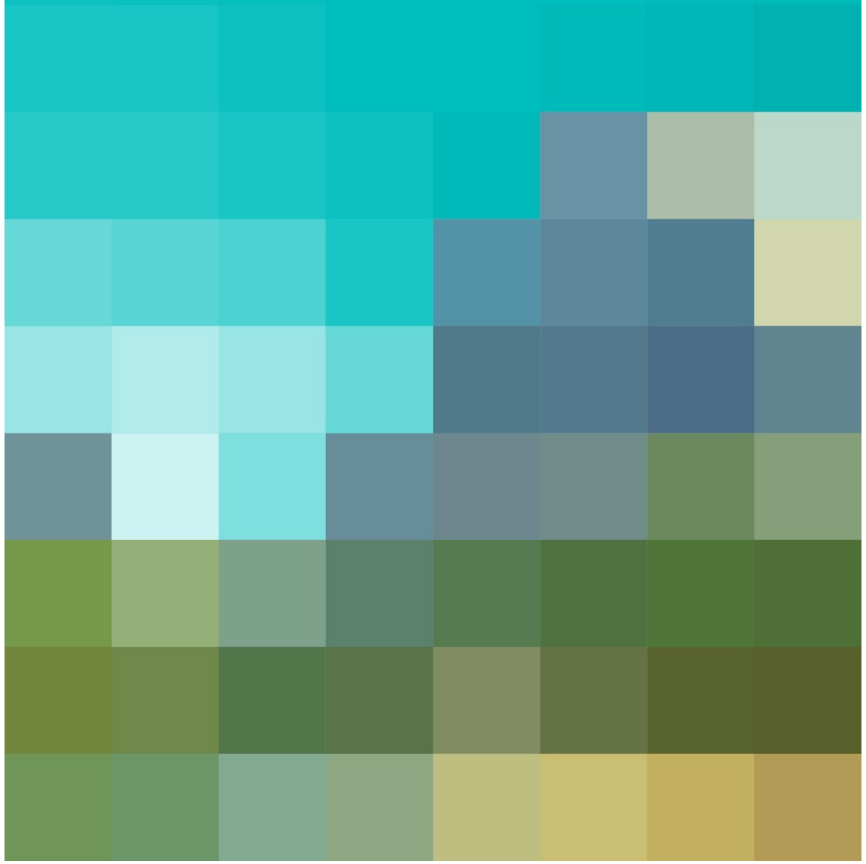
cambio.website

A PELICAN BOOK

Being Ecological

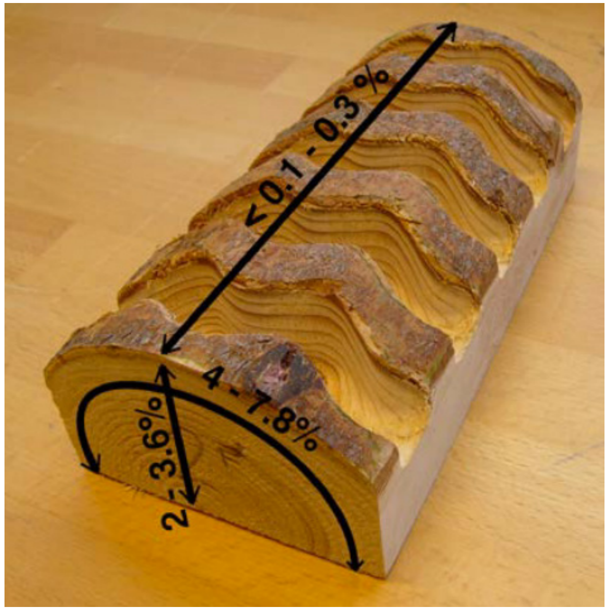
Timothy Morton

‘I have been reading Tim’s books for a while and I like them a lot’ BJÖRK

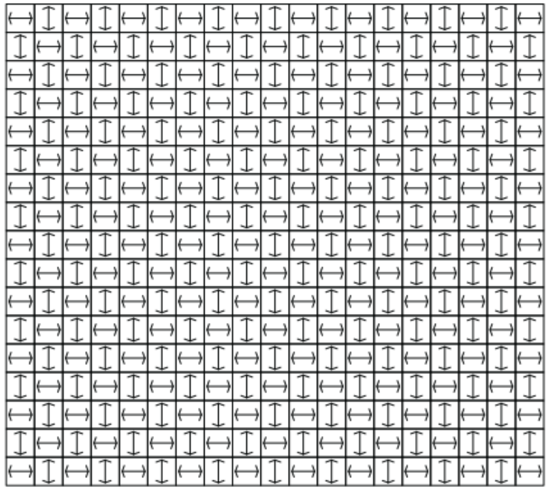


Cross Laminated Timber (CLT)

BackToBack, Marcin Wójcik



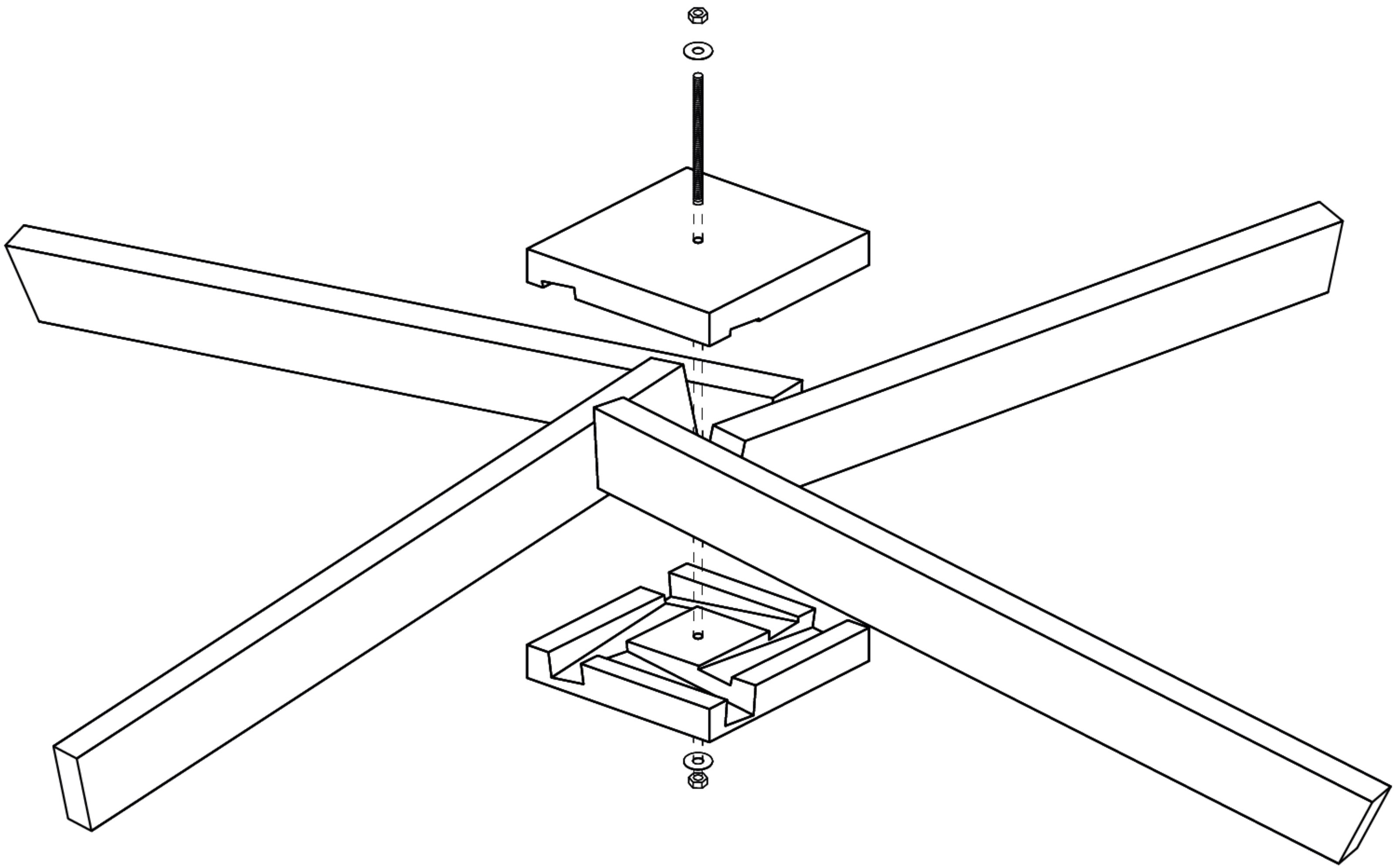
Swelling Vault, Marcin Wójcik

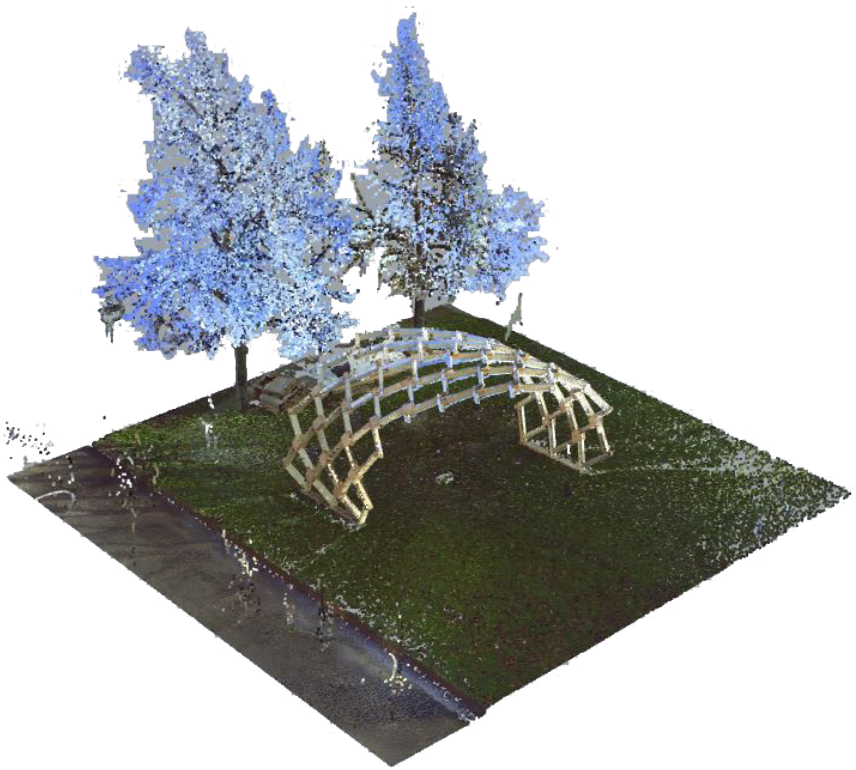


Wood Chip Barn, Hooke Park

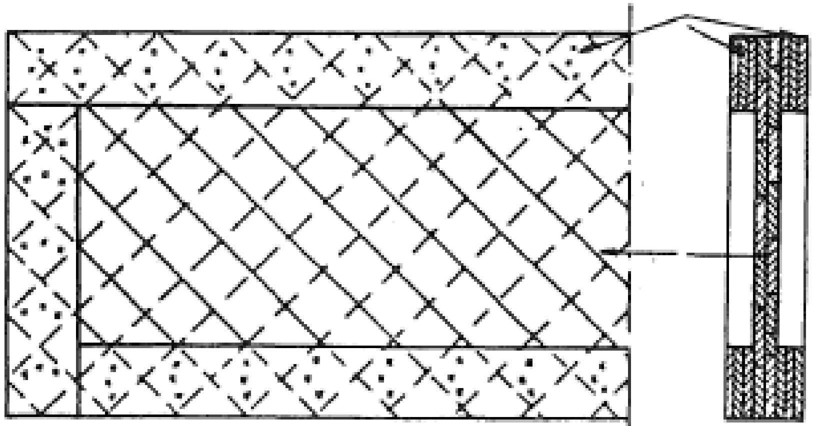
*Vis M., U. Mantau, B. Allen (Eds.) (2016) Study on the optimised cascading use of wood. No 394/PP/ENT/RCH/14/7689. Final report. Brussels 2016. 337 pages

Waste wood canopy

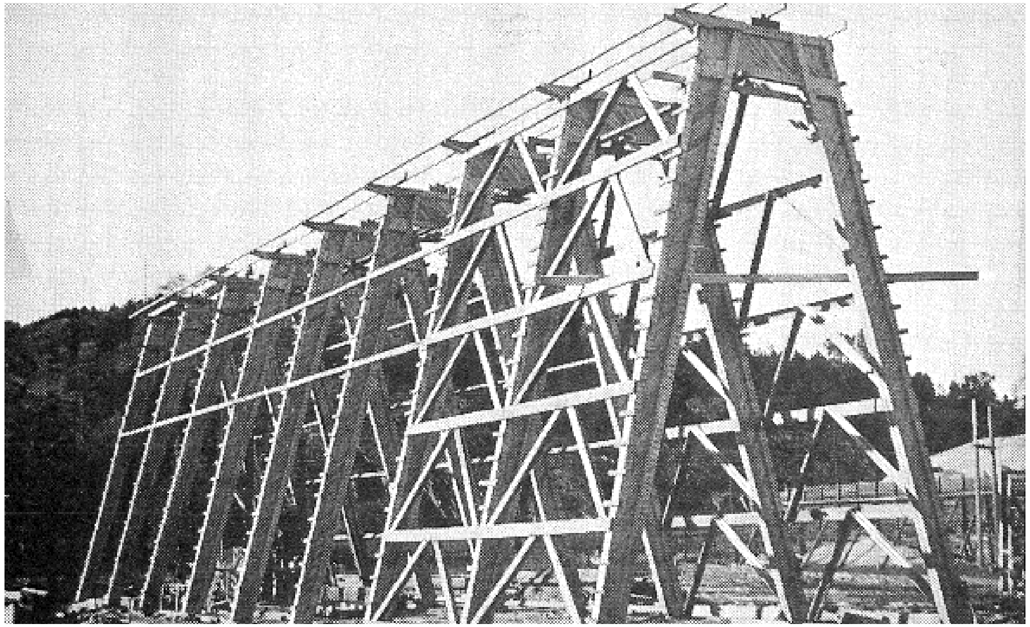


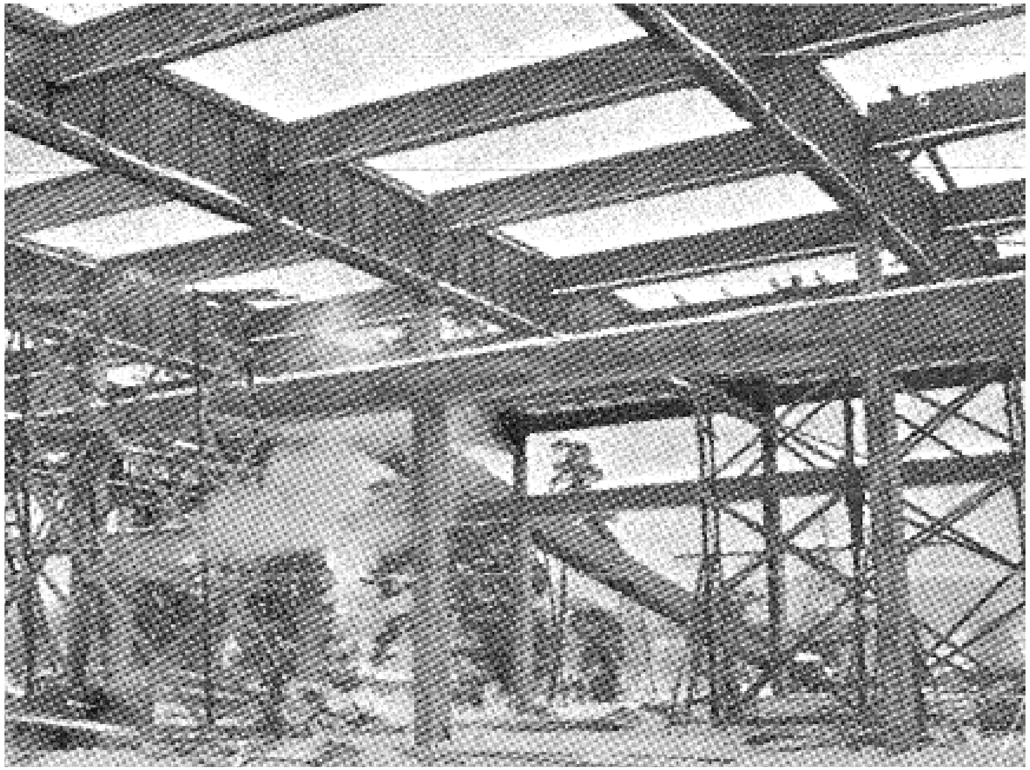


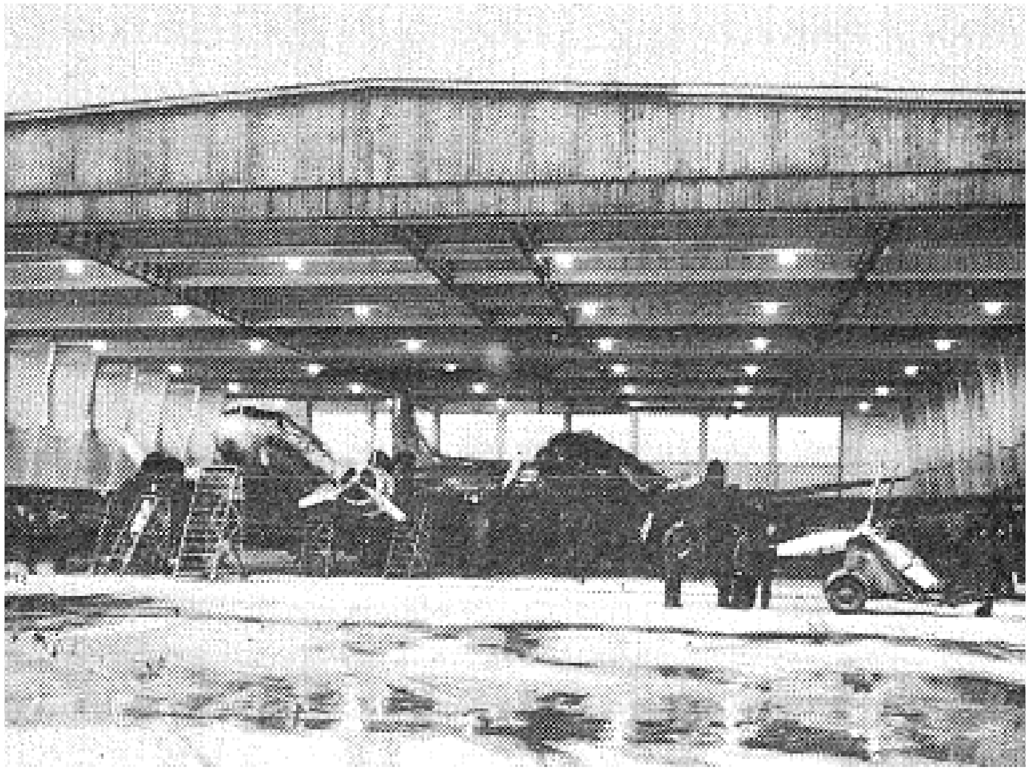
“HB-Balken”, Hilding Brosenius Beam



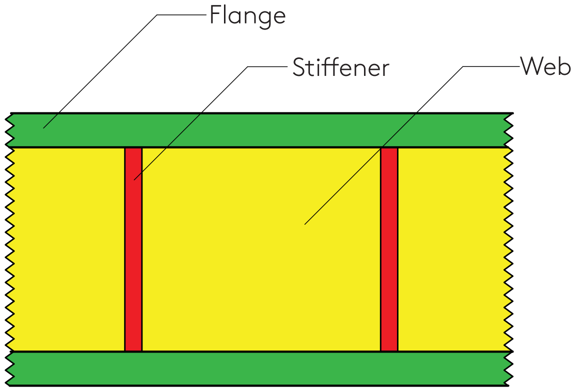
Beam elevation and section

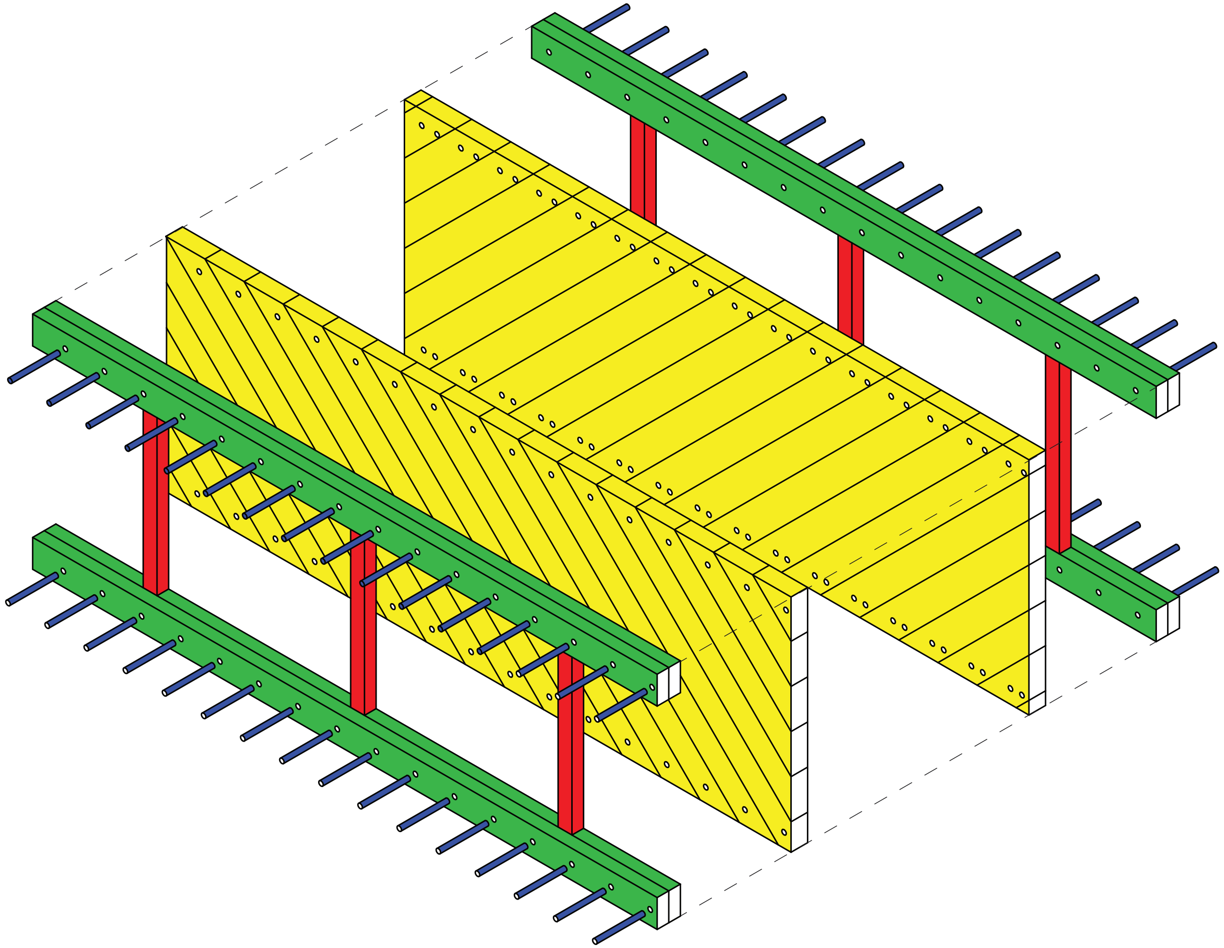


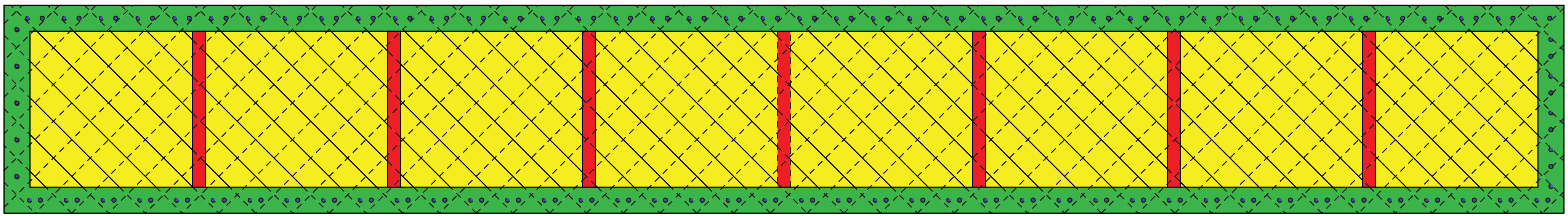




Beam parts

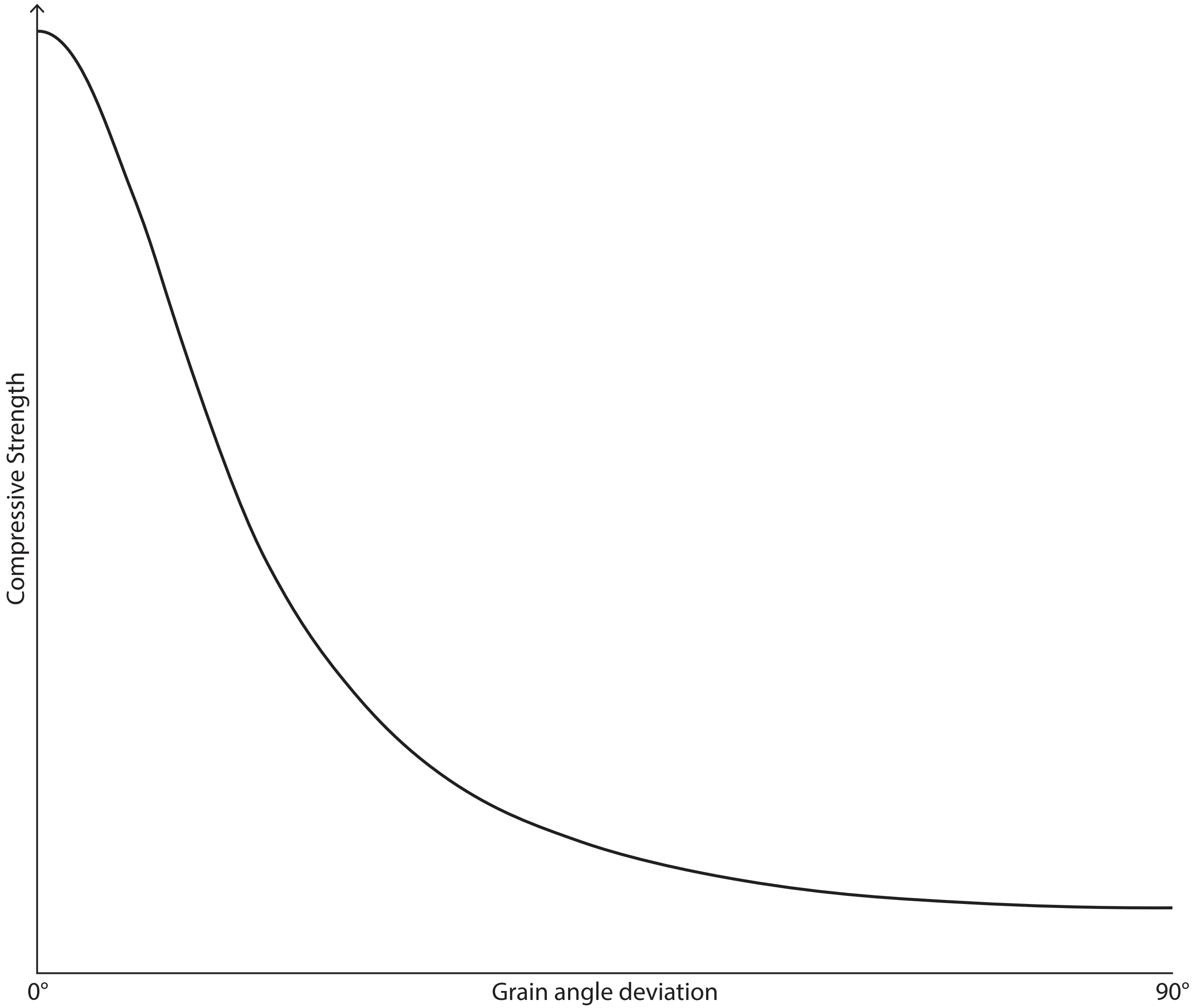




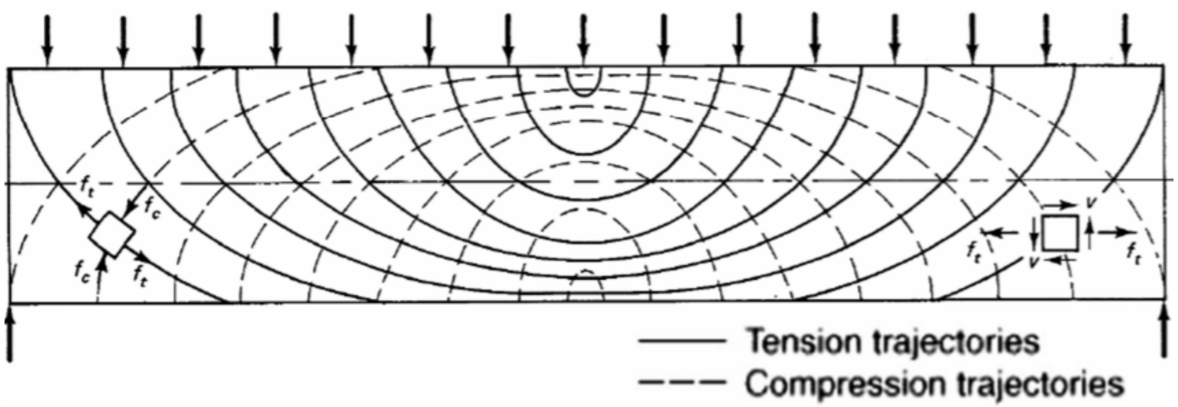


Elevation

Hankinson's equation, 1921



Topology optimised isotropic beam



Principle stress trajectories in an isotropic beam

Standard

Specific

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