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A plea for the efficient use of wood in construction

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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.

The dilemma: sustainable supply

The defossilization of the global construction sector is a key issue in combating climate change. To meet the Paris Agreement goals, the global building materials sector must halve its emissions by 2030 and must become net zero by 2050. This is especially important as landowners and policymakers strive to create a climate-friendly living space for the projected additional 2.5×10^9 urban residents by 2050 (ref. [1]).

The ability of wood to reduce the environmental impact of the building sector has long been part of the public debate[2]. Several landmark projects (such as the Ascent tower in the USA, currently the tallest timber structure in the world, 87 m tall; the Mjøstårnet building in Norway, 85 m; the HoHo tower in Austria, 84 m; and the Sara Kulturhus Centre in Sweden, 75 m) have successfully demonstrated that wood-based construction materials are a suitable alternative to steel and concrete and can pave the way to turn urban environments from a carbon source to a carbon sink[3].

Modern engineered wood products like cross-laminated timber are experiencing rapid market growth and are becoming increasingly popular with architects and planners. As a result, the market share of wood-based building materials is poised to increase in the coming decades[3]. According to a recent study[3], the additional demand for wood in construction could reach 1.36 gigatons of carbon per year until 2050, assuming that 90% of new mid-rise urban buildings (4–12 storeys) in countries with both high and low industrialization levels will be designed with wood-based materials (the “90% timber” scenario[3]). Supposing that one ton of wood stores 500 kg of carbon and that the used materials have an average density of 450 kg m^{-3}, the additional round wood demand would reach 6.1×10^9 m^3 annually. This demand significantly exceeds the current annual global round wood production, which is approximately 3.9×10^9 m^3 (1.98×10^9 m^3 industrial and 1.92×10^9 m^3 fuel wood)[4], potentially adding pressure to the already fluctuating supply of sustainable building materials.

In addition to the building sector, the demand for natural textile fibres, sustainable packaging and biochemicals as well as thermal and electric energy is also poised to rise in the coming decades. Already, about 50% of the world’s annual round wood supply is directly used for energy purposes[4]. After the recent United Nations climate conference (COP 27), where participating countries underlined the need for a clean energy mix, this share could further increase. In the European Union (EU, including Great Britain), for example, the annual demand for fuel wood could increase from 0.12×10^9 m^3 in 2020 (ref. [4]) to 0.43×10^9 m^3 by 2030 (ref. [5]), which corresponds to almost the entire EU round wood supply of 2020 (ref. [4]) (0.51×10^9 m^3).

Adding to this, the ongoing adaptation of forests caused by climate change will lead to a shift from a few dominant conifers (softwoods) towards a wider range of potentially more resilient deciduous (hardwood) tree species[6]. This change is predicted to cause a severe loss in the economic value of forests due to the varying productivity of different wood species[7]. The situation is further complicated by the fact that the wood industry in industrialized nations is predominantly optimized for homogeneous softwood assortments and can only partially process the more complex hardwoods. This will compound the pressure on the wood value chain and will probably create a round wood supply dilemma of yet unknown dimensions.

The solution: efficient materials

Against this background, it becomes clear that the renaissance of wood in urban construction will require a significant increase in productivity of the wood-based sector and a strategic re-thinking of the large-scale energy-first utilization of forest biomass in general, and of industry co-products in particular. Currently, this extensive re-direction of raw materials from one-time use (such as energy) to long-term use cycles (such as building products) appears to be an enormous challenge in view of the energy crisis in Europe and the general dependency on firewood in developing countries. However, there is already a viable way forward. We present four key opportunities to better meet the projected demand for wood in urban construction and dampen the pressure on the wood value chain.

First, the resource efficiency of products must be incorporated into the decision-making process of industry stakeholders, landowners, architects and planners. Available engineered wood products for construction are predominantly manufactured based on sawmilling, veneer peeling or log stranding, and the resource efficiency of the final product strongly depends on the process (Fig. 1). In addition, sawmilling and veneer peeling require uniform logs with bigger diameters compared with log stranding, which can process inhomogeneous logs with smaller diameters. It is clear that the broad material-first utilization of all kinds of wood assortments requires an intelligent mix of available processing technologies, for example, by combining sawmilling and stranding in a single process. In this way, the construction industry could not only maximize the efficient use of forest resources but also free up additional raw material for other applications.

Second, the material efficiency of existing material concepts must be optimized. Currently, most building materials are optimized for an efficient industry throughput, accepting a certain material excess (for example, material-intensive solid glued laminated timber beams versus labour-intensive truss structures). Components are

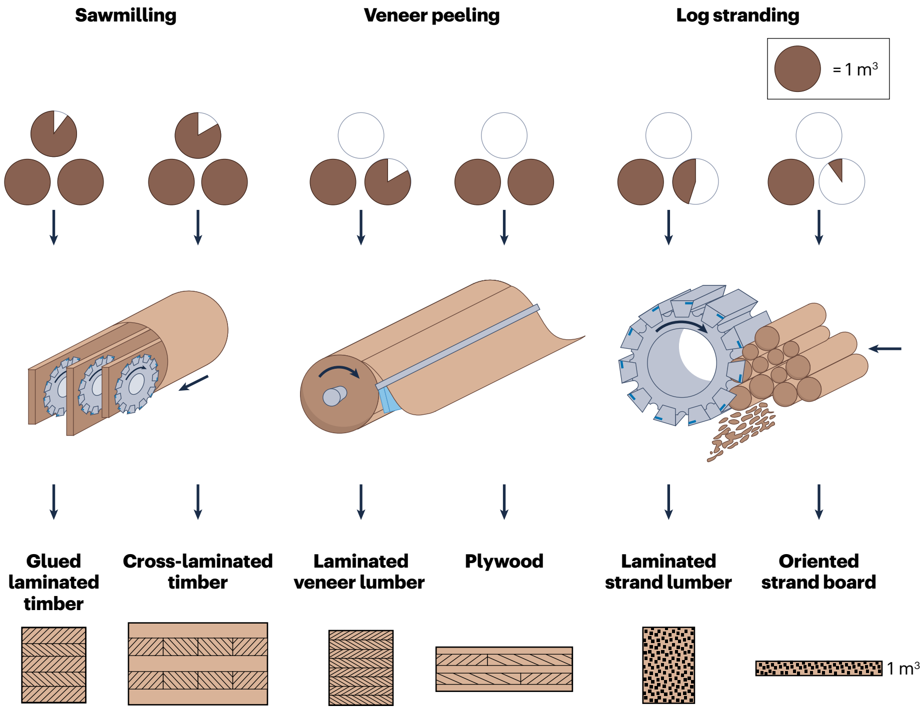

Fig. 1 | Resource demand of established engineered wood products. Estimated amount of round wood (without bark) required to produce 1 m^3 of glued laminated timber, cross-laminated timber, laminated veneer lumber, plywood, laminated strand lumber or oriented strand board.

not dimensioned based on the actual stress distribution within the application, but rather based on the largest load, and have a constant cross-section throughout. This often leads to a substantial amount of excess material in certain areas, which unnecessarily increases the required amount of raw material. To overcome this issue, the external shape and internal structure of the material could be optimized based on the application-specific local load conditions[8].

Third, new material concepts that can add value to low-quality forest resources and co-products of existing process streams must be developed. For example, the use of non-uniform branches and stem tops could create a new form of engineered product, as these low-value assortments can account for up to 50% of a tree's above-ground biomass[9] but are currently hardly used in materials. From a technological point of view, it should be possible to process them into structural materials. Furthermore, the utilization of co-products like sawdust or wood chips could help new processing technologies (such as 3D printing) to gain a foothold in the wood industry[10].

Finally, the cooperation between publicly funded basic and applied research and industry focusing on the technological potential of climate-resilient tree species for structural building purposes must be intensified. Compared with the currently dominant softwoods like spruce, pine and fir, future hardwoods like beech, oak and poplar feature a much more inhomogeneous property profile due to their different anatomical and chemical structure. Closing technological knowledge gaps will improve the suitability of hardwoods for construction applications and potentially prevent loss of economic value[7].

Outlook

The material-first utilization of wood in structural building materials, with the possibility to recycle the wood at the end of a building's life, will be the key to successfully transform the building sector into a long-time carbon storage. It will be up to policymakers to decide on the sustainable distribution of the available raw materials, and to the scientific community to support the industry and the public with environmentally friendly material concepts.

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Competing interests

The authors declare no competing interests.