buildings

MDPI

Review

Current Market Landscape and Industry Voices in Key Timber Construction Markets

Libo Yan [1,2,*], Raoul Klingner [2], Ahmad Al-Qudsi [1,2], Haoze Chen [1] and Junaid Ajaz Dand [1]

[1] Department of Organic and Wood-Based Construction Materials, Institute for Building Materials, Concrete Construction and Fire Safety, Technische Universität Braunschweig, Hopfengarten 20, 38102 Braunschweig, Germany; alqudsi86@hotmail.com (A.A.-Q.); haoze.chen@tu-braunschweig.de (H.C.); junaid-ajaz.dand@tu-braunschweig.de (J.A.D.)

[2] Fraunhofer Institute for Wood Research Wilhelm-Klauditz-Institut WKI, Riedenkamp 3, 38108 Braunschweig, Germany; raoul.klingner@wki.fraunhofer.de

* Correspondence: l.yan@tu-braunschweig.de or libo.yan@wki.fraunhofer.de

Abstract

The global timber construction market is experiencing steady growth, driven by increasing demand for sustainable building solutions, advancements in engineered timber technologies, and supportive policy frameworks. This study provides an overview of the global market for timber construction. Current status and industrial perspectives of the key timber construction markets from Australia, the United States, Austria, Switzerland, Finland, Sweden, Germany, and the SUDOE region (Southwest France, Portugal and Spain) are discussed and summarized. It was found that key markets such as Europe, North America, and Australia are leading this shift in the construction of more timber buildings, with growing numbers of mid- and high-rise timber projects. Industry voices highlight both the opportunities, such as carbon reduction, reduced construction times, and timber design benefits, and the challenges, including supply chain limitations, cost competitiveness, building code restrictions, and a need for broader industry education. Collaboration across architects, engineers, developers, and policymakers is emphasized as essential to scaling mass timber adoption in mainstream construction practices.

Keywords: timber construction; market status; industrial voices; challenges

check for updates

Academic Editors: Igor Martek and Mehdi Amirkhani

Received: 8 August 2025
Revised: 4 September 2025
Accepted: 6 September 2025
Published: 18 September 2025

Citation: Yan, L.; Klingner, R.; Al-Qudsi, A.; Chen, H.; Dand, J.A. Current Market Landscape and Industry Voices in Key Timber Construction Markets. *Buildings* **2025**, *15*, 3381. https://doi.org/10.3390/buildings15183381

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

The built environment is a significant contributor to global greenhouse gas emissions, accounting for nearly 40% of annual CO_2 emissions through building operations and material production [1]. As the urgency to address climate change intensifies, architects, engineers, and policymakers are increasingly seeking sustainable alternatives to traditional construction materials such as concrete and steel. Timber, particularly engineered wood products like cross-laminated timber (CLT), glue-laminated timber (glulam), and laminated veneer lumber (LVL), has emerged as a promising low-carbon alternative due to its renewable nature, carbon storage capacity, and reduced embodied energy [2].

Timber's environmental advantages extend beyond carbon storage. Timber harvesting, when managed sustainably, supports reforestation and responsible forestry practices, contributing to the sequestration of atmospheric CO_2 over the lifecycle of a forest stand [3]. Moreover, modern timber construction enables prefabrication, reducing onsite construction waste and noise pollution, and allowing for faster project timelines compared to conventional methods [4]. However, timber is not without challenges; concerns about fire safety,

durability, and sourcing sustainability must be addressed through rigorous engineering, certification, and responsible forest management [5–7].

Over the last 20 years, timber construction has evolved from primarily low-rise residential and small-scale commercial buildings to include mid- and high-rise structures, reshaping urban skylines. This transition has been enabled by advancements in engineered timber products, improved connection systems, and growing confidence in timber's structural performance. Iconic projects such as the 18-story Mjøstårnet in Norway (completed in 2019) and the 25-story Ascent tower in the United States (completed in 2022) illustrate the expanding possibilities of timber high-rise design [8,9], as illustrated in Figure 1.



Figure 1. The 18-story and 85.4 m tall Mjøstårnet in Norway (**left**) (original author: NinaRundsveen) [10,11] and the 25-story and 86.6 m tall Ascent tower in the United States (**right**) (timber supplier: WIEHAG, photographer: Flor Projects LLC) [12] (permission granted).

Europe, particularly the Nordic countries, Austria, and Switzerland, has led the timber construction movement, driven by strong environmental policies and a tradition of timber craftsmanship. North America has followed closely, with recent changes to the International Building Code (IBC) in the United States enabling taller timber buildings up to 18 stories [13]. Australia, Canada, and Japan are also emerging markets, showcasing growing interest in mass timber construction. Despite these advancements, the global market for mass timber remains a niche segment compared to concrete and steel. Its growth has been constrained by factors such as limited manufacturing capacity, inconsistent building codes, and a lack of widespread industry expertise [14]. Nonetheless, as sustainability targets become more stringent and the building industry seeks climate-positive solutions, the trajectory of tall timber buildings is expected to continue upward.

Recent research has highlighted the environmental benefits and technical feasibility of mass timber construction, including reduced embodied carbon, improved life-cycle

performance, and the successful realization of mid- and high-rise buildings across Europe, North America, and other regions [2,6,14]. Studies also emphasize the role of policy frameworks, forest resource management, and engineering innovations in shaping market development. However, most existing work has focused on either material performance or individual case studies, with fewer studies comparing how market dynamics, regulatory environments, and stakeholder perspectives interact across different regions. Building on these findings, the present study aims to synthesize current market trends and industry voices from key timber construction regions—including Europe, North America, Australia, and the Asia-Pacific region—providing a comparative perspective on opportunities and barriers. By doing so, this work contributes to filling the gap between material/technical research and market-level analyses and proposes insights that can guide future research, policy development, and industrial strategies for scaling up sustainable timber construction.

1.1. Objectives of This Study

Recent research has underscored the environmental benefits and technical feasibility of mass timber construction, showing its capacity to reduce embodied carbon, improve life-cycle performance, and support mid- and high-rise projects across Europe, North America, and beyond [2,6,14]. Policy frameworks, sustainable forest management, and engineering innovations have further shaped its development. Yet, much of the literature remains focused on material properties or isolated case studies, with limited cross-regional comparisons of market dynamics, regulatory environments, and stakeholder perspectives. As timber construction moves from pilot projects to broader adoption, understanding these variations is essential: forestry resources, regulatory conditions, cultural acceptance, and technical expertise differ widely across regions. Building on these insights, the present study synthesizes market trends and industry voices from key timber construction regions, including Europe, North America, Australia, and the Asia-Pacific region, offering a comparative perspective on opportunities and barriers. In doing so, it bridges material-level research with market-level analysis and provides guidance for future research, policy frameworks, and industrial strategies to advance sustainable and scalable timber construction.

1.2. Research Approach and Methodology

This study adopts a scoping review methodology to examine the current status and industry perspectives of mass timber construction across key global markets. A scoping review was chosen because it allows for the structured integration of heterogeneous sources, academic research, government reports, and industry publications, as well as interviews with industrial stakeholders, while identifying research gaps and future directions. The methodological process followed four main steps: (1) literature identification and selection includes peer-reviewed articles, policy and regulatory documents, and industrial and market reports; (2) data extraction and synthesis considers the collection of information on market status, regulatory and policy context, industrial adaption and perceived barriers and opportunities; (3) thematic analysis and gap identification includes analysis of results of regional case studies (Australia, United States, Austria, Switzerland, Sweden, Finland, Germany, SUDOE region, Norway, Canada, China and Japan) to highlight similarities and differences; and (4) the authors' own interviews with German industrial stakeholders to discuss individual building cases.

By integrating diverse evidence sources, this study contributes not only to documenting current market trends but also to framing research and policy priorities for advancing timber construction for sustainable built environments.

2. Market Perspective and Industry Voices Towards Timber Construction

2.1. Global Market Overview

The global mass timber construction market has expanded steadily over the past decade. In May 2023, Allied Market Research released a report [15] on the global timber construction market. It indicates that in 2021, the global mass timber construction market had a revenue of USD 857.1 million and is projected to reach USD 1542.2 million by 2031, reflecting a compound annual growth rate (CAGR) of 6.0% from 2022 to 2031 [15]. This outlook aligns with other analyses suggesting rapid growth from a still modest base; for example, a recent industry roadmap estimated the current global mass timber market at around USD 1.6–2.3 billion [16]. Several key drivers are fueling this market expansion. Increasing awareness of the high carbon footprint of conventional concrete and steel construction has spurred interest in timber as a low-carbon alternative [17]. Additionally, there is growing demand for construction methods that are more cost-efficient yet durable compared to steel and concrete [15]. Engineered wood systems can meet stringent structural and fire safety requirements [18] and are often cost-competitive when factoring in faster assembly and lighter foundation needs [19].

However, the market's growth is still being constrained by the high installation costs associated with timber components (such as roofing) and issues related to timber decay [20]. On the other hand, the carbon storage potential (approximately 0.9 t CO_2 stored per 1 m^3 timber utilization [21]) as well as employer satisfaction in office buildings are increasingly incorporated in the cost–benefit analysis of mass timber buildings. Additionally, it is expected that the emerging economies, such as China and India, create substantial chances for market expansion [15].

2.1.1. Timber Buildings with 1–8 Stories Segment to Keep Leadership from 2022 to 2031

With respect to building height, the low- to mid-rise segment (1–8 stories) represented nearly 66% of global mass timber market revenue in 2021 and is expected to retain its leading share through 2031 [15]. This dominance reflects the fact that most completed mass timber buildings worldwide remain under 8–10 stories [22]. Developers and owners have shown a strong preference for this range, as the relatively low weight of timber reduces foundation and seismic design demands, thereby lowering overall construction costs [19]. In particular, the use of wood-frame or panel systems in mid-rise construction has proven to be more cost-effective than heavier alternatives [15]. Evidence from North America underscores this trend: by 2023, more than 1750 mass timber projects in the United States had been completed or were in development, the vast majority within the low- and mid-rise categories [23]. In contrast, the high-rise segment (above eight stories), while still a smaller portion of the market, is projected to expand most rapidly, with a compound annual growth rate of 7.5% from 2022 to 2031 [15]. This acceleration is being fueled by an increasing number of tall timber projects and landmark towers in both developed and emerging economies. Recent updates in building codes—for example, the 2021 International Building Code [13] permitting wood buildings up to 18 stories—have further catalyzed the design and construction of taller timber structures [18]. Although tall mass timber buildings currently account for only several hundred projects worldwide, prominent cases such as the 25-story Ascent tower in Milwaukee and the 18-story Mjøstårnet in Norway, as mentioned above, have demonstrated technical feasibility and stimulated global interest. This momentum underpins the strong growth forecast for the 8+ story segment.

Regarding timber type, the CLT segment accounted for the largest market share in the year of 2021, capturing about 40% of the global timber construction market. This segment is expected to continue leading the market throughout the forecast period, largely because CLT is versatile and used in a wide range of structures, including houses, high-rise office

buildings and residential apartment buildings. Meanwhile, the nail-laminated timber (NLT) segment is foreseen to exhibit the highest CAGR of 8.3% between 2022 and 2031. NLT is an older but resurging technology consisting of dimensional lumber nailed together, and its growing popularity can be attributed to several factors. First, NLT assemblies can achieve fire-resistance ratings that comply with local fire codes, easing approval in jurisdictions with strict combustibility requirements [15]. Second, NLT is often seen as a cost-competitive alternative to CLT for certain applications [19]. Additionally, since NLT can be fabricated using standard lumber and nails without specialized adhesives or presses, it offers potential cost savings and simpler fabrication.

2.1.2. Residential Building Segment to Maintain Leadership from 2022 to 2031

In 2021, the residential building sector dominated the timber construction market, accounting for over 50% of global revenue. This segment is projected to retain its leading role through 2031, supported by robust activity in the housing market, which makes up about half of the total mass timber products used in new single-family and multi-family homes. Glulam, among other materials, is commonly used in these projects to achieve long spans without intermediate support, especially in components like bridge decks and floor beams. But the commercial sector is expected to experience the highest CAGR of 8.1% in the period from 2022 to 2031. The expansion of low-rise nonresidential and multi-story buildings, particularly in North America and Europe, is driving an increased demand for mass timber products [15].

2.1.3. Europe to Maintain Market Dominance Through 2031

Regionally, Europe had the largest market share revenue in 2021, contributing to over 50% of the global market revenue. The region is expected to continue its dominance throughout the estimated period. The increase in Europe is largely driven by government initiatives aimed at promoting sustainability and the increasing adoption of eco-friendly construction materials. For example, the European Commission's climate strategies explicitly encourage the use of wood in construction as a means to store carbon and substitute for high-emission materials [24]. However, the LAMEA region (such as Latin America, the Middle East, and Africa) is projected to experience the fastest CAGR of 18.6% during the forecast period, fueled by an increase in construction activities, industrialization, and an increased focus on sustainability initiatives [15].

2.2. National and Regional Perspectives

Overall, the global market perspective in the previous section highlights both the untapped growth potential of tall timber and non-residential applications and the continuing barriers of high upfront costs and regulatory challenges. These dynamics provide important context for the following country- and region-specific analyses. In this section, insights into the national and regional market perspective and industry viewpoints from key timber construction markets, including Australia, the USA, Sweden, Finland, Germany, the SUDOE region (Southwest France, Portugal and Spain), Norway, New Zealand, China and Japan, are presented.

2.2.1. Australia

The Clean Energy Finance Corporation (CEFC), often referred to as Australia's 'green bank', has spent the past decade investing in emission reduction efforts throughout the economy. It collaborates with co-investors, businesses, industries, and government bodies to support Australia's goal of achieving net-zero emissions by 2050. In February 2022, the CEFC introduced a Timber Building Program with a budget of AUD 300 million, designed to promote the application of timber construction in Australia through customized debt

financing for qualifying projects. On 16 December 2023, during COP28 in Dubai, the "Forest and Climate Leaders Partnership Coalition on Greening Construction with Sustainable Wood" agreed that, along with 16 other nations, Australia has pledged to boost the use of timber in construction by 2030 [25].

In Australia, adoption of mass timber building is not as advanced as in more established markets like Europe and North America. It was reported that in Australia, the forests and plantations captured and stored around 57 million tons of CO_2 until 2021, which accounts for approximately 10% of total GHG emissions in the year 2020 in the country [26]. IndustryEdge's analysis of the CLT market in Australia indicates that the market was approximately 50,000 cubic meters annually in 2020, with a rapid increase to over 80,000 cubic meters by the end of 2022. Current domestic production meets about 40% of this demand, with the rest being imported [26].

Australia's commercial building sector is known for its competitiveness and has incorporated efficiencies through the use of precast concrete and steel. Despite this, mass timber has not seen widespread adoption, primarily due to fire safety and structural standards. Prior to the NCC 2016 revision, these standards restricted the utilization of mass timber products to structures no taller than three stories under 'Deemed-to-Satisfy' provisions. The limitation required the performance solutions approach, which involved an extra design period, costs, and higher approval risks. In addition, the sector of residential building, characterized by many smaller builders, is fragmented and tends to follow the prescriptive AS1684 standard [27] for buildings up to three stories. It does not commonly pursue performance-based outcomes as outlined in AS1720 [28] (which includes provisions for GLT and LVL but no provisions for CLT) or refer to other standards like Eurocode 5 [29].

The adoption of mass timber products for medium-to-large-scale building projects in Australia is constrained by several factors. One key issue is that the cost savings from decreased labor and shorter construction times are often not included in project feasibility evaluations, leading to the perception that mass timber has higher upfront costs compared to traditional materials based on a 'bill of quantities' approach. Additionally, the limited experience of builders with mass timber products and hesitance from financial institutions and insurers to back off-site prefabrication further hinders its widespread adoption. Although mass timber offers significant advantages over traditional construction methods—such as embodied carbon savings, enhanced productivity from faster construction, reduced physical impact on the site, and enhanced site safety—the level of adoption and increase seen in Europe as well as in North America has yet to be mirrored in Australia [30].

How to change the mass timber market in Australia demands a comprehensive and collaborative approach across various sectors. At this moment, certain initiatives are addressing the barriers to mass timber adoption in Australia.

Regulation: Building standards greatly influence material choices and construction methods. The updated National Construction Code (NCC) better supports the utilization of mass timber products in mid-rise buildings up to 25 m in height [31].

Disclosure: Measuring embodied carbon and collecting relevant data are crucial for benchmarking. Rating tools have a key role in promoting consistency and encouraging positive market behavior. The Green Building Council of Australia has introduced the Responsible Products Framework [32,33]. Some Australian states are also implementing policies that require measurement and reporting of embodied emissions for residential and commercial developments [34].

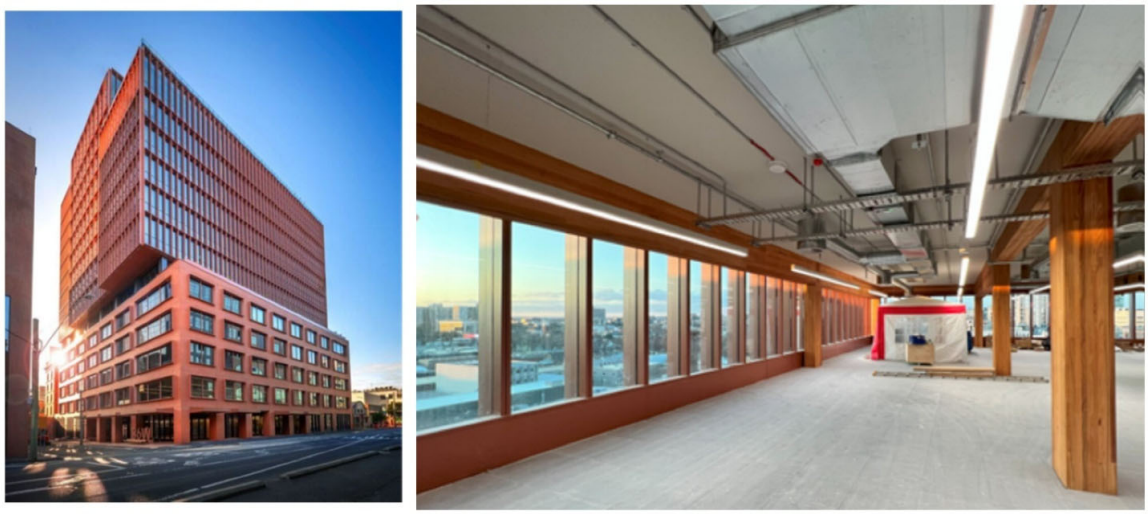
Partnership with industry: Cooperation among industry stakeholders helps identify and address broad challenges while providing feedback to inform policy and regulation. For instance, the Materials and Embodied Carbon Leaders' Alliance, which includes over

100 industry partners such as the CEFC, serves as a think tank with a shared goal of decarbonization [35].

Education: Building professionals' confidence in adopting new materials and methods can be significantly boosted by enhancing technical knowledge. For instance, Forest & Wood Products Australia Limited, through its WoodSolutions program, offers comprehensive professional services to Australia's forest and timber products industry, the building and construction sectors, and the other communities.

Supportive capital: Financial investment is crucial for advancing the timber construction market. The Clean Energy Finance Corporation (CEFC) supports mass timber projects through its Timber Building Program, helping to demonstrate the benefits of mass timber construction and stimulate domestic market development programs [30,34].

In September 2022, the CEFC successfully implemented its inaugural finance package under the Timber Building Program, contributing to the T3 Collingwood project—a 63 m tall timber building in Melbourne (Figure 2).



(**a**) (**b**)

Figure 2. T3 Collingwood project—a 63 m tall timber building in Melbourne: (**a**) Building outlook and (**b**) mass timber floor [36] (permission granted).

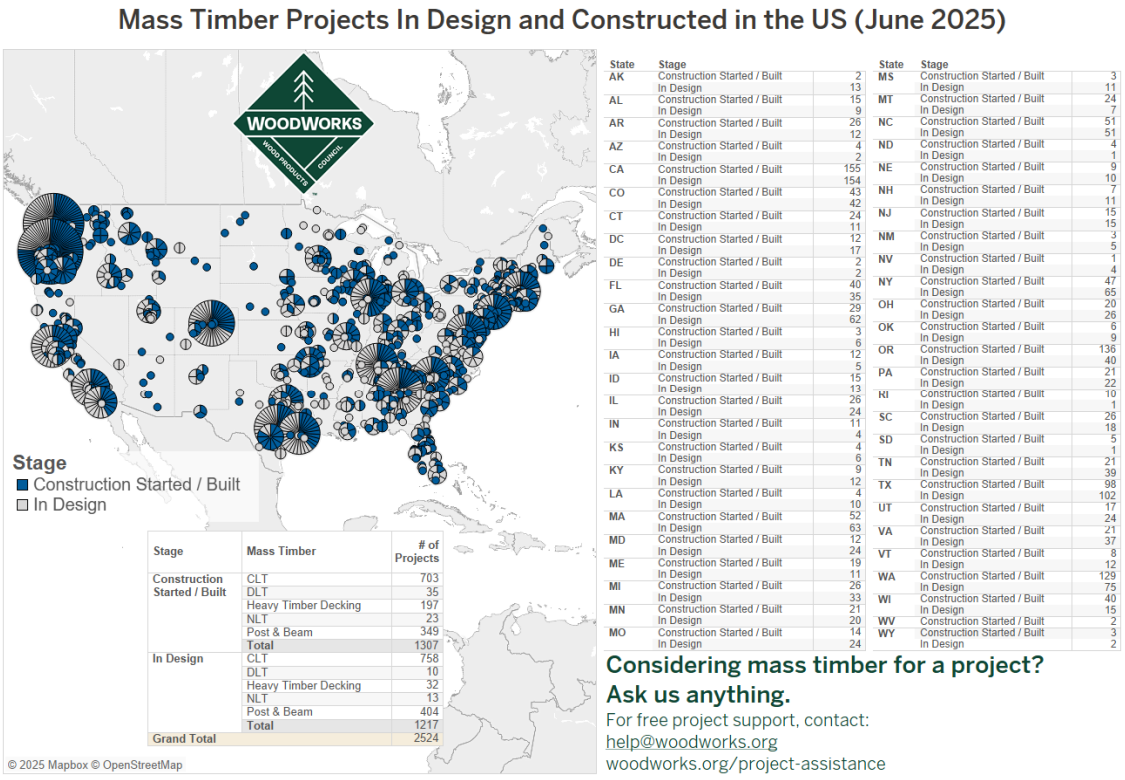
2.2.2. The United States of America

In the United States, more than two thousand mid- and high-rise mass timber projects have either been planned, are currently being built, or have already been finished [37]. Figure 3 displays the mapping of mass timber projects in design and construction across the United States as of June 2025, according to the WoodWorks website [38]. WoodWorks has been tracking mass timber and post-and-beam structures since the inception of the modern mass timber movement [39]. The map is updated quarterly, offering a snapshot of mass timber projects nationwide (Figure 3). Most of these projects are concentrated in the coastal states.

In the USA, mass timber currently constitutes just 0.4% of the softwood industry, equating to 0.36 million cubic meters. However, it holds the potential to expand to 9–15 million cubic meters annually, offering about 10.0–16.5 million tons of "carbon benefit"—which represents around 20% of the USA's carbon sequestration through harvested wood products [39]. For mass timber to achieve widespread adoption in the U.S., it is crucial to identify the barriers to its progress and develop effective strategies to address them [40].

Lauren Wingo [40], a senior structural engineer at ARUP specializing in mass timber construction, notes that many sustainability-focused developers in the U.S. are hesitant to

use mass timber due to three main challenges: (1) cost, (2) restrictions of building codes, and (3) the absence of federal, state, and regional policies that incentivize its use. However, Wingo believes that these challenges are not insurmountable. There are numerous instances of developers successfully overcoming these barriers, such as the 80 m tall Ascent Tower in Milwaukee. To promote the broader use of mass timber products across the U.S., it will be essential for design professionals, developers, investors, and government officials to collaborate in addressing these obstacles and making mass timber a more appealing and cost-effective choice [40].



Stage	Mass Timber	# of Projects
Construction Started / Built	CLT	703
	DLT	35
	Heavy Timber Decking	197
	NLT	23
	Post & Beam	349
	Total	1307
In Design	CLT	758
	DLT	10
	Heavy Timber Decking	32
	NLT	13
	Post & Beam	404
	Total	1217
Grand Total		2524

State	Stage		State	Stage	
AK	Construction Started / Built	2	MS	Construction Started / Built	3
	In Design	13		In Design	11
AL	Construction Started / Built	15	MT	Construction Started / Built	24
	In Design	9		In Design	7
AR	Construction Started / Built	26	NC	Construction Started / Built	51
	In Design	12		In Design	51
AZ	Construction Started / Built	4	ND	Construction Started / Built	4
	In Design	2		In Design	1
CA	Construction Started / Built	155	NE	Construction Started / Built	9
	In Design	154		In Design	10
CO	Construction Started / Built	43	NH	Construction Started / Built	7
	In Design	42		In Design	11
CT	Construction Started / Built	24	NJ	Construction Started / Built	15
	In Design	11		In Design	15
DC	Construction Started / Built	12	NM	Construction Started / Built	3
	In Design	17		In Design	5
DE	Construction Started / Built	2	NV	Construction Started / Built	1
	In Design	2		In Design	4
FL	Construction Started / Built	40	NY	Construction Started / Built	47
	In Design	35		In Design	65
GA	Construction Started / Built	29	OH	Construction Started / Built	20
	In Design	62		In Design	26
HI	Construction Started / Built	3	OK	Construction Started / Built	6
	In Design	6		In Design	9
IA	Construction Started / Built	12	OR	Construction Started / Built	136
	In Design	5		In Design	40
ID	Construction Started / Built	15	PA	Construction Started / Built	21
	In Design	13		In Design	22
IL	Construction Started / Built	26	RI	Construction Started / Built	10
	In Design	24		In Design	1
IN	Construction Started / Built	11	SC	Construction Started / Built	26
	In Design	4		In Design	18
KS	Construction Started / Built	4	SD	Construction Started / Built	5
	In Design	6		In Design	1
KY	Construction Started / Built	9	TN	Construction Started / Built	21
	In Design	12		In Design	39
LA	Construction Started / Built	4	TX	Construction Started / Built	98
	In Design	10		In Design	102
MA	Construction Started / Built	52	UT	Construction Started / Built	17
	In Design	63		In Design	24
MD	Construction Started / Built	12	VA	Construction Started / Built	21
	In Design	24		In Design	37
ME	Construction Started / Built	19	VT	Construction Started / Built	8
	In Design	11		In Design	12
MI	Construction Started / Built	26	WA	Construction Started / Built	129
	In Design	33		In Design	75
MN	Construction Started / Built	21	WI	Construction Started / Built	40
	In Design	20		In Design	15
MO	Construction Started / Built	14	WV	Construction Started / Built	2
	In Design	24	WY	Construction Started / Built	3
				In Design	2

Figure 3. Projects using mass timber being designed and built in the United States (https://www.woodworks.org/, accessed on 7 August 2025) [38] (permission granted).

Cost is a critical factor in any new project, and the current higher expense of mass timber compared to traditional building materials affects its popularity. However, this higher cost is not inherent to the material itself but rather reflects the current market conditions, possibly also the level of experience with mass timber projects of the suppliers. In the U.S., there are only a few mass timber suppliers, leading to higher prices also due to the limited production capacity. As demand for mass timber increases, more suppliers are expected to enter the market, and existing suppliers will expand their production capabilities [40].

Many mass timber projects in the U.S. encounter delays due to restrictive building code requirements. Municipal authorities who are not familiar with tall mass timber construction often reject these projects early in the design phase, especially when they lack clarity on how to solve fire safety concerns. However, this situation is evolving. The introduction of new tall timber provisions in the 2021 International Building Code (IBC2021) is expected to offer new pathways for mass timber buildings, which were previously restricted to a height of 26 m under the older code. Although the IBC2021 provisions now give permission for mass timber buildings up to 83 m, this comes with a trade-off: as the height increases, more of the timber should be concealed. In addition, for commercial developers, who prefer to showcase exposed mass timber products to attract higher rents, the requirement to hide

timber at greater heights can alter the cost–benefit balance, particularly given the additional expenses involved in concealing the timber [40].

In progressive building jurisdictions, the IBC2021 provisions can help identify solutions that address the demand for exposed timber while meeting fire safety requirements. To fully unlock the potential of tall timber structures, it is important for project teams and clients to work together with jurisdictions that are receptive to ambitious projects, even if they do not fully align with the current code's prescriptive requirements [40].

Supportive government policies and commercial investment are also vital for scaling mass timber use. Countries with robust forestry sectors, such as Austria, were early adopters of removing code restrictions and introducing incentives for mass timber. These countries were among the first to see significant growth in mass timber construction. Following their lead, other nations like France and England have also begun to experience a surge in mass timber projects, inspired by the success of these pioneering countries [40].

Much like Europe, certain regions in North America, which have well-established forestry industries, are leading the charge in advancing mass timber adoption. For instance, British Columbia's Wood First initiative mandates the use of timber as the primary building material in provincially funded projects. In the U.S., various regions have introduced financial incentives to support the forestry products industry, with some initiatives benefiting from federal funding. A notable example is the Maine Mass Timber Commercialization Center, where significant financial backing was provided by the U.S. Economic Development Administration. Furthermore, states like California, Washington, and Oregon are proactively eliminating code barriers by incorporating the 2021 IBC timber provisions. This forward-thinking approach has sparked a surge in timber construction, illustrating that supportive policy changes can be a powerful tool for driving industry growth [40].

To promote the widespread adoption of mass timber, it is essential to expand federal, state, and regional incentives that support both the supply and demand sides. Increasing funding in timber-abundant regions, such as the Southeastern U.S., can further stimulate the growth of mass timber products. These incentives should also guarantee that mass timber buildings are sourced from forests managed according to sustainable practices. Additionally, policies aimed at reducing building-related carbon emissions could make mass timber products more appealing and likely boost demand. The increasing acceptance of low-carbon procurement policies, such as Buy Clean legislation, at various levels of government signals a shift toward valuing embodied carbon [40]. Further measures to encourage mass timber adoption could involve offering tax incentives, revising regulations, or expediting the permitting process. In addition, major corporations focused on sustainability can enhance the impact of these incentives by leveraging their purchasing power to drive economies of scale in the mass timber industry [40].

Regardless of the strategies employed, it is evident that achieving widespread uptake of mass timber projects in the USA will require a concerted effort from government officials, investors, and industry professionals to overcome the existing cost, code, and policy barriers. Addressing these obstacles will demand substantial effort and investment, but it is essential for leveraging mass timber to reduce carbon emissions in the building sector [40]. The new Trump administration will most likely not derive the necessary impulse for mass timber buildings from their CO_2 storage potential and the Paris Climate Agreement but may be motivated by the local impact through regional sourcing and value add in timber-rich regions.

2.2.3. Austria

The forest and timber industries are very important sectors for the Austrian economy. In 2016, the implementation of the "Austrian Forest Strategy 2020+" progressed as planned.

This strategy was created in collaboration with more than 80 organizations and institutions through the Austrian Forest Dialogue [41,42].

The Austrian Forest Inventory has transitioned to a permanent surveying system. According to the 2016–2021 surveys, the total forest area has slowly increased to 4.02 million hectares, while the forest area available for wood supply (FAWS) has seen a slight decrease to 3.36 million hectares. Additionally, the overall growing stock rose to 1216 million m^3, with FAWS contributing 1180 million m^3 (an average of 351 m^3/ha). At the same time, the annual increment dropped to 29.2 million m^3, and the annual harvest experienced a modest increase to 26.0 million m^3 [43].

Forests cover 48% of Austria's federal territory and involve approximately 137,000 landowners, making them crucial, particularly in rural areas. The maintenance and enhancement of forest yields are vital not only for forest owners but also for the wood-processing industry. Austria's wood and paper sector has substantial capacities, utilizing a significant portion of wood and sawmill by-products for energy generation and importing considerable quantities of roundwood. Mobilizing domestic resources remains a central objective of Austria's forest policy [41,42].

In 2022, a total of 19.36 million m^3 of timber under bark was harvested, marking a 5.1% increase from the previous year and an 8.8% rise compared to the ten-year average. Of this total, sawlogs comprised about 55.3 percent, pulpwood and other roundwood made up 16.7%, and fuelwood and forest chippings accounted for 28.0%. Out of the total volume harvested, 13.93 million m^3 were used for material purposes, while 5.42 million m^3 were dedicated to the generation of energy. Coniferous wood represented 83.7% of the total volume felled [41,42].

According to the European Forest Account methodology—which factors in the net increment of standing timber—the production value of domestic forestry reached nearly EUR 3.0 billion in 2022, compared to EUR 2.4 billion in 2021 and EUR 1.7 billion in 2020. Of this total, approximately EUR 1.7 billion was derived from raw timber production [41,42].

In 2022, the production value of wood in the construction segment reached EUR 3.94 billion, marking an 8.3% increase from the previous year. This upward trend is also evident in related industries such as doors and prefabricated timber construction. Due to legal regulations, data from some sub-sectors remain confidential. Key industries include manufacturers of glued structural components and doors, prefabricated timber houses, and parquet and other wooden flooring [41,42].

Exports of laminated timber products totaled EUR 1.231 billion as by far the largest segment, up by 4.7%; windows reached EUR 126 million, an increase of 30.0%; parquet exports were EUR 306 million, up by 4.0%; and doors amounted to EUR 53 million, reflecting a 10.2% rise. The primary export markets for parquet and doors (and windows) were Germany, Switzerland, and Italy. For laminated timber, the major destinations were Italy (31%), Germany (25%), and France (9%) [41,42].

A recent study by the Austrian Federal Ministry of Agriculture, Forestry, Regions and Water Management on the economic impact of Europe's forestry and timber sector highlights the critical role of sustainable forest management and timber utilization for different countries. The study estimates that the sector supports roughly 17.5 million jobs across Europe and contributes approximately EUR 1.1 trillion in gross value added per year [43].

Recently, wood has emerged as a high-tech material, widely being used in urban settings, e.g., the 84 m tall high-rise "HoHo Wien" timber building. To support such initiatives, the Federal Ministry of Agriculture, Forestry, Regions, and Water Management established the "Wood-based Value Chain" division [44].

The Austrian Wood Initiative includes a variety of measures across several thematic areas, including governance, timber construction, innovation, education, communication, and wood as energy generation. A key component of this initiative is the "CO_2 Bonus," which provides subsidies for large residential and public buildings constructed primarily from timber and renewable materials from sustainable sources. This subsidy amounts to EUR 1 per kilogram of wood used, capped at 50% of the total construction costs [43–45].

In a bid to bolster wood-related collaboration at the European level, Austria and Finland have introduced the European Wood Policy Platform, known as "woodPoP." The platform is designed to refine the regulatory framework for the wood-based value chain and underscore its political importance [41,42].

2.2.4. Switzerland

With the introduction of the Ordinance on Placing Timber and Wood Products on the Market on 1 January 2022, the Federal Council of Switzerland, following the Swiss Parliament's directive, established regulations equivalent to those of the European Union (EU; EU Timber Regulation 995/2010). This regulation aims to prevent the market entry of timber and wood products that are illegally harvested or traded. Currently, the forestry and timber industries benefit significantly from the growing recognition of wood as a carbon-neutral, renewable, and locally sourced material amid the climate change challenge [46].

The construction industry is a significant driver of timber demand in Switzerland, though a slowdown is anticipated. Despite this, the need for living space is expected to remain strong due to ongoing immigration. Recently, timber-framed construction has gained appeal compared to other materials. The long-term storage of CO_2 through the sustainable and repeated use of wood has been a topic of discussion for some time. The Swiss timber industry is well-positioned to meet demand in the short term, thanks to the growth of domestic production of glued timber components and advanced digitalization in planning and production [46]. Additionally, high-strength bonded wood sheets and large-scale ceiling and wall elements made from hardwood are opening new possibilities for timber construction in multi-story residential, commercial, and public buildings. The strength properties of timber components made from beech, oak, and ash allow them to substitute steel and concrete in many applications. The reduced volume of wood used enables the creation of elegant, slender timber structures, enhancing timber's competitiveness against concrete and steel. By incorporating ash and oak alongside beech, Fagus Suisse has broadened its raw material base, expanded its product range, and increased the design possibilities in timber construction [46].

Timber construction share in Switzerland continues to grow, especially for multi-story residential buildings and large-scale wooden structures. Timber construction has regained popularity, with the number of planning applications for primarily wooden apartment blocks more than doubling since 2005 [46]. This resurgence is driven by several factors: new fire safety regulations, reduced construction costs, shorter project times with less disruption to residents, and the high quality achievable through extensive prefabrication and streamlined processes in controlled environments. The increasing visibility of wood as a building material is further accelerating this trend [46].

The construction industry, particularly timber-framed construction, remains the largest market for sawnwood. In addition, the updated fire protection standards for timber structures in 2015 have significantly boosted the construction of multi-story residential apartment and commercial office buildings, including buildings up to 80 m tall. The timber construction sector continues to thrive and expand its market share [46]. In 2020, wood usage in support structures varied across different building types: 8.6% for residential buildings with three or more units, 14.1% for hospitals and care homes, 14.9% for com-

mercial and administrative buildings, 16.4% for industrial buildings, 22.5% for sports and leisure facilities, 19.6% for residential buildings with up to two units, 23.4% for educational buildings, and 36.7% for agricultural buildings [46]. Overall, wood constituted 15.6% of support structures across all building categories in 2020. This indicates significant potential for increasing wood's share in construction and further leveraging its benefits as a regenerative, indigenous material for CO_2 reduction [46].

In Switzerland, the digitization of building design and construction, along with robotic production of complex structures, has reached advanced levels compared to other markets and continues to evolve rapidly. This research is conducted in close collaboration with the timber construction sector [46]. Potential for further efficiency gains and cost reduction is apparent. These advancements in research and timber construction are only gradually making their way also into the forestry sector and the initial production stages, such as sawmills. Switzerland is increasing its production capacity for glulam timber sections to meet high demand. Nonetheless, substantial amounts of glulam components will still need to be imported from Austria and Germany for the foreseeable future [46].

2.2.5. Sweden

The Swedish government announced a national strategy for a circular economy in 2020, highlighting the goals and pathways for Sweden's long-term transition towards sustainability. This strategy is a key step in Sweden's ambition to become the first fossil-free welfare country in the world and supports the advancement of the forest sector, including the timber construction industry [45].

During the pandemic, Sweden experienced historically high levels of housing investment. However, this trend is now expected to further decline. The rising costs of commodities and materials, along with increasing market interest rates and decreasing housing prices, are anticipated to reduce the profitability of new construction projects. Additionally, the high volume of housing starts in 2021 contributed to elevated investment in 2022. Consequently, housing starts have been decreasing in both 2022 and 2023, leading to a drop in overall housing investment of over 8.5% in 2023 [45].

In 2022, the commencement of new housing construction totaled around 60,000 residential units. However, there was a noticeable decline, with forecasts by the National Board of Housing, Building, and Planning predicting further reductions to 27,000 units in 2023 and 21,500 units in 2024. The primary factors contributing to this downturn include decreased purchasing power among households, rising interest rates, declining building prices, and increasing construction costs. Despite this overall decline, the number of new single-family homes constructed with wood saw a 15% increase in 2022, reaching 6436 units. Conversely, the total order intake for new wooden houses dropped by 42% to 4860 units. The production and new orders for wooden houses are anticipated to decline further in 2023 and 2024, reflecting the challenges outlined above [45].

A study by Färnström [47] focusing on views of architects and structural engineers on Swedish multi-story timber construction indicates that the major challenges that limit the Swedish timber construction industry are developers' and contractors' know-how gaps, high construction costs, and the lack of standardized processes. To address these challenges and promote greater use of wood, industry stakeholders require enhanced education on wood construction, the implementation of carbon taxes on materials, the incorporation of wood-focused strategies in master plans and zoning policies, and increased production of prefabricated wood products by manufacturers. The industry needs increased education and access to information about wood, both in academic institutions and within the sector itself. This could address misinformation, correct misconceptions, and support decision-makers in opting for wood as a construction material. Industry-wide education can be

promoted through collaborations and publications that showcase proven solutions and practical examples. Regulatory measures, such as carbon taxes or economic incentives, could further encourage the adoption of wood construction. Additionally, municipalities can leverage their authority by incorporating wood construction strategies into zoning policies and master plans for allocating land plots [47].

2.2.6. Finland

The Finnish government is advancing its National Forest Strategy 2035, which received approval from the Forest Council in 2022. However, the government program and state budget announced in October 2023 reveal financial cuts that could impact various sectors. Despite somewhat more optimistic projections for 2024, the economic outlook remains uncertain. Economic growth for Finland in 2024 is anticipated to be just under one percent annually, with growth expected to become more pronounced towards the end of the year [48].

At the end of 2022, Finland experienced a decline in both sawnwood production and export volumes, accompanied by a significant drop in export prices. Consequently, expectations for 2023 were relatively subdued in August 2022. However, the first half of 2023 exceeded these expectations. During this period, sawnwood exports remained stable compared to the first half of 2022, and production saw a decrease of less than three percent. Additionally, the export price of sawnwood increased until May 2023 [48].

High interest rates, rising costs of construction, and also increased economic uncertainty have led to a decline in construction volumes and wood demand across many markets in 2023. However, the extent of this decline and the expectations for recovery vary by region. In the United States, while sawnwood consumption has decreased in 2023, it is expected to rebound in 2025. This anticipated growth is largely supported by housing construction, which remains relatively low compared to the demand. In the EU, significant decreases in construction volumes were expected in 2023, particularly in Sweden and Germany. Conversely, in France, a key export market for Finnish spruce sawnwood, construction output was expected to see a slight increase in 2023. Forecasts suggest that many countries, including Great Britain, experienced an uptick in construction activity from 2024 [48].

A web-based survey conducted among Finnish architects, which garnered 147 responses (Ilgın et al. [49]), highlighted several key findings: (1) Architects recognized wood as a lightweight, ecological, and locally sourced material, which were seen as its primary advantages; (2) There were concerns regarding wood construction compared to concrete, with perceptions that wood is more expensive and involves more complex engineering; (3) While architects generally favored using wood for low-rise residential buildings, they expressed predominantly negative views about its application in tall buildings, including timber structures. The study sought to understand the benefits of wood over concrete, the motivations and obstacles associated with wood use in residential construction, and architects' opinions on tall timber buildings in Finland. The lightweight nature, ecological benefits, local sourcing, and minimal climatic impact of wood were emphasized as major advantages and key motivations for its use in residential projects [49].

However, several concerns were noted regarding using wood in buildings compared to concrete. These concerns included cost-competitiveness of wood, acoustic insulation, durability, and fire safety. Architects highlighted that these factors often pose disadvantages when compared to concrete construction. Additionally, obstacles such as limited client demand, the entrenched familiarity of using concrete, and a lack of knowledge in wood construction—along with apprehensions about price and fire safety—were identified as significant barriers to the adoption of structural timber [49].

Participants generally held a positive attitude towards low-rise (1–3 stories) and mid-rise (4–7 stories) timber housing but expressed a predominantly negative view of tall residential apartment buildings (above 7 stories), regardless of whether they were constructed from timber or concrete [49]. Based on the long-standing dominance of concrete in Finnish residential construction, the following recommendations are proposed to enhance attitudes towards timber buildings and overcome perceived barriers: (1) offer architects support and increase industry trainings by means of seminars/workshops—focused on timber structures to enhance their awareness and know-how of technological innovations in timber products and to address challenges related to satisfying legislative building code requirements; (2) work to shift the attitudes of contractors and clients, who are the final decision-makers, by raising awareness of timber's benefits through professional organizations; (3) encourage governmental bodies to implement more regulations and legislation to promote the use of timber as a primary building material in multi-story buildings [49].

As concluded by Ilgın et al. [49], future research on the adoption of multi-story residential buildings (over two stories) in Finland should focus on the attitudes and interests of contractors, designers, building commissioners and structural engineers, as these groups play a crucial role in the selection of structural materials. Additionally, future studies could investigate how architects' educational backgrounds and participation in ongoing education influence the perceptions of wood. It would also be beneficial to examine how familiarity with wood affects architects' decisions to specify timber to be used in Finland.

2.2.7. SUDOE Region (Southwest France, Portugal and Spain)

Using timber as a structural material for multi-story constructions is growing in the SUDOE region, which includes Southwest France, Portugal, and Spain. Since the construction of the first multi-story timber building (exceeding three stories) in the SUDOE region in 2013, the annual number of such buildings has been increasing globally [50].

Until recently, timber construction in the SUDOE region was predominantly focused on large-span buildings utilizing glulam in post-and-beam structural systems. This trend is evolving, with a notable shift toward multi-story timber buildings. As of 2023, 39 such multi-story timber buildings have been completed in the SUDOE areas. This change is largely attributed to the establishment of CLT production facilities in the SUDOE area [50]. Currently, timber structural systems, including CLT, are the most widely used for residential and mixed-use buildings, both within the SUDOE region and worldwide. In contrast, the category of post-and-beam building system remains more prevalent in the SUDOE countries compared to global practices and is primarily used for educational and office buildings [50].

Regarding wood species, European standards list 21 species for structural use, yet only four species—all softwoods—are found in the multi-story buildings of the SUDOE region. Spruce remains the most widely used species both globally and within the SUDOE area, despite not being locally cultivated [50]. However, locally grown species such as radiata pine and Douglas fir are gaining prominence in the SUDOE region, making up 28% and 12% of the timber used in the studied buildings, respectively. In the SUDOE region, the average ratio of wood volume to built area in multi-story timber buildings is 0.32 m^3/m^2, with the majority of buildings ranging between 0.3 and 0.4 m^3/m^2. These figures align with findings from a US study, i.e., combined cross-laminated timber (CLT) and glulam use factors of 0.26 m^3/m^2 for buildings with four to six stories, 0.33 m^3/m^2 for those with six to twelve stories, and 0.24 m^3/m^2 for buildings exceeding thirteen stories [51]. This increased use of timber correlates with a greater amount of CO_2 being sequestered within the buildings. However, it is also noted that higher wood volumes lead to increased emissions from transportation.

In Portugal, the construction sector has shown notable resilience according to recent indicators [52]. The Portuguese building stock was evaluated to comprise 3.6 million buildings and 6.0 million conventional dwellings, reflecting a modest increase of about 0.3% from 2021. In 2021, there were 25,409 building permits issued, marking an 8.2% rise from the previous year. Additionally, the number of new dwelling licenses for family housing reached 28,508, representing an 11.0% annual increase [52].

The Portuguese forest sector, historically export-oriented, has become a significant part of the country's economy. Forest product exports have consistently been among Portugal's major exports, accounting for 9% of total exports in recent years, while imports in this sector represent only 4%. Since 2012, the value of exports has exceeded imports by over EUR 2.5 billion, highlighting the sector's heavy dependence on international markets [52].

The French housing market exhibits a unique dynamic characterized by an 8% vacancy rate, although it often takes several months to find a studio in Paris, which is known for having some of the highest apartment prices in Europe on a per-square-meter basis. There is a notable divergence in market conditions between major metropolitan areas and less populated regions. Additionally, there is significant concern about the shortage of affordable housing, particularly in desirable metropolitan areas and for sectors like student accommodation [51].

Over the past 15 years, residential construction in France has not reached the pre-financial crisis levels, with recent slowdowns in the construction sector reminiscent of those experienced during the Global Financial Crisis (GFC) and the European debt crisis. Despite these challenges, timber construction holds considerable potential in the French market across various construction segments. Timber is increasingly favored for new buildings, especially with France's RE2020 regulations, and is also a viable option for renovations and extensions [53].

The French government's 2021–2026 National Resilience and Recovery Plan (NRRP) includes several legislative measures to support its green transition, including the 'Climate and Resilience Law' and a revision of the thermal regulations for new buildings (RE2020). Additionally, the '2019 Mobility Law' aims to overhaul mobility policies, and other proposed reforms such as the 'ASAP Law' (which focuses on accelerating and simplifying public action) and the '4D Law' (which seeks to differentiate, deconcentrate, decentralize, and reduce complexity) also impact the timber construction sector. Under the NRRP, EUR 5.8 billion has been earmarked for the renovation of building stock with the aim of improving energy efficiency [53].

2.2.8. Germany

The key opportunity to improve the role of forests in climate protection is through sustainable and near-natural forest management, which boosts carbon sequestration through practices like the management of timber, deadwood, and soil. Promoting the use of timber in long-lasting products is also a key element in this effort. The German government's Climate Action Plan 2050, implemented in 2016, focuses on increasing the carbon storage capacity of forests. The plan outlines strategies to reduce CO_2 emissions through sustainable forest practices, expanded timber utilization, and leveraging the climate benefits of natural forests. In 2021, the Federal Ministry of Food and Agriculture [54] introduced the Forest Strategy 2050 as a national policy framework. Currently, the German government is planning a new strategy for forests aimed at guiding forest management for the future. This strategy will emphasize adapting forests to the effects of climate change, preserving biodiversity, and ensuring sustainable forest practices that contribute to long-term CO_2 storage in wood products. The majority of forests in Germany (approximately 33.3% of the land area) are mixed forests, which make up 76% of the total forest area [55].

The Federal Government's 'Climate Action Plan 2050' underscores the importance of the 'Charter for Wood 2.0,' marking a significant milestone [56]. This initiative seeks to encourage the use of wood derived from sustainable forestry practices, emphasizing its role in climate protection, value generation and resource efficiency. The 'Charter for Wood 2.0' outlines activities in seven key areas, aligning with the main goals outlined in the coalition agreement. The German building sector faces considerable climate policy challenges, having emitted more than 110 million tons of CO_2 in 2020. Despite an 18% reduction in emissions from 2010 to 2019, the sector did not meet the targets of climate protection set by the Federal Climate Change Act for either 2020 or 2021. In 2021, emissions were recorded at 115 million tons of CO_2 equivalents, falling short of the 113-million-ton target and accounting for 15% of total annual emissions. To address this, the federal government plans to significantly increase efforts in promoting energy-efficient building renovations. EUR 4.5 billion, as part of the Immediate Climate Action Programme, will be allocated over the next two years to support these initiatives [56].

In June 2023, the Federal Cabinet approved the Federal Government's wood construction initiative (*Holzbauinitiative*), aimed at advancing timber construction as a vital component of climate-friendly and resource-efficient building practices. This initiative aligns with the objectives of the coalition agreement and is set to run until 2030. The new German government established in 2025 also holds on to these objectives. The new Construction and Housing Minister Verena Hubertz of Germany pointed out the German housing crisis and announced a plan to help ease the shortage of affordable housing [57]. It connects with various policy strategies and programs, including significant EU-level initiatives such as the EU Green Deal and the New European Bauhaus [55]. Additionally, the new government initiated a "*building turbo*" to accelerate approval procedures for new building projects. The goal is to initiate and finish new buildings, urban densification and building extensions (primarily constructed in wood) quicker and thus more cost-efficiently, as well as reduce the cost of administrative procedures [58]. Specifically, in 2026, an impressive EUR 4 billion have been secured for this purpose. By 2029, federal funds will even grow to EUR 5.5 billion. The funding will be increased by the states again by a comparable amount [58].

In the building sector, wood is currently the only technology that allows for carbon sequestration within the structural and shell elements of buildings. With the ongoing high requests for affordable housing, timber construction presents significant opportunities for urban densification through the addition of floors, extensions, and infill development. In Germany, approximately 50–67% of roundwood is converted into construction materials for buildings. In 2022, the carpentry and timber construction industry employed around 75,000 people across more than 12,000 companies, generating approximately EUR 9 billion in revenue, reflecting a slight decrease from the previous year. That same year, roughly 23,500 residential timber construction projects were approved, representing around 21% of all approved residential buildings. In contrast, the number of approved non-residential timber buildings dropped by nearly 12%, totaling just over 5500, which made up around 21% of all approved non-residential buildings [55,59].

To obtain first-hand professional perspectives, our team conducted a targeted expert survey between 2024 and 2025 among leading German architectural and engineering firms specializing in multi-story and high-rise timber construction. The survey was organized as structured online interviews with representatives from the following three companies recognized for their pioneering contributions to the sector:

- Knippershelbig GmbH, an internationally respected engineering design firm and structural designer of the proposed *Burj Zanzibar* (96 m), anticipated to become the world's tallest timber building.

- Kaden + Lager GmbH, regarded as Germany's trailblazer in multi-story timber architecture, with landmark projects such as *Skaio* (34 m, Heilbronn), *Famju* (20 m, Heilbronn), and *WA 16 West* in Munich's Prinz-Eugen-Park.
- C4 Engineers GmbH, the structural engineering office behind *The Cradle* (22 m, Düsseldorf), Germany's first circular-economy timber-hybrid office building.

The interviews followed a semi-structured question–answer format, focusing on four main themes: (i) the current state of the German mass timber market, (ii) key technical and regulatory challenges, (iii) opportunities and drivers for future adoption, and (iv) the role of innovative design in promoting sustainability and circular economy principles. All responses were qualitatively coded and thematically analyzed to identify converging viewpoints and recurring issues. This approach ensured that the perspectives of leading practitioners were systematically incorporated into our market analysis. The main findings from this survey are summarized below.

The outlook for mid-rise and high-rise timber construction in Germany is quite optimistic, reflecting the growing role of timber in the construction sector. Thanks to its advantageous properties, particularly its ability to lower CO_2 emissions, timber is becoming an increasingly vital material. Presently, timber accounts for approximately 20% of building permits in the multi-story residential market in Germany, suggesting a strong foundation for future growth. However, the adoption rate has not yet reached expected levels. The sector's full potential is anticipated to be unlocked with advancements in CO_2 pricing mechanisms. Recent initiatives, such as the introduction of model timber construction guidelines, have facilitated the use of timber in higher building classes. Despite the generally slow pace of progress in the construction industry, especially in residential sectors, there is considerable potential for expanding timber construction in both mid-rise and high-rise buildings moving forward.

When discussing the pace of wood adoption in the construction industry, opinions among German architects vary. Some believe that the development is progressing relatively quickly, reflecting a positive shift towards timber use. Conversely, others feel that the adoption has been slower than anticipated. The recent downturn in the single-family house market has particularly affected carpenters and smaller timber construction firms, leading them to explore new avenues in response to these challenges.

German architects generally agree that using wood in construction can lead to significant energy savings. Wood construction demands far less energy compared to reinforced concrete or steel, as these traditional materials require extremely high temperatures for production, which involves substantial fuel combustion. Although research is underway to develop low-CO_2 or "green" steel, including the potential use of hydrogen, such materials are not yet commercially available. Regarding costs, there have been fluctuations in material prices. While the costs of steel, cement, gravel, and sand have risen sharply in recent years, wood prices experienced a temporary spike but have since stabilized. Typically, wood is less expensive than these traditional materials. However, labor costs for timber construction are higher compared to concrete, where wages are generally lower. To enhance cost-effectiveness, increased industrialization and automation in timber construction are essential. For standard buildings without intricate designs, timber construction costs are often comparable to those of reinforced concrete, according to some architects.

When asked about the speed of wood construction technology, some German architects affirm that it is indeed a fast-building method. The prefabrication aspect of wood construction significantly accelerates the building process, leading to quicker assembly on-site. However, other architects point out that while wood construction can expedite on-site assembly, it does not necessarily shorten the overall project timeline. Although a significant portion of the construction is prefabricated in factories and workshops, the

total duration of the project remains similar to other construction methods. The on-site phase is reduced, but this does not drastically change the overall timeline. The total project duration largely depends on the efficiency and experience of the teams involved. Typically, the on-site construction phase constitutes about one-third of the entire project time, and even though the process is more streamlined, the overall duration is comparable to traditional methods.

Regarding emerging trends and technologies that could impact the timber construction sector, German architects currently perceive limited groundbreaking advancements. Cross-laminated timber (CLT) has been established for about 20 years and is extensively utilized in wall and ceiling systems. With numerous companies in Germany, Austria, and Switzerland now producing CLT on a large scale, significant technological progress has already been achieved. Most multi-story wooden buildings today use a mix of post-and-beam structures and CLT slabs, often incorporating concrete cores for lateral force resistance and fire protection. While improvements in details like connections continue, there are no revolutionary developments anticipated in the near future. A notable trend with the potential to impact the sector is hybrid construction. This approach utilizes timber together with other materials, e.g., steel or reinforced concrete, to optimize overall performance. Hybrid methods, where wood is used alongside other materials, offer flexibility and efficiency. For example, while reinforced concrete cores might be necessary for certain structural functions, timber can make up a substantial portion of the building's structure, potentially 60–80% in some cases. This method allows for significant use of wood, especially in horizontal systems like CLT and LVL, while integrating other materials was advantageous. Hybrid construction represents a versatile and balanced approach, utilizing the strengths of different materials while maximizing the use of timber.

German architects identify several key challenges in planning and constructing mid-rise and high-rise timber buildings, ranked as follows:

Obtaining Building Permits: Securing the necessary approvals from authorities is considered the most significant obstacle.

Fire Protection and Building Regulations: Addressing stringent fire protection requirements and navigating complex building regulations are major concerns.

Cost Management: Managing construction costs remains a critical issue.

Climate Impact: While climate impact is generally seen as an advantage due to timber's sustainability, it also requires consideration.

Wind loads are not perceived as a major challenge, as they affect all high-rise buildings. Established methods are available to evaluate and manage these loads. Overall, while climate impact is viewed positively, fire protection and regulatory compliance are the primary challenges faced in the timber construction sector.

Challenges in timber construction projects can vary significantly. For instance, the Cradle building project (Figure 4) in Düsseldorf (*The-cradle* 2024) faced notable difficulties in integrating a reinforced concrete core (Figure 5) with exposed diagonal timber braces (Figure 6). The building follows a timber-concrete hybrid design, featuring a rectangular plan measuring 26 by 48 m and rising to a total height of 22 m. The structure incorporates three basement levels and a ground floor, all realized in cast-in-place concrete, forming a solid and durable substructure. Above this, five timber-framed stories and a setback penthouse floor complete the vertical extension of the building, highlighting the use of engineered wood in the superstructure [60]. A key architectural and structural highlight is the integration of V-shaped structural elements positioned within the façade planes. These inclined columns not only contribute to the architectural expression of the exterior but also play a crucial structural role, channeling both gravity and lateral loads toward the foundations. Working in tandem with the reinforced concrete core zones, they ensure the

building's lateral stability, particularly addressing the stringent seismic demands associated with Earthquake Zone 1 classification [60]. The connections between the timber façade columns and the horizontal structural elements are carefully engineered. Custom-machined beech brackets are installed at the beam-column interfaces, engaging with prefabricated plug-in edge beam connections. To guarantee precision and performance, both the brackets and the mating surfaces on the timber columns are produced using CNC machining techniques, ensuring a highly accurate fit and optimized load transfer within the hybrid structural system [60]. This project required balancing the stiffness between timber and concrete, as using a single material for bracing—be it wood, concrete, or steel—simplifies stiffness calculations and load distribution. As buildings increase in height, fire protection becomes more critical, and visible wood can complicate safety measures. A common misconception is that timber is less safe in fires compared to steel, largely due to limited experience with timber construction. In Germany, fire protection often relies on cladding and burn tests, rather than proactive measures like sprinkler systems, which are more commonly used in Scandinavia and the UK. Sprinkler systems, known for their effectiveness in containing fires and enhancing safety, could significantly benefit timber construction if adopted in Germany, particularly in a manner similar to practices employed in hospitals.



Figure 4. Cradle building in Düsseldorf, Germany (photographed by the author).

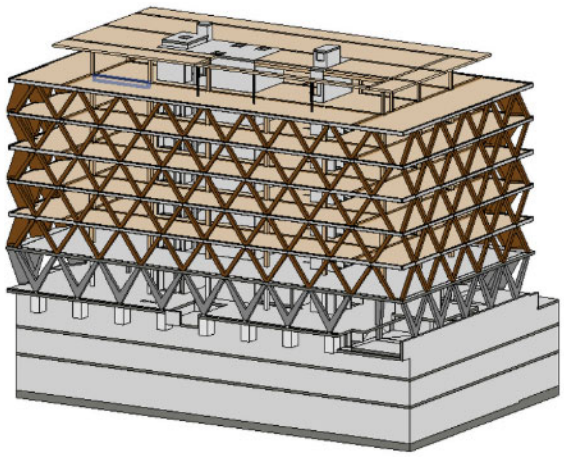


Figure 5. The structure of the Cradle building with reinforced concrete core in gray color in the middle [60] (permission granted).



Figure 6. Diagonal timber braces in the Cradle building [60] (permission granted).

Another example is the *Skaio* building project (34 m tall) in Heilbronn [61], as shown in Figure 7, which faced specific challenges related to integrating steel beams (Figure 8) into the outer walls to support large windows. Using wooden beams for this purpose would have necessitated impractically high beam dimensions, posing issues with deflection and affecting both the beam size and window installation. In this project, steel elements were selected for mechanical connections over reinforced concrete due to their superior efficiency in assembly. Steel components were favored because they provide more straightforward and adaptable assembly compared to concrete.



Figure 7. Skaio building in Heilbronn, Germany (Lagerschwertfeger [62]; Von-fragstein [63]) (permission granted).

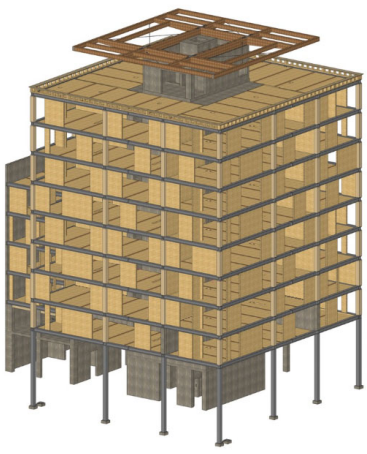


Figure 8. Steel beams (gray color at each story) (Von-fragstein [63]) (permission granted).

For the *WA 16 West* Holzbausiedlung (Figure 9) in Munich [64], the primary challenge was achieving building reversibility, meaning the structure needed to be designed for future disassembly. This requires using a dry construction method, avoiding screed or plaster, to ensure that components could be easily removed or repurposed. Although this approach proved to be more cost-effective compared to projects like Skaio, it introduced additional complexity in the construction process.



Figure 9. WA 16 West Holzbausiedlung in Munich (© Klaus-Reiner Klebe | bauart\Beratende Ingenieure, https://www.bauart-ingenieure.de/, accessed on 7 August 2025) (Bauart-ingenieure [65]) (permission granted).

Advancing high-rise timber construction requires robust support and collaboration with research institutions. Key areas for research include the following:

Component Connections and Stiffness: Investigating how different components connect and contribute to the overall stiffness of timber structures is crucial for ensuring structural integrity.

Fire Protection: Research into fire protection specific to timber structures is essential, especially given the limited data on the performance of wooden high-rise buildings in fire scenarios. This is particularly important for insurance companies that rely on statistical risk assessments.

Acoustics: Addressing issues related to acoustics, especially impact sound transmission between floors, is another critical area for further study.

Conducting experiments on component assemblies and validating them through measurements will provide valuable insights and drive progress in the field.

Mechanical connections play a vital role in maintaining the structural integrity of high-rise timber buildings, particularly when employing diagonal timber bracings for horizontal reinforcement. The stiffness of these connections is critical for the overall stability of the structure. In buildings with a reinforced concrete core, the connections of support beams have a reduced impact on horizontal stiffness. However, in designs featuring free-form surfaces, skeletal structures with diagonal bracing, or cross-laminated timber walls, the

stiffness of these connections becomes crucial. The importance of connection stiffness and the shear stiffness of the walls is significantly higher in timber structures compared to those made of concrete. This underscores the need for meticulously designed and robust mechanical connections to ensure the stability and safety of high-rise timber buildings.

In designing high-rise timber buildings, it is crucial to account for the effects of shrinkage and creep, similar to considerations in reinforced concrete structures. Timber, especially species such as beech, undergoes notable shrinkage and swelling due to moisture fluctuations. This behavior can affect mechanical connections over time. To address these challenges, it is essential to mathematically model the shrinkage and swelling characteristics of the timber. Such modeling ensures that the connections remain effective and the overall structural integrity is preserved, accommodating the natural movement of the wood throughout the building's lifespan.

In German high-rise timber construction projects, several strategies are employed by structural engineers to enhance fire protection and sound insulation. For fire protection, engineers use sprinkler systems and improve escape routes by adding external escape balconies. These balconies provide safe gathering areas and quick exits, helping to meet lower fire protection requirements by offering additional means of escape. Cross-laminated timber (CLT) is utilized for its fire safety benefits, as it chars on only one side of the ceiling rather than three sides, as seen with traditional beams. For sound insulation, structural tests are conducted to measure and improve soundproofing performance, leading to better outcomes.

In Germany, the height of timber high-rise buildings is regulated primarily by development plans, which set maximum building heights. Typically, there are restrictions to ensure new buildings do not exceed the height of significant landmarks, such as church towers. While building regulations do not directly impose height limits, projects that exceed standard limits require specific approvals and evidence to ensure compliance. Securing these approvals can be both time-consuming and costly. To construct higher than allowed by development plans, developers often need to seek modifications to the plans. Additionally, buildings over 22 m are classified as high-rise structures and are subject to their own set of regulations [66]. These height restrictions ensure new constructions do not overshadow or conflict with existing important buildings, as outlined in the development plans.

In Germany, any building that exceeds 22 m in height is classified as a high-rise, subject to a distinct set of regulations and requirements. Contrary to mandates for non-combustible materials, high-rise regulations require a fire protection report to confirm that the construction method adheres to safety standards. If a high-rise timber building incorporates materials or design details typically approved for up to 90 min of fire resistance, it may require special project-specific approval. This approval process ensures that every aspect of the design meets the rigorous standards applicable to high-rise structures.

Cost analyses comparing timber and reinforced concrete construction are frequently carried out. For example, a recent analysis for a hospital project revealed that the cost difference between timber and concrete construction was minimal, with timber being only 3% more expensive. Generally, the initial tender for timber buildings may be 5 to 10% higher than for concrete buildings. However, the efficiencies gained from prefabrication in timber construction often result in final costs that are comparable to those of concrete construction by the project's completion.

Timber projects often benefit from reduced construction time due to extensive pre-construction planning, which minimizes errors and unforeseen issues. Prefabrication in timber construction can lead to a construction phase that is typically 2–3 months shorter than conventional methods. For projects utilizing prefabricated room modules, the timeline can be further accelerated. However, it is important to consider that the overall project

duration includes both planning and construction phases. While the planning and preparation stages may not be faster with timber construction, the actual on-site construction phase is significantly quicker. This shorter construction time can be particularly advantageous, especially since project financing often starts when construction begins.

2.2.9. China

The share of timber construction in China is much lower compared with those countries discussed above; it was reported that timber-frame construction currently represents a small fraction of the residential market, estimated at less than 0.05% [67], while the market of timber construction in China is growing, especially for low-rise private housing. This growth is supported by government initiatives like the National Forest Protection Program (NFPP, China's flagship program for forest conservation and restoration) and the focus on sustainable development and green buildings, which include targets for applying green building standards to all new urban buildings by 2025 [68]). China's "30·60" targets (carbon peaking by 2030 and neutrality by 2060) frame the construction sector's decarbonization pathway [69]; during the 14th Five-Year Plan, the government committed to increase national forest coverage to ~24.1% by 2025, supported by large-scale afforestation programs and shelterbelt projects [69,70]. In 2024, the building sector accounted for a substantial share of national energy use, underscoring mitigation potential through material substitution and efficiency [70].

Key national regulations and policies include updated technical codes for timber structures, promotion of timber as a green building material, and efforts to increase domestic timber supply through afforestation [71], e.g., Design of Timber Structures (GB 50005-2017 [72]) provides the structural design basis; GB/T 51226-2017 [73] specifically addresses multi-story and high-rise timber buildings. China also issued a product standard for CLT (LY/T 3039-2018; implemented 2019 [74]), enabling domestic certification and design data. Secondary technical guidance notes that GB/T 51226-2017 permits mid- to high-rise timber under defined conditions (e.g., up to 18 stories in certain non-seismic contexts), with fire design governed by GB 50016 [75]. China's Assessment Standard for Green Building (GB/T 50378-2019) [76] is the national benchmark for rating building environmental performance [77]. In parallel, central policy aims for ~30% of new buildings to be prefabricated (assembly construction) in the medium term, an instrument relevant to mass timber industrialization and off-site manufacturing [78].

For the consumption of wood products, China is a major wood-products player (2024 timber output forecast ~121 million m^3) and a leading importer, yet mass-timber buildings remain a niche relative to reinforced concrete. Published surveys indicate the emergence of domestic CLT manufacturing ($\geq$4 factories)—with single-plant capacity reported up to ~60,000 m^3/year—and a growing number of pilot and mid-rise projects, particularly in education and public buildings. Prefabricated construction is expanding overall, providing an enabling industrial base for mass timber [78–80].

Interviews and reviews highlight code interpretation (fire/performance), limited supply chain maturity, higher upfront costs, and stakeholder familiarity as principal constraints; stakeholders call for clearer multi-standard alignment (GB 50005/GB 50016/GB-T 51226 with CLT product norms [81]), broader pilot programs, and procurement incentives to internalize carbon benefits [81,82]. It also pointed out that (1) public understanding and acceptance of modern timber building are essential factors that affect its development; reasonable market positioning can enhance the public's awareness and purchase desire. (2) As an important gatekeeper and liaison, the cost of modern timber building development has a strong role in controlling and mediating the information transmission in the network. (3) The role of government is particularly critical during the initial phases of developing

the modern timber construction sector. (4) At the same time, effective collaboration among designers, prefabrication manufacturers, and construction firms is essential, as their technical expertise strongly affects the pace and success of implementation. To accelerate the uptake of timber-based green buildings in China, broader dissemination of knowledge and training on timber technologies, material performance, and the environmental advantages of mass timber systems is required across multiple levels of practice. The insights presented in this study can serve as a valuable resource for stakeholders in mass timber construction and provide guidance for advancing more sustainable building practices in China [82].

2.2.10. Japan

Japan's forests cover ~25 million ha (≈two-thirds of national land), with ~40% as planted forests—predominantly sugi (Japanese cedar) and hinoki (cypress)—and a large share now at harvestable age; forest growing stock has continued to expand [83]. Domestic wood supply reached 34.62 million m^3 in 2022 versus total wood product demand of 85.09 million m^3 (RWE), while the timber self-sufficiency rate has risen from 18.9% (2000) to ≈41% (2021) as policy encourages greater use of domestic wood [83,84].

Japan's Building Energy Efficiency Act (2015) established performance requirements (with labeling and F.A.R. incentives), and June 2022 revisions set the trajectory for ZEH/ZEB performance in new buildings by 2030 to support 2050 carbon neutrality (Mlit 2016 [85], Japan 2025). In parallel, the Act for Promotion of Use of Wood in Public Buildings (2010) was amended in 2021 as the Act for Promotion of Use of Wood in Buildings Contributing to a Decarbonized Society, broadening promotion from public to private buildings and explicitly linking wood use to decarbonization [83,84]. Timber legality is addressed by the Clean Wood Act (2016; revised 2023), which promotes distribution and use of legally harvested wood in domestic and imported supply chains [86].

In recent years, Japan has witnessed a surge in the popularity of prefabricated wood buildings (constructed using pre-cut and pre-engineered wood components that are manufactured off-site and then assembled on-site) because of the various advantages, such as reduced time of construction, cost-effectiveness, and enhanced sustainability [87]. The Japan prefabricated wood building market is expected to witness continued growth in the coming years. Advancements in manufacturing technologies, coupled with increased awareness of sustainability, will drive the demand for wood buildings. Those ongoing efforts by the government to promote eco-friendly construction will create a favorable environment for the industry's expansion. Independent market analyses estimate Japan's timber construction market revenue at ~USD 728.6 million in 2024, with an expected CAGR of ~9.8% (2025–2033); within this, the CLT market volume is estimated at ~89,823 m^3 in 2024 with an expected CAGR ~10.8% to 2033 [88,89]. Low-rise housing remains the primary outlet for wood; 80% of one- to two-story new homes use wood framing—while the policy thrust is to expand non-residential and mid-/high-rise adoption [90,91].

Japan continues to invest in advancing modern timber construction technologies such as seismic and fire performance research for mass timber; for example, full-scale shake-table programs for 10-story mass-timber buildings contribute data for performance-based design in high seismicity [92]. Guidance documents (e.g., global fire-safe mass-timber design) and domestic practice emphasize limiting fire growth, ensuring structural fire resistance, and compartmentation consistent with building height/use.

Stakeholders point to strong policy alignment (ZEH/ZEB; wood-promotion acts; legality) and an improving domestic supply base as key enablers but also cite up-front cost, code interpretation (fire/performance), insurer acceptance, and supply chain maturity for large non-residential projects as the principal constraints. Continued expansion of JAS-graded structural supply, performance-based approvals, and standardized connection/fire

solutions are viewed as the near-term levers to scale mid-/high-rise timber [84,92]. With extensive forest resources in place, targeted wood-use promotion acts, ZEH/ZEB energy policy, and codified CLT pathways, Japan represents a high-potential growth market for mass timber—especially in non-residential and taller buildings as recent code revisions and R&D results translate into market practice [84].

2.2.11. New Zealand

New Zealand's planted production forest covers ~1.79 million ha (as of April 2024), dominated by radiata pine and supported by a mature wood-processing sector; growing stock is broadly aligned with an increasing share of domestically processed engineered wood products. Radiata pine remains the principal structural species for both light-frame and mass-timber applications [93]. In 2024, NZ's forestry contributed NZD 5.89 billion in annual export revenue—NZD 3.13 billion from logs and NZD 2.76 billion from other forest products such as sawn timber and wood pulp [93].

New Zealand has pledged, under the Paris Agreement, to align its climate efforts with limiting global warming to 1.5 °C and to achieve a net-zero carbon economy by 2050 [94]. Despite these ambitions, the *2022 Global Status Report for Buildings and Construction* highlighted that the building sector worldwide is not yet on track to meet its mid-century decarbonization goals. In 2021, buildings and construction were responsible for over one-third of global energy consumption and roughly 37% of energy- and process-related CO_2 emissions. To address this challenge domestically, New Zealand introduced the *Building for Climate Change (BfCC)* program, which sets a pathway toward "near zero carbon" buildings by 2050 [95]. Such buildings are designed to be highly energy efficient and to minimize embodied carbon, with any residual emissions managed through offsets, thereby enabling a transition to fully net-zero carbon performance.

Despite New Zealand's extensive forest resources, timber remains underutilized in larger-scale commercial and institutional construction projects [95]. Growth in wood use has been modest—around 1% annually—and the country still trails behind other leading markets such as Australia, Austria, Canada, Germany, and the United States in mass timber adoption [94]. To encourage broader uptake, the government has collaborated with Red Stag Investments Limited to launch the *Mid-Rise Wood Construction* program [96]. This initiative is projected to generate significant economic returns, with an estimated net benefit of NZD 155 million by 2023 and NZD 330 million by 2036. In New Zealand, residential currently dominates CLT uptake, with non-residential poised for growth as procurement frameworks tilt toward embodied-carbon disclosure/reduction. Government forestry reporting further indicates rising domestic demand from mass-timber customers, supporting predictable log flows into engineered-wood plants [96]. Prominent examples of mass timber developments in New Zealand include Clearwater Quays, recognized as the country's first mid-rise residential building constructed with mass timber [97,98], and the Tauranga City Council headquarters, which is expected to be the nation's largest office facility built primarily from engineered timber [99].

Industry surveys and commentary indicate strong momentum—driven by seismic resilience, construction speed, and embodied-carbon reduction—but identify recurring constraints: (i) up-front cost and supply chain depth for large non-residential projects; (ii) consenting/insurance uncertainty for exposed-timber fire strategies; and (iii) uneven experience across the delivery chain. Stakeholders emphasize the need for standardized fire/connection solutions, performance-based consenting familiarity, and long-term demand signals (public procurement, carbon caps) to de-risk investment and scale production. Recent sector reporting and practitioner research document growing market confidence alongside these challenges [100,101].

2.2.12. Norway

Norway has a substantial forest endowment: ~12.08 million ha total forest area (120,780 km^2), of which ~8.59 million ha are productive forest. The growing stock reached ~1.00 billion m^3 in 2019–2023, with an annual increment of ~24.1 million m^3; the species mix is ~44% spruce, ~31% pine and ~25% broadleaved by volume. These figures indicate long-term availability for wood construction and engineered timber feedstock [102].

Norway has introduced a range of national strategies and policy measures aimed at achieving climate neutrality by 2050, with an interim target of cutting emissions by 50–55% by 2030. These measures are increasingly shaping the construction sector. Key initiatives include (1) a commitment to fossil-free construction sites by 2025, led by Oslo in cooperation with six other major municipalities—Bergen, Drammen, Kristiansand, Stavanger, Tromsø, and Trondheim; (2) progressive tightening of the national building code, particularly regarding energy efficiency. Since 2015, minimum requirements have been set at passive house standards, and new regulations under preparation are expected to approach near-zero energy performance; (3) implementation of the sustainable public procurement law, which stipulates that environmental criteria must account for at least 30% of the weighting in public tenders [103].

In addition, since 1 July 2022 (mandatory from 1 July 2023), the building code TEK17 §17-1 requires a climate declaration (GHG account) for residential blocks and non-residential buildings, which is an explicit regulatory pull for embodied-carbon transparency and reduction [104]. Norway's technical regulations (TEK17) enable timber structures; however, for Fire Class 3 buildings (generally $\geq$5 stories), analytical (performance-based) fire design is required, driving demand for advanced fire engineering, testing, and documented solutions for exposed mass timber [104]. Norway also uses BREEAM-NOR (v6.1.1) as a widely adopted certification scheme aligned with EU Taxonomy criteria, and national roadmaps aim to tighten whole-life carbon limits in line with other Nordic countries. Major municipal programs such as FutureBuilt require pilot projects to cut GHG emissions by $\geq$50% versus business-as-usual, accelerating low-carbon materials uptake (incl. mass timber) [105].

Similarly to Sweden and Finland, Norway has an exceptionally high proportion of timber-based housing, with wooden dwellings representing around 90% of the market. In these Nordic countries, the construction sector benefits from abundant local timber resources and a well-developed supply chain, unlike in many Western European nations such as Germany. This ready access to raw material not only reduces costs but also underpins the long-standing tradition of extensive wood use in residential and other building types across the region [106].

Norway has domestic CLT and glulam manufacturing. Splitkon (Åmot) operates an industrial CLT line rated up to ~50,000 m^3/y (equipment supplier data), with trade-press reports noting a theoretical capacity up to ~100,000 m^3/year as demand scales. Moelven Limtre is a leading glulam producer supplying Nordic large-span and high-rise timber projects [107]. Norway delivered the 18-story, 85.4 m Mjøstårnet [10,11], for that time the world's tallest timber building (now the 2nd highest timber building (Figure 1))—using Moelven glulam and CLT elements—demonstrating high-rise feasibility, hybridization strategies, and performance-based fire/wind design. Norway is positioned for continued growth in non-residential and mid-/high-rise mass timber, while residential wood framing remains mature. Emerging Nordic policy work suggests progressive whole-life-carbon limit values will tighten over time, further favoring low-carbon structures and procurement of EPD-backed wood products [108,109]. In general, anchored by a large forest resource, codified climate-declaration requirements, active municipal programs, and growing CLT/GLT capacity, Norway is a high-potential market for expanding mass timber,

especially in non-residential and high-rise buildings, as performance-based fire pathways, insurer acceptance, and standardized details continue to mature.

However, it should be pointed out that a most recent study, which also calls for the new competence to be developed in the wood-based construction industry in Norway [110] with the industrial perspectives: The Norwegian wood-based construction industry is experiencing acute labor shortages, with two-thirds of firms reporting difficulties in recruiting employees with the required competences. The strongest needs lie in vocational and technical skills, particularly related to timber processing, glulam, building physics, and industrialized wood production, which are essential for efficiency and competitiveness. At the same time, generic competences such as teamwork, communication, and digital skills are increasingly emphasized, reflecting the professionalization and collaborative nature of construction projects. A notable trend is the sharp rise in demand for sustainability-related competences: over half of recent job postings highlight environmental awareness, while knowledge of life-cycle assessment (LCA) and environmental product declarations (EPDs) is gradually gaining importance. Employers also stress the value of "green attitudes," seeking candidates motivated by environmental values and willing to upskill through on-the-job training. To attract talent in a competitive labor market, companies are softening formal qualification requirements and investing heavily in lifelong learning. However, the industry faces a tension between the strategic need for innovation and sustainability expertise and the operational focus on cost efficiency and basic production skills. Addressing these competence gaps will be critical for advancing Norway's green transition in wood-based construction [110].

2.2.13. Canada

Canada has one of the world's largest forest estates (≈369 Mha; ~9% of global forests). Annual harvest is small relative to area (≈669,000 ha in 2022; ~0.2% of forest area), and deforestation rates are among the world's lowest (≤0.02%/year). Most forests are publicly owned and legally required to be regenerated, underpinning a stable, certified supply for long-lived wood products [111].

In Canada, Public Services and Procurement Canada (PSPC) now requires disclosure and is moving toward reduction in embodied carbon in major projects, aligning with the Canada Green Building Council's Zero Carbon Building (ZCB) standards that address both operational and embodied emissions. Provinces have also acted: the 2020 National Building Code of Canada (NBCC) introduced Encapsulated Mass Timber Construction (EMTC) to 12 stories; British Columbia adopted tall-wood provisions early and launched a Mass Timber Action Plan; Ontario permitted EMTC to 12 stories in 2022 and, with the 2024/2025 OBC updates, is moving to enable up to 18 stories. Several municipalities (e.g., Vancouver) have aligned bylaws to facilitate tall mass-timber [16]. Collectively, these measures expand allowable height/occupancies and strengthen the policy pull for low-carbon materials (Canadian Wood Council [112]; Canada Green Building Council [113]; Government of British Columbia [114]; Ontario [115]).

In the timber construction market, Canada is already a major adopter. Recent roadmapping estimates report almost 700 completed mass-timber buildings nationwide, with more than 140 more in construction/planning [16]. North American output was around 350,000 m^3 (2022) with at least 800,000 m^3 capacity. Canada's share includes 20 manufacturing facilities and about 0.5 million m^3 effective capacity per year, with growth targeted to CAD ~1.2 billion revenue by 2030 [16]. Canada's mass timber sector serves 25% of the world mass timber market at the current moment, values at around CAD 379 million. It is further estimated that the value of the Canadian mass timber market will increase to CAD 1.2 billion by 2030 and double that to CAD 2.4 billion by 2035. The national target envisions a

production capacity of 1 million cubic meters of Glulam, CLT, DLT, and NLT by 2030, rising to 2 million cubic meters by 2035. This goal includes achieving a 5% domestic market share of all construction materials, with timber components integrated into 25% of multi-family residential developments and non-residential buildings in the 4–6 and 7–12 story range. A key focus is on expanding the use of modular and prefabricated systems to accelerate adoption and improve efficiency [16].

The national roadmap highlights a need to vertically integrate from forest to prefabrication to ensure lamella supply, reduce logistics costs, and scale from demonstration projects to mainstream non-residential and tall residential markets. Targeted procurement, larger integrated plants, and smoother code pathways are identified as levers. In addition, it also highlights that to fully unlock potential, stakeholders consistently point to (i) continued code modernization (height/occupancy, exposure allowances), (ii) standardized insurance/risk mitigation, and (iii) supply chain integration and data-backed carbon reporting—areas now being addressed through federal standards, provincial action plans, and industry roadmaps [16].

2.3. Cross-Regional Insights and Discussion on Different Industrial Voices

A cross-national comparison reveals that mass timber construction is expanding globally but at markedly different paces, shaped by local forestry resources, regulatory frameworks, and market maturity. Europe remains the frontrunner, with strong policy support, established CLT/GLT production, and broad acceptance in both residential and non-residential markets. Countries such as Austria, Switzerland, and Germany combine sustainability strategies with industrial capacity, though challenges around fire protection, building permits, and cost competitiveness continue to slow widespread uptake. Nordic countries (Sweden, Finland, and Norway) benefit from abundant forest resources and long traditions of wood use in residential buildings but still face competence gaps in engineering, design, and large-scale prefabrication that must be addressed to sustain growth.

In North America, the U.S. and Canada represent contrasting but complementary cases. The U.S. has experienced a rapid increase in tall mass timber projects, but adoption is limited by cost perceptions, restrictive building codes, and fragmented supply chains. Industry voices emphasize the need for expanded incentives, streamlined permitting, and insurer acceptance to accelerate mainstream use. Canada, by contrast, has a more vertically integrated forestry sector and a coherent national mass timber roadmap. Its industrial voices highlight the importance of code modernization, insurance harmonization, and scaling production capacity through integrated plants and procurement frameworks to double output over the next decade.

The Asia-Pacific region presents significant growth potential. Australia and New Zealand are making important strides through targeted financing programs (e.g., *CEFC Timber Building Program*, *Mid-Rise Wood Construction Programme*), though industry stakeholders cite high upfront costs, fragmented residential markets, and limited builder experience as barriers. Japan and China represent large-scale opportunities: Japan leverages extensive domestic forest resources and strong policy frameworks promoting wood use in both public and private buildings, while China's timber market is growing under the twin drivers of "30·60" climate targets and domestic CLT production. However, both countries face familiar industrial concerns: the need for standardized fire solutions, broader industry education, and greater supply chain maturity for large-scale non-residential applications.

Across all regions, industry stakeholders highlight converging opportunities and barriers. On the opportunity side, timber construction is consistently associated with lower embodied carbon, faster prefabricated construction, biophilic design benefits, and alignment with national climate strategies. Industrial voices from Germany, the U.S., and

Norway stress timber's potential role in urban densification and affordable housing, while Canadian and Japanese experts emphasize the importance of prefabrication and modular construction in scaling adoption. On the barrier side, recurring themes include higher upfront material costs, restrictive or inconsistent building codes, insurance challenges, and gaps in technical and vocational competences. Employers across multiple countries (e.g., Norway, Sweden, and Finland) report acute labor shortages in wood-based construction, particularly in areas such as advanced timber processing, fire engineering, digital skills, and sustainability competences (LCA/EPDs).

Taken together, these insights suggest that while mass timber construction is emerging as a global low-carbon alternative to concrete and steel, its trajectory depends on addressing both technical and systemic constraints. Common needs include (i) harmonized and performance-based regulatory frameworks, (ii) stronger financial incentives and procurement policies that internalize carbon benefits, (iii) workforce upskilling to meet new competence demands, and (iv) scaling supply chain integration to reduce costs and secure consistent material quality. The cross-regional evidence points to a dual imperative: supporting innovation in tall and non-residential timber buildings while simultaneously professionalizing and expanding the skills base required to deliver sustainable and competitive wood construction at scale.

3. Results, Discussions and Conclusions

3.1. Results and Discussions

The global mass timber construction market has expanded steadily over the past decade. Growth is primarily driven by demand for low-carbon materials, while barriers remain in the form of high upfront costs, fire safety concerns, and limited supply chain capacity. Table 1 summarizes the current status and perspectives of major markets worldwide, including Europe, North America, the Asia-Pacific region, and emerging regions.

Table 1. Current status and perspectives of mass timber construction in major markets.

Country/Region	Current Status and Perspectives
Global market	USD 850M in 2021; USD 1.54 billion by 2031 (CAGR 6%). Growth driven by demand for low-carbon materials; barriers include high costs and durability concerns. CLT leads; NLT has the fastest growth. Residential dominates; commercial is the fastest-growing. Europe leads; LAMEA has the fastest growth.
Australia	The CEFC AUD 300M program supports timber uptake. Domestic production is limited; imports are high. Barriers: outdated codes, cost perception, insurer/financier hesitance. Initiatives: new codes, carbon reporting, training, and financing schemes.
The United States	More than 2000 projects completed/planned. Growth potential huge (0.4% of softwood industry). Barriers: cost, code limits, few suppliers. The 2021 IBC permits taller timber; incentives and collaboration needed to scale.
Switzerland	New EU-aligned timber regulation (2022). Growing multi-story timber sector. Drivers: prefabrication, hardwood use, and robotics/digitization. Still reliant on imports; potential in public and residential sectors.
Finland	The National Forest Strategy 2035 promotes sustainable forestry. Construction slowdown since 2022; recovery expected in 2025. Architects value wood's ecology but note cost/fire safety issues. Barriers: cost, sound/fire concerns, and knowledge gaps.
SUDOE region (Southwest France, Portugal and Spain)	Since 2013, 39 multi-story timber buildings. CLT production boosted growth. Spruce dominant, local pine/Douglas rising. Portugal: strong exports; France: RE2020 regulation and NRRP investments drive timber use. Challenges: market dynamics.

Table 1. *Cont.*

Country/Region	Current Status and Perspectives
Austria	Forests cover 48% of the land. Harvest 19.4M m^3 in 2022. Strong exports (laminated timber, parquet). Incentives: "CO_2 Bonus" subsidy. Iconic projects (HoHo Wien) illustrate advanced timber adoption.
Germany	Climate Action Plan 2050 and Forest Strategy 2050 drive wood use. Wood is ~20% of multi-story residential permits. Industry: ~75k employees, EUR 9 billion turnover. Barriers: fire safety, permits, cost. Government initiatives: "Holzbauinitiative" and "building-turbo".
China	Timber construction is <0.05% of the residential market but is growing in low-rise and public buildings. Strong policy push (NFPP, "30·60" climate targets, prefab 30% by 2025). Domestic CLT standards (LY/T 3039-2018) and mid-rise allowances up to 18 stories. Emerging supply (≥4 CLT plants), but barriers remain: cost, fire/code complexity, and limited stakeholder familiarity.
Japan	Timber construction revenue is USD ~729M in 2024; projected CAGR is ~10%. Forest-rich, rising wood self-sufficiency (~41%). Strong policy alignment (ZEH/ZEB, wood promotion acts, Clean Wood Act). Prefab wood housing dominates (80% of low-rise homes); policy focuses on scaling mid-/high-rise. Barriers: cost, insurer/code acceptance; enablers: R&D in seismic/fire safety and CLT growth.
New Zealand	The 1.79M ha plantation forest is radiata pine dominant. Forestry exports USD ~5.9 billion (2024). Mass timber is still limited, mainly residential CLT. The government BfCC program targets "near-zero" buildings by 2050. The Mid-Rise Wood Programme drives uptake; notable projects include Clearwater Quays and Tauranga Council HQ. Constraints: cost, fire consenting, uneven supply chain. Growing momentum in non-residential.
Canada	The world's second largest mass timber market after Europe. Approximately 700 completed projects; 140+ underway. Market USD ~379M in 2024, forecast USD ~1.2 billion by 2030, USD ~2.4 billion by 2035. Strong provincial policies (e.g., BC, Ontario) allow 12–18 story EMTC. ~20 production facilities, ~0.5M m^3 CLT/GLT capacity. Barriers: insurance, logistics, and supply chain integration. Opportunities: scaling prefab, code modernization, and procurement incentives.

From Table 1, it can be seen that the key patterns of global timber construction market include the following:

- Europe maintains global leadership, underpinned by strong climate policy, advanced CLT/GLT production, and growing mid- and high-rise timber adoption. Europe accounts for more than half of global revenue and remains the most advanced market. Austria and Switzerland have strong export-oriented timber industries; Germany integrates timber into national climate strategies; and the Nordic countries continue to rely heavily on wood-frame traditions while moving toward high-rise timber. Policies such as France's RE2020 and the German Holzbauinitiative provide regulatory pull, while digitalization and prefabrication improve competitiveness. Challenges persist in fire protection and labor shortages. Some countries in Europe, such as Switzerland, Norway, Finland, Austria and Germany, emphasize sustainability, digitalization, and regulatory innovation but echo recurring constraints of cost, permitting, and skills gaps.
- North America shows rapid project growth (particularly the U.S.) but still faces cost, code, and insurance barriers; Canada benefits from a more integrated strategy and significant production capacity.
- Australia and New Zealand advance through targeted financial programs (e.g., *CEFC Timber Building Program*, *Mid-Rise Wood Programme*), though domestic uptake remains uneven.

- Japan and China represent large-scale opportunities, supported by strong forest resources and government policies. Both countries, however, face technical and market challenges such as fire design, insurer acceptance, and supply chain maturity.

The industry stakeholders across nations and regions consistently highlight both opportunities and barriers. Opportunities include reduced embodied carbon, faster prefabricated construction, and biophilic design benefits. Barriers include higher upfront material costs, fragmented approval processes, and limited technical expertise. Voices from architects, engineers, developers, and policymakers converge on the need for the following:

- Harmonized building codes (especially performance-based fire safety);
- Expanded financial incentives and procurement frameworks that internalize carbon benefits;
- Supply chain integration and scaling of prefabrication;
- Workforce upskilling to address gaps in timber engineering, digital construction, and sustainability competences.

These results suggest that while adoption pathways differ across countries, the global mass timber movement is shaped by the interplay of policy frameworks, industrial capacity, and market perception.

3.2. Conclusions

This review highlights that mass timber is no longer confined to niche applications but is increasingly positioned as a mainstream low-carbon building material. Key conclusions include the following:

- Market growth trajectory: The global market is expected to nearly double from 2021 to 2031, with Europe leading and the Asia-Pacific region showing the fastest growth potential.
- Opportunities: Carbon reduction, speed of construction, prefabrication, and biophilic benefits make timber an attractive alternative to steel and concrete.
- Barriers: Common hurdles include high upfront costs, regulatory and fire safety challenges, insurance constraints, and limited technical skills.
- Regional contrasts: Europe and Canada illustrate the benefits of integrated policy and industrial ecosystems; the U.S. demonstrates rapid project expansion but fragmented frameworks; Australia and New Zealand rely on targeted financing to overcome supply chain gaps; and China and Japan highlight how large markets can be mobilized by strong policy but still face cultural and technical barriers.
- Cross-cutting needs: Harmonized codes, financial and procurement incentives, integrated supply chains, and workforce training are the most frequently cited levers for scaling up adoption.

Overall, the evidence indicates that mass timber construction is at a tipping point: technical feasibility and market demand are clear, but widespread adoption depends on addressing systemic challenges. Future progress will rely on coordinated action among policymakers, industry stakeholders, and researchers to mainstream timber as a core material in the global low-carbon construction transition.

Funding: This work was funded by Fachagentur Nachwachsende Rohstoffe e. V. (FNR, Agency for Renewable Resources), founded by Bundesministerium für Ernährung und Landwirtschaft (BMEL, Federal Ministry of Food and Agriculture of Germany), under the project "Erstellung eines Leitfadens zum Bauen mehrgeschossiger Gebäude mit Holz unter expliziter Berücksichtigung von Windlasten" (Grant Nos.: 2221HV069A, 2221HV069B) and the project "Nachwuchsgrupp: Langzeitverhalten von klebstoffgebundenen Holz mit Faser-Kunststoff-Verbund und Holz-Beton-Verbund Hybridsystemen für Gebaute Nachhaltigkeit—Akronym: HolzFKV-HolzHBV-Bau (Grant No.: 22011617)". The authors

also would like to extend their gratitude to colleagues from Novicos GmbH, Kaden+Lager GmbH, C4 Engineers GmbH, and Knippershelbig GmbH for discussions on German timber construction status. The APC was funded by Publication Fund provided by TU Braunschweig.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. United Nations Environment Programme. 2020 Global Status Report for Buildings and Construction. 2020. Available online: https://globalabc.org/sites/default/files/inline-files/2020%20Buildings%20GSR_FULL%20REPORT.pdf (accessed on 29 November 2024).
2. Ramage, M.H.; Burridge, H.; Busse-Wicher, M.; Fereday, G.; Reynolds, T.; Shah, D.U.; Wu, G.; Yu, L.; Fleming, P.; Densley-Tingley, D.; et al. The wood from the trees: The use of timber in construction. *Renew. Sustain. Energy Rev.* **2017**, *68*, 333–359. [CrossRef]
3. Gustavsson, L.; Pingoud, K.; Sathre, R. Carbon dioxide balance of wood substitution: Comparing concrete- and wood-framed buildings. *Mitig. Adapt. Strateg. Glob. Change* **2006**, *11*, 667–691. [CrossRef]
4. Jones, D.; Brischke, C.; Humar, M. The Role of Timber in a Circular Bioeconomy. *Eur. J. Wood Sci.* **2016**, *74*, 15–26.
5. Green, M.; Karsh, E. The Case for Tall Wood Buildings. 2012. Available online: https://cwc.ca/wp-content/uploads/2020/06/Second-Edition-The-Case-for-Tall-Wood-Buildings.pdf (accessed on 27 August 2025).
6. Mishra, A.; Humpenöder, F.; Churkina, G.; Reyer, C.P.O.; Beier, F.; Bodirsky, B.L.; Schellnhuber, H.J.; Lotze-Campen, H.; Popp, A. Land use change and carbon emissions of a transformation to timber cities. *Nat. Commun.* **2022**, *13*, 4889. [CrossRef] [PubMed]
7. Pramreiter, M.; Nenning, T.; Malzl, L.; Konnerth, J. A plea for the efficient use of wood in construction. *Nat. Rev. Mater.* **2023**, *8*, 217–218. [CrossRef]
8. Stora, E. Mjøstårnet: The Tallest Timber Building. 2020. Available online: https://www.storaenso.com/-/media/documents/download-center/documents/annual-reports/2020/storaenso_annual_report_2020.pdf (accessed on 27 August 2025).
9. Hines. T3 Collingwood. 2023. Available online: https://www.hines.com/properties/t3-collingwood-melbourne (accessed on 27 August 2025).
10. Tensorflight. Mjøstårnet. A Wooden Skyscraper. 2025. Available online: https://tensorflight.com/mjostarnet-a-wooden-skyscrapper/ (accessed on 10 July 2025).
11. Wikipedia. 2025. Available online: https://de.m.wikipedia.org/wiki/Datei:Mj%C3%B8st%C3%A5rnet.jpg (accessed on 18 August 2025).
12. Wiehag. Ascent Tower. 2025. Available online: https://www.wiehag.com/en/references/ascent-tower/ (accessed on 10 July 2025).
13. ICC. International Building Code (IBC). 2021. Available online: https://codes.iccsafe.org/content/IBC2021P2 (accessed on 15 March 2025).
14. Espinoza, O.; Laguarda-Mallo, M.F.; Buehlmann, U. Mass Timber: US Market Outlook and Policy Landscape. *For. Prod. J.* **2019**, *69*, 232–243.
15. Prnewswire. Mass Timber Construction Market to Reach $1.5 Billion, Globally, by 2031 at 6.0% CAGR: Allied Market Research. 2023. Available online: https://www.prnewswire.com/news-releases/mass-timber-construction-market-to-reach-1-5-billion-globally-by-2031-at-6-0-cagr-allied-market-research-301814502.html (accessed on 16 November 2024).
16. Allan, B.; Eaton, D.; Leung, P. The Mass Timber Roadmap—An Integrated Forest-to-Buildings Value Chain. 2024. Available online: https://transitionaccelerator.ca/wp-content/uploads/2024/06/MT_Roadmap_Digital_vf.pdf (accessed on 18 December 2024).
17. Churkina, G.; Organschi, A.; Reyer, C.P.O.; Ruff, A.; Vinke, K.; Liu, Z.; Reck, B.K.; Graedel, T.E.; Schellnhuber, H.J. Buildings as a global carbon sink. *Nat. Sustain.* **2020**, *3*, 269–276. [CrossRef]
18. Riddle Anne, A. Mass Timber: Overview and Issues for Congress. Congressional Research Service (CRS) Reports and Issue Briefs. 2023. Available online: https://www.congress.gov/crs-product/R47752 (accessed on 28 August 2025).
19. Abed, J.; Rayburg, S.; Rodwell, J.; Neave, M. A Review of the Performance and Benefits of Mass Timber as an Alternative to Concrete and Steel for Improving the Sustainability of Structures. *Sustainability* **2022**, *14*, 5570. [CrossRef]
20. Ayanleye, S.; Udele, K.; Nasir, V.; Zhang, X.F.; Militz, H. Durability and protection of mass timber structures: A review. *J. Build. Eng.* **2022**, *46*, 103731. [CrossRef]
21. Nath, S.K. Use Wood—Combat Climate Change. In *Wood Is Good: Current Trends and Future Prospects in Wood Utilization*; Springer: Singapore, 2017; pp. 469–478.
22. Safarik, D.; Jacob, E.; Miranda, W. State of tall timber 2022. *CTBUH J.* **2022**, *2022*, 22–31.
23. VSJF. Fairbanks Museum Home to Vermont's First Demonstration Mass Timber Building. 2023. Available online: https://www.vsjf.org/2023/05/15/fairbanks-museum-home-to-vermonts-first-demonstration-mass-timber-building/ (accessed on 29 August 2025).
24. European Commission. *New EU Forest Strategy for 2030—Communication COM (2021) 572 Final*; European Commission: Brussels, Belgium, 2021.

25. Advance-Timber-Hub. Australian Government Signs Up to Increase the Use of Timber in Buildings by 2030. 2024. Available online: https://www.advance-timber-hub.org/media-releases/australian-government-signs-up-to-increase-the-use-of-timber-in-buildings-by-2030/ (accessed on 16 November 2024).
26. Forest2market. Australia's Growthig Market for Cross-Laminated Timber. 2024. Available online: https://www.forest2market.com/blog/australias-growing-market-for-cross-laminated-timber (accessed on 16 November 2024).
27. *AS1684.4*; Residential Timber Framed Construction. Standards Australia Technical Committee: Sydney, Australia, 2024.
28. *AS1720.1*; Australian Standard for Timber Structures. Standards Australia Technical Committee: Sydney, Australia, 2022.
29. *EN 1995-1-1*; Eurocode 5: Design of Timber Structures—Part 1-1: General—Common Rules and Rules for Buildings. European Standard: Brussels, Belgium, 2004.
30. Ross, J. New QLD Premier's $7B Pledge for 'Greener' Olympic Venues: What's Next? 2023. Available online: https://woodcentral.com.au/brisbane-olympics-7b-pledge-for-greener-venues-whats-next/ (accessed on 16 November 2024).
31. Wijeratne, C.; Lavisci, P. Investing in mass timber construction in Australia: The clan energy finance corporation timber building program. In Proceedings of the Wolrd Conference on Timber Enginering, Oslo, Norway, 19–22 June 2023.
32. England, P.; Bennetts, I. *Fire Safety Design of Midrise Timber Buildings*; WoodSolutions: Melbourne, Australia, 2016.
33. Chapa, J.; Cornell, T.; Barbov, N.; Bezzina, E.; Wouters, T. *Driving Responsible Products in the Built Environment—Changes to Green Star Buildings and Our Strategy for the Future*; Green Building Council of Australia: Barangaroo, Australia, 2021.
34. Vickers, J.; Sullivan, N.; Davies, A.; Kogileru, T.; Wouters, T. *Embodied Emissions Technical Report*; NABERS: Parramatta, Australia, 2022.
35. Materials and Embodied Carbon Leaders Alliance: MECLA Partners. 2023. Available online: https://mecla.org.au/partners (accessed on 30 November 2024).
36. Whyte, S.; Kaburagi, R.; Gan, V.; Candido, C.; Avazpour, B.; Fatourehchi, D.; Chan, H.F.; Dong, Y.; Dulleck, U.; Finlay, S.; et al. Exploring the Benefits of Mass Timber Construction in the Workplace: A Novel Primer for Research. *Buildings* **2024**, *14*, 2072. [CrossRef]
37. Ross, J. Mass Timber Coluld Surge 25-Fold: Is US Ready Fort All-Timber Boom? 2024. Available online: https://woodcentral.com.au/mass-timber-could-surge-25-fold-fueled-by-us-south-high-rise/ (accessed on 29 August 2024).
38. Woodworks. Mass Timber Project Designed and Constructed in the US (June 2025). 2025. Available online: https://www.woodworks.org/wp-content/uploads/WoodWorks-Mass-Timber-Projects-June-2025.png (accessed on 19 August 2025).
39. Woodworks. Mapping Mass Timber. 2024. Available online: https://www.woodworks.org/resources/mapping-mass-timber/ (accessed on 11 November 2024).
40. Wingo, L. The Obstacles Opportunities of Mass Timber Construction in the, U.S. 2024. Available online: https://www.arup.com/insights/the-obstacles-and-opportunities-of-mass-timber-construction-in-the-us/ (accessed on 22 December 2024).
41. UNECE. 2023 Country Market Statements. *Austrian Market Report 2023*. 2023. Available online: https://unece.org/forests/2023-country-market-statements (accessed on 22 December 2024).
42. Forest Europe 2020. Implementation of the Forest Europe Commitments. National and Pan-European Actions 2016–2020. 2020. Available online: https://foresteurope.org/wp-content/uploads/2016/08/Implementation-of-the-FOREST-EUROPE-Commitments.pdf (accessed on 22 December 2024).
43. Waldinventur. 2024. Available online: https://www.waldinventur.at/#/ (accessed on 22 December 2024).
44. Econmove, Economica. The ECONOMIC impact of the Forestry and Wood Industry in Europe in Terms of Bioeconomy, Vienna. 2023. Available online: https://www.forstholzpapier.at/images/fhp_0623_studie_EN_web.pdf (accessed on 22 December 2024).
45. Swedish Forest Agency. Market Statement 2022—Sweden: UNECE Committee on Forest and the Forest Industry and European Foresty Commission (Foresta 2022). 2022. Available online: https://unece.org/sites/default/files/2022-10/sweden-country-market-statement-2022.pdf (accessed on 24 November 2024).
46. Schafer, A. 2022 Market Statement for Switzerland Developments in Forest Product Markets. Seoul, Republic of Korea. 2022. Available online: https://unece.org/sites/default/files/2022-11/switzerland-country-market-statement-2022.pdf (accessed on 24 November 2024).
47. Färnström, I. Market Development for Multi-Story Wood Construction—Views of Architects and Structural Engineers. Master's Thesis, Faculty of Forest Sciences, Swedish University of Agricultural Sciences, Uppsala, Sweden, 2022.
48. Natural Resources Institute Finland. Forest Sector Market Statement for Finland 2023. 2023. Available online: https://unece.org/sites/default/files/2023-11/Market%20statement%20Finland%202023.pdf (accessed on 22 December 2024).
49. Ilgın, H.E.; Karjalainen, M.; Pelsmakers, S. Finnish architects' attitudes towards multi-storey timber-residential buildings. *Int. J. Build. Pathol. Adapt.* **2024**, *42*, 352–368. [CrossRef]
50. Basterra, L.A.; Baño, V.; López, G.; Cabrera, G.; Vallelado-Cordobés, P. Identification and Trend Analysis of Multistorey Timber Buildings in the SUDOE Region. *Buildings* **2023**, *13*, 1501. [CrossRef]
51. Timberfinance. Frence Residential Market. 2024. Available online: https://timberfinance.ch/en/france-construction-activity/ (accessed on 22 December 2024).
52. Statistics Portugal. *Estatísticas da Construção e Habitação—2021*; Lisboa Instituto Nacional de Estatística: Lisbon, Portugal, 2023.

53. European Construction Sector Observatory 2022-Country Profile France. 2022. Available online: https://single-market-economy.ec.europa.eu/document/download/ac4e49de-9746-43b6-a6ca-084c98a072d1_en (accessed on 22 December 2024).
54. BMEL. Forestry Strategy 2050. 2024. Available online: https://www.bmel.de/DE/themen/wald/waldstrategie2050.html (accessed on 22 December 2024).
55. UNECE. 2023 Country Market Statements German Market Report 2023. *2023 Country Market Statements*. 2023. Available online: https://unece.org/sites/default/files/2023-10/Market%20Statement_81th%20COFFI_Germany.pdf (accessed on 22 December 2024).
56. BMUB. 2024. Available online: http://www.bmub.bund.de/themen/klima-energie/klimaschutz/klima-klimaschutz-download/artikel/klimaschutzplan-2050/?tx_ttnews%5BbackPid%5D=3915 (accessed on 20 December 2024).
57. DW. German Housing Crisis: Government Plans Construction Boost. 2025. Available online: https://www.dw.com/en/german-government-plans-construction-boost-amid-major-housing-shortage/a-73351540 (accessed on 8 August 2025).
58. BMWSB. Auch in 2026: Kabinett Beschließt Rekordetat des Bundesbauministeriums. 2025. Available online: https://www.bmwsb.bund.de/SharedDocs/pressemitteilungen/DE/2025/07/haushalt.html?nn=42820 (accessed on 8 August 2025).
59. Holzbau Deutschland. Lagebericht 2023. 2023. Available online: https://www.holzbau-deutschland.de/fileadmin/user_upload/eingebundene_Downloads/Lagebericht_2023_mit_Statistiken.pdf (accessed on 15 March 2025).
60. Knippershelbig. The Cradle. 2025. Available online: https://www.knippershelbig.com/en/projects/the-cradle/ (accessed on 10 July 2025).
61. Holzbauoffensivebw. Skaio—Germany's First Wood-Hybrid High-Rise Building. 2025. Available online: https://www.holzbauoffensivebw.de/de/frontend/product/detail?productId=4 (accessed on 8 July 2025).
62. Lagerschwertfeger. Skaio Project. 2025. Available online: https://www.lagerschwertfeger.de/projekte/skaio (accessed on 8 July 2025).
63. Von-Fragstein. 2025. Available online: https://www.von-fragstein.com/referenzen/mehrgeschossiger-holzbau/skaio-heilbronn/ (accessed on 19 August 2025).
64. Kadenplus. WA 16 West Project. 2025. Available online: https://www.kadenplus.de/projekt/pe16w (accessed on 8 July 2025).
65. Bauart-Ingenieure. WA 16 West Project. 2025. Available online: https://www.bauart-ingenieure.de/projekt/pep-wa-16-west-muenchen/ (accessed on 8 July 2025).
66. Baunetzwissen. 2024. Available online: https://www.baunetzwissen.de/brandschutz/fachwissen/sonderbauten/hochhaeuser-3154225 (accessed on 22 December 2024).
67. Margulesgroome. Market Potential of Structural Timber for Chinese Wood-Frame Construction Industry. 2018. Available online: https://margulesgroome.com/publications/market-potential-of-structural-timber-for-chinese-wood-frame-construction-industry/#:~:text=Currently%2C%20wood%20frame%20construction%20represents%20a%20minor,brick%20and%20mortar%20construction%20dominates%20the%20market (accessed on 28 August 2025).
68. Edgebuildings. China—Green Building Market Snapshot 2020. 2023. Available online: https://edgebuildings.com/wp-content/uploads/2023/11/IFC0077-2023-China-Green-Building-Market-Maturity-Sheet.pdf (accessed on 28 August 2025).
69. Chineseclimatepolicy. Guide to Chinese Climate Policy: 23. Forestry. 2025. Available online: https://chineseclimatepolicy.oxfordenergy.org/book-content/domestic-policies/forestry/ (accessed on 26 August 2025).
70. Climatepolicydatabase. The 14th Five-Year Plan for the Development of Forestry and Grassland Conservation (2021–2025) China (2021). 2025. Available online: https://climatepolicydatabase.org/policies/14th-five-year-plan-development-forestry-and-grassland-conservation-2021-2025 (accessed on 25 August 2025).
71. Zhai, Y.K.; Li, Y.N.; Tang, S.; Liu, Y.X.; Liu, Y.Z. Lightweight strategies for wooden-structure buildings based on embodied carbon emission calculations for carbon reduction. *Buildings* **2024**, *14*, 3460. [CrossRef]
72. *GB 50005-2017*; Standard for Design of Timber Structures. National Standard of China: Beijing, China, 2017.
73. *GB/T 51226-2017*; Technical Standard for Multi-Story and High-Rise Timber Buildings. Chinse National Standard: Beijing, China, 2017.
74. *LY/T3039-2018*; Cross Laminated Timber. Forestry Industry Standard of China: Beijing, China, 2018.
75. *GB 50016*; Code for Fire Protection Design of Buildings. National Standard of China: Beijing, China, 2018.
76. *GB/T 50378-2019*; Assessment Standard for Green Building. Chinese Standards: Beijing, China, 2019.
77. Wang, Z.Q.; Yin, T.X. *Cross-Laminated Timber: A Review on Its Characteristics and an Introduction to Chinese Practices*; IntechOpen: London, UK, 2021. [CrossRef]
78. Luo, T.; Xue, X.L.; Wang, Y.N.; Xue, W.R.; Tan, Y.T. A systematic overview of prefabricated construction policies in China. *J. Clean. Prod.* **2021**, *280*, 124371. [CrossRef]
79. USDA. Solid Wood Annual 2024 for The People's Republic of China. 2024. Available online: https://www.fas.usda.gov/data/china-solid-wood-annual-2024 (accessed on 27 August 2025).
80. Lu, H.Y.; You, K.R.; Feng, W.; Zhou, N.; Fridley, D.; Price, L.; de la Rue du Can, S. Reducing China's building material embodied emissions: Opportunities and challenges to achieve carbon neutrality in building materials. *iScience* **2024**, *27*, 109028. [CrossRef]

81. Li, H.M.; Li, J.J. Prospects for the application of modern wood construction in China based on SWOT analysis: Towards socially sustainable cities. *J. Arts Cult. Stud.* **2023**, *2*, 1–14. [CrossRef]
82. Du, Q.; Zhang, R.; Cai, C.; Jin, L. Factors Influencing Modern Timber Structure Building Development in China. *Sustainability* **2021**, *13*, 7936. [CrossRef]
83. Maff. *Annual Report on Forest and Forestry in Japan*; Ministry of Agriculture, Forestry, and Fisheries: Tokyo, Japan, 2022; Available online: https://www.maff.go.jp/e/data/publish/attach/pdf/index-193.pdf (accessed on 28 August 2025).
84. Yamashita, N.; Fishman, T.; Kayo, C.; Tanikawa, H. An interlinked dynamic model of timber and carbon stocks in Japan's wooden houses and plantation forests. *Sustain. Prod. Consum.* **2024**, *52*, 314–323. [CrossRef]
85. Mlit. Overview of the Art on the Improvement of Energy Consumption Performance of Buildings. 2016. Available online: https://www.mlit.go.jp/common/001134876.pdf (accessed on 28 August 2025).
86. Fujisaki, T. Policies and Initiatives for Sustainable Wood Use Promotion by Public and Private Sectors in Japan. 2023. Available online: https://www.rinya.maff.go.jp/j/boutai/attach/pdf/japan_policy.pdf (accessed on 28 August 2025).
87. Forestpolicy. Japan Revised Clean Wood Act (Act to Partially Amend the Act on Promotion of Use and Distribution of Legally-Harvested Wood and Wood Products). 2025. Available online: https://forestpolicy.org/policy-law/japan-revised-clean-wood-act (accessed on 22 August 2025).
88. Markwideresearch. Japan Prefab Wood Building Market Analysis—Industry Size, Share, Research Report, Insights, COVID-19 Impact, Statistics, Trends, Growth and Forecast 2025–2034. 2025. Available online: https://markwideresearch.com/japan-prefab-wood-building-market/ (accessed on 28 August 2025).
89. Grandviewresearch. Japan Timber Construction Market Size & Outlook, 2024–2033. 2025. Available online: https://www.grandviewresearch.com/horizon/outlook/timber-construction-market/japan (accessed on 22 August 2025).
90. Imarcgroup. Japan Cross Laminated Timber (CLT) Market Report by Application (Residential, Government/Public Buildings, Commercial Buildings, Educational Institutes) 2025–2033. 2025. Available online: https://www.imarcgroup.com/japan-cross-laminated-timber-market (accessed on 22 August 2025).
91. USDA. JAS Program Supports Domestic Lumber in Japan. 2020. Available online: https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=JAS+Program+Supports+Domestic+Lumber_Tokyo_Japan_04-20-2020 (accessed on 27 August 2025).
92. Tachibana, K.; Nagashima, T.; Pei, S.L.; Isoda, H.; Miyazaki, T.; Abe, S.; van de Lindt, J.W.; Pryor, S.E. Shake table test of a full-scale ten-story mass timber building designed with Japanese building standard law. *Eng. Struct.* **2025**, *343*, 120851. [CrossRef]
93. MPI. Forestry and Wood Processing Data. 2025. Available online: https://www.mpi.govt.nz/forestry/forest-industry-and-workforce/forestry-wood-processing-data/ (accessed on 22 August 2025).
94. MBIE. Building and Construction Sector Trends. 2023. Available online: https://www.mbie.govt.nz/assets/building-and-construction-sector-trends-annual-report-2023.pdf (accessed on 28 August 2025).
95. A Plea for the Efficient Use of Ministry for Primary Industries. Mid-Rise Wood Construction. 2022. Available online: https://www.mpi.govt.nz/funding-rural-support/primary-growth-partnerships-pgps/currentpgp-programmes/mid-rise-wood-construction/ (accessed on 28 August 2025).
96. Midrisewood. 2025. Available online: https://midrisewood.co.nz/ (accessed on 22 August 2025).
97. Imarc. Australia and New Zealand Cross Laminated Timber (CLT) Market Size, Share, Trends and Forecast by Application, 2025–2033. 2025. Available online: https://www.imarcgroup.com/australia-newzealand-clt-market (accessed on 28 August 2025).
98. WoodWorks. Clearwater: Showcase for Sequestration. 2023. Available online: https://woodworks.events/clearwater-showcase-for-sequestration/ (accessed on 11 November 2024).
99. Tauranga City Council. New Zealand's Largest Mass Timber Office Building Coming to Town. 2023. Available online: https://www.tauranga.govt.nz/council/council-news-andupdates/latest-news/artmid/456/articleid/8672 (accessed on 28 August 2025).
100. Wong, F.P.W.; Oldfield, P.; Osmond, P. Industry perceptions of mass engineered timber (MET) construction: A comparison of South-East Asia with other regions. *Archit. Eng. Des. Manag.* **2024**, *20*, 1543–1565. [CrossRef]
101. Building. Climate Change Work Programme. 2025. Available online: https://www.building.govt.nz/getting-started/climate-change-work-programme (accessed on 22 August 2025).
102. Statistics Norway. The National Forest Inventory. 2025. Available online: https://www.ssb.no/en/jord-skog-jakt-og-fiskeri/skogbruk/statistikk/landsskogtakseringen (accessed on 22 August 2025).
103. RVO. Market Study: Sustainable Building in Norway. 2021. Available online: https://www.rvo.nl/sites/default/files/2021/06/Norway-Sustainable-Building-Market-Study-2021.pdf (accessed on 28 August 2025).
104. DIBK. Building Technology Regulations (TEK17) with Guidance. 2025. Available online: https://www.dibk.no/regelverk/byggteknisk-forskrift-tek17/17/17-1 (accessed on 23 August 2025).
105. Byggalliansen. BREEAM-NOR v6.1.1 New Construction. 2025. Available online: https://byggalliansen.no/wp-content/uploads/2025/01/BREEAM-NOR-6.1.1-English.pdf (accessed on 22 August 2025).
106. Zahiri, N. Timber high-rises in Nordic countries: Current trends. *CTBUH J.* **2023**, *2023*, 44–50.

107. Ledinek. Complete CLT Manufacturing Facility for Splitkon AS in Norway. 2025. Available online: https://www.ledinek.com/clt-production-line-norway (accessed on 23 August 2025).
108. FutureBuilt. What is FutureBuilt? 2025. Available online: https://www.futurebuilt.no/English (accessed on 23 August 2025).
109. Nordic Innovation. Harmonised Carbon Limit Values for Buildings in Nordic Countries. 2024. Available online: https://pub.norden.org/us2024-415/us2024-415.pdf (accessed on 28 August 2025).
110. Skatvedt, K.A.; Ullah, S.; Normann, H.E.; Ingeborgrud, L. Competence needs in the wood-based construction industry in Norway. *For. Policy Econ.* **2025**, *178*, 103589. [CrossRef]
111. Natural Resources Canada. How Much Forest Does Canada Have? 2025. Available online: https://natural-resources.canada.ca/forest-forestry/state-canada-forests/much-forest-does-canada-have? (accessed on 23 August 2025).
112. Canadian Wood Council. Encapsulated Mass Timber Construction. 2025. Available online: https://cwc.ca/articles/encapsulated-mass-timber-construction/ (accessed on 23 August 2025).
113. Canada Green Building Council. Zero Carbon Building—Design Standard Version 3. 2024. Available online: https://www.cagbc.org/wp-content/uploads/2022/06/CAGBC_Zero_Carbon_Building-Design_Standard_v3.pdf (accessed on 18 December 2024).
114. British Columbia. Mass Timber Action Plan. 2024. Available online: https://www2.gov.bc.ca/gov/content/industry/construction-industry/mass-timber/mass-timber-action-plan (accessed on 23 August 2025).
115. Ontario. Building Code updates. 2025. Available online: https://www.ontario.ca/page/building-code-updates (accessed on 26 August 2025).

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.