Wood it be possible: Constructing timber houses in the Netherlands

A. Horsting, P.J. Woltjer, A. van Eckeveld, U.G.W. Sass-Klaassen

WAGENINGEN
UNIVERSITY & RESEARCH

TRANSFORMATIVE
Bioeconomies

Wood it be possible: Constructing timber houses in the Netherlands

A. Horsting,[1] P.J. Woltjer,[1] A. van Eckeveld,[2] U.G.W. Sass-Klaassen[2, 3]

1 Wageningen Economic Research

2 Van Hall Larenstein

3 Wageningen University

This study was carried out by Wageningen Economic Research and was commissioned and subsidised by the Dutch Ministry of Agriculture, Nature and Food Quality within the context of the investment theme Transformative Bioeconomies: Towards a materials transition that phases out fossil feedstock (Project number: KB 45-005-012)

Wageningen Economic Research
Wageningen, January 2024

REPORT
2024-005
ISBN 978-94-6447-182-3

Horsting, A., P.J. Woltjer, A. van Eckeveld, U.G.W. Sass-Klaassen, 2024. *Wood it be possible: Constructing timber houses in the Netherlands.* Wageningen, Wageningen Economic Research, Report 2024-005. 26 pp.; 1 fig.; 1 tab.; 30 ref.

The Dutch government has set a target to build 900,000 new houses by 2030, with a focus on circular and sustainable materials, such as wood. This study aims to identify the underlying barriers and enablers to realise more timber constructions in the Netherlands. To categorise the different barriers and enablers we rely on the COM-B framework which distinguishes capability, opportunity, and motivation of system behaviour. We found that stakeholders, throughout the construction chain, remain positive, with significant investments in timber construction indicating potential growth. However, advocating for timber construction's environmental benefits in industry assessments is necessary to ensure fair competition with traditional materials.

Key words: Wooden house construction, timber houses, wooden houses, timber construction, the Netherlands, housing expansion goal, barriers, enablers

This report can be downloaded for free at https://doi.org/10.18174/646111 or at www.wur.eu/economic-research (under Wageningen Economic Research publications).

P.O. Box 29703, 2502 LS The Hague, The Netherlands, T +31 (0)70 335 83 30,
E communications.ssg@wur.nl, http://www.wur.eu/economic-research. Wageningen Economic Research is part of Wageningen University & Research.

Wageningen Economic Research Report 2024-005 | Project code 2281100005

Cover photo: Shutterstock

Contents

Preface

This project has been funded by the investment theme Transformative Bioeconomies: Towards a materials transition that phases out fossil feedstock.

To phase out fossil feedstock transformative changes are essential. Therefore, within this project we explore the barriers and enablers of constructing with wood in the Netherlands.

Ir. O. (Olaf) Hietbrink
Business Unit Manager Wageningen Economic Research
Wageningen University & Research

Summary

S.1 Main research question

The main research question of this study was: *What are the underlying structural barriers and enablers in wooden house construction in the Netherlands that stand in the way or facilitate the realisation of the Dutch government's sustainable housing expansion goal?*

S.2 Background

The Dutch government has set a target to build 900,000 new houses by 2030, with a focus on circular and sustainable methods using renewable and partly locally sourced material, such as wood. To support these goals, a transformation in the supply chain of timber constructions as well as an overhaul of construction practices in the Netherlands is needed.

Previous research has concentrated on the local availability of timber for house construction. This research concluded that the Dutch forestry, timber processing, and construction industries are currently unable to satisfy the goals set out by the government. However, there is still a lack of knowledge about other factors that currently hinder or facilitate the ambition to increase the share of wooden house construction. This study aims to categorise the different barriers and enablers by taking a closer look at critical elements related to system behaviour: Capability, Opportunity, and Motivation. In the context of wooden house constructions, 'capability' ensures that a person can physically construct the house and has the necessary knowledge to do so effectively. 'Opportunity' refers to external factors that currently obstruct (barrier) or facilitate (enabler) to increase the share of wooden constructions. 'Motivation' focuses on beliefs and emotions behind choosing or not choosing wooden house construction.

In the realm of timber construction, *capability barriers* include knowledge gaps across the entire chain starting from wood-quality selection, through commissioning, design, construction, until practical implementation. This knowledge gap appears to be the result of a longstanding dominance of concrete and steel in construction, leaving many industry professionals unfamiliar with wood as a primary material. This is compounded by outdated educational curricula and insufficient knowledge transfer among stakeholders across the entire value chain, which lead to projects that lack scalability and collaboration. However, enablers from European regions with more expertise in wooden construction, such as Scandinavia, offer valuable lessons. Investments in timber projects are increasing, and technological advancements (new timber products) are optimising the construction process and diversifying the construction possibilities (frame constructions, panel constructions (CLT)). A rise in specialised training programmes and knowledge sharing on critical aspects related to building with timber through digital platforms is helping to close the expertise gap.

Opportunity barriers in wooden house construction are multifaceted, ranging from complex supply chains and capacity constraints in timber mills to regulatory inconsistencies (e.g. wood certification) and technical challenges such as durability of wooden constructions (no rotting), fire safety and structural acoustic vibrations. These issues not only hamper immediate material availability and challenge construction designs but may also result in high initial costs and a lack of streamlined construction processes. However, enablers are emerging in the form of regulatory movements towards standards, which, if implemented correctly, could make wood construction more cost-effective. The growing demand for sustainable methods, alongside advancements in prefabrication, but also recycling, is supporting the shift towards timber as renewable material in both national and international markets.

Motivation barriers are deeply rooted in historical biases and (partly) misconceptions about wood's sustainability, with respect to the way of harvesting, and structural properties, with concerns about fire hazards, durability, and acoustic insulation still prevalent. Both, sustainability and material properties, still deserve special attention and expertise when working with wood – a renewable and biobased material.

Despite these barriers, which are currently addressed through sustainable forest management and technical innovations, the motivations for timber construction are shifting in a positive direction, driven by its benefits for healthy living environments, sustainability, and economic efficiency. Consumers' growing eco-consciousness and the recognition of wood as renewable material and hence its intrinsic circular economy alignment is strengthening the case for wood as a material for the future, reflecting a favourable trend towards timber construction.

The Dutch construction industry is witnessing a significant pivot towards sustainability, with a growing interest in timber construction. Over 60 companies have now established specialised departments for timber construction, with both timber frame construction and particularly cross-laminated timber (CLT) becoming prominent. This starting evolution from a niche interest towards a more mainstream practice has already enhanced the sector's professional expertise, narrowed the knowledge and cost gaps, and has improved structural capabilities.

The positive market outlook, noted by several of the interviewed stakeholders, is also reflected in some considerable investments by timber construction companies. In the short term, it is critical to close the existing knowledge gap and to prioritise a design ethos with more attention on wood in combination with other bio-based products. To propel the industry ahead, a focus on educational measures and publicity is crucial. Looking to the long term, it is essential to correctly assess and capitalise on the advantages of timber. This requires:

- Monitoring the performance of realised building projects
- A critical evaluation of the available European (EPD) and Dutch (MPG; NMD) tools for product evaluation
- A reform to align with current needs and achieving a standardised approach to construction methodologies.

In summary, to maintain and accelerate the expansion of wood construction, the Dutch market will benefit from an educational push to reduce the knowledge gap, a design philosophy that includes timber as renewable building material, and robust communication strategies – towards clients as well as designers, architects and construction companies – that highlight inspiring projects and encourage a competitive yet collaborative spirit among industry players. With these actions, the industry can navigate the short-term challenges while laying a foundation for long-term growth and innovation in sustainable construction practices.

S.3 Methodology

This research started with a literature review of (scientific) articles and media output on wooden house construction in the Netherlands. Following the literature review, the COM-B framework was used to identify barriers and enablers for wooden house building in the Netherlands. These results were used as a guide in the interviews with stakeholders to test if the barriers found in literature matched the stakeholder perspective on barriers and enablers in wooden house building in the Netherlands. In total, information from 18 in-depth interviews with stakeholders ranging from design to planning and construction experts were included in this study. Seven of these interviews were done during the period of this research. In addition, these interviews were supplemented by two expert interviews from previous research in 2021 on wooden house construction at Wageningen Economic Research as well as nine expert interviews from Wageningen Environmental Research from 2022 research to validate findings from literature and add to the discussion.

S.4 Terminology Glossary

Biophilic design: Reconnecting people with natural environment, wooden houses for example can be seen as a more natural environment for humans than concrete houses.
CLT: Cross Laminated Timber is a strong multi-layered building material of wood that is crosswise glued together. CLT is often used in the context of high-rise construction.
COM-B Framework: A behaviour change framework which cites capability (C), opportunity (O), and motivation (M) as three key factors capable of changing behaviour (B).
EPD: Environmental Product Declaration. https://www.environdec.com.
MPG: Milieu prestatie gebouwen. The MPG indicates the environmental impact of the materials used in a building. https://www.rvo.nl/onderwerpen/wetten-en-regels-gebouwen/milieuprestatie-gebouwen-mpg.
NMD: Nationale Milieudatabase. The Dutch Environmental Database is filled with product cards that contain general information about products, as well as environmental information that has been obtained via a Life Cycle Assessment (LCA). https://milieudatabase.nl.
Scale Economies: The cost advantages that companies obtain due to their scale of operation, with cost per unit of output decreasing with increasing scale as fixed costs are spread out over more units of output.
TFC: Timber Frame Construction (in Dutch houtskeletbouw HSB) is a method of building that uses timber jointed together with pegged mortise and tenon joints to create the structure of a house. TFC is often recommended for residential building up to four stories; beyond this, it becomes less cost-effective.
Thermal phase shift: The delay in heat transfer through the wood, meaning the time it takes for heat to pass from the exterior to the interior of a building, helping to naturally regulate indoor temperatures by slowing down the heating process during the day and releasing stored heat during cooler periods.
Value Chain: Describes the full range of activities that businesses go through to bring a product or service from its conception to its end use by customers. This includes everything from design, production, and distribution to after-sales service.

1 Introduction

1.1 Background

In its coalition agreement, the Dutch government has set itself the goal to construct 100,000 houses annually, resulting in a total of 900,000 new units by 2030 (Programma woningbouw, 2022). Given historical trends of the expansion of the housing stock, this is an ambitious plan, which is made even more challenging by the stated aim of the government to build these houses in a circular and sustainable way – fully relying on domestically sourced secondary and renewable (recycled or bio-based) materials by 2050. To gain a better comprehension of the potential for circular and sustainable building, ter Hedde et al. (2022) conducted a Flagship Building Materials pilot study on the construction of timber houses using locally grown and produced wooden materials. This research concluded that the Dutch forestry, timber processing, and construction industries are currently unable to satisfy the goals set out by the government. However, the study also concluded there is considerable scope to develop the supply chain for biobased (and wooden) building materials. This could provide the necessary inputs for the planned extension of the housing stock – particularly if imported timber is utilised and novel building techniques and materials used abroad are adopted in the Netherlands. Nonetheless, the ambition to use more timber in construction requires a transformation of the supply chain for (wooden) building materials as well as a rethink in the way in which we can build houses with renewable building materials in the Netherlands.

1.2 Research question

In the scientific literature there has been a focus on the availability of timber to construct wooden houses. For example, Lerink et al. (2023) found that the realistic potential of Europe's wood production can be 90 million m^3/year in the coming 10 to 20 years. A study from ter Hedde et al. (2022) found that the Netherlands currently only produces enough wood to construct about 90,000 houses with a timber frame construction (that means houses only with a timber frame and not yet fully constructed with wood) calculated with the average stock of all tree species types, which means that the actual number of useful materials will actually be much lower.

However, there is still a lack of knowledge about other factors that currently hinder or facilitate the ambition to increase the share of wooden house construction. This study aims to identify the structural barriers that prevent wooden house construction in the Netherlands, but also to identify the enablers which can make it possible to make the transition towards building more wooden houses in the Netherlands. Timber construction already receives widespread attention in Dutch newspapers, but there is still a lack of a systematic evaluation of the barriers in this industry. Therefore, this study remedies this using a systematic and integrative approach to better understand the barriers and enablers in wooden house construction in the Netherlands.

1.3 Framework

The information from the literature review and the interviews is analysed with the COM-B system framework of Michie et al. (2011). In this framework – for our version of the framework see Figure 1.1 – barriers and enablers can be identified for capability, opportunity, and motivation of system behaviour. Michie et al. (2011) describe the capability, opportunity, and motivation components as the following: "*Capability is defined as the individual's psychological and physical capacity to engage in the activity concerned. It includes having the necessary knowledge and skills. Motivation is defined as all those brain processes that energize and direct behaviour, not just goals and conscious decision-making. It includes habitual processes, emotional responding, as well as analytical decision-making. Opportunity is defined as all the factors that lie outside the individual that make the behaviour possible or prompt it.*" (p.4).

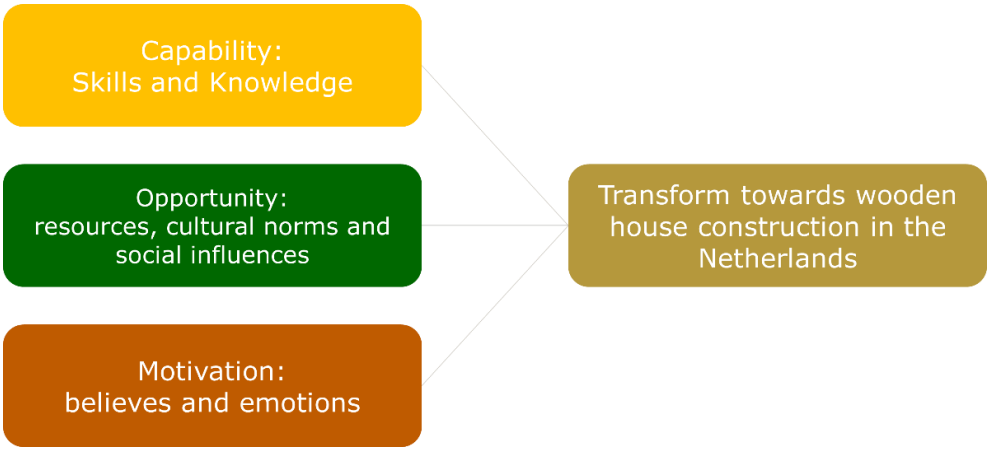

Figure 1.1 *COM-B framework in the case of wooden house construction*
Source: Based on COM-B framework in Michie et al. (2011).

This study adopts an approach to examine the barriers and enablers within the timber construction supply and processing chain in the Netherlands, focusing on key stakeholders. The investigation into capability centres on assessing the skills and knowledge essential for timber construction. It examines whether individuals possess crucial construction skills, such as the ability to build with wood, proficiency in using tools, interpreting blueprints, and assembling structures correctly. Additionally, it evaluates their knowledge about the various steps in building a wooden house, including selecting the appropriate timber species or products, designing the construction, treating wood to prevent decay or fire hazards, and effectively insulating a wooden house.

Regarding opportunity, the research delves into the availability of resources, cultural norms, and social influences. It explores whether individuals have access to the necessary tools, materials, and space for building a wooden house. It also considers the cultural acceptance and encouragement of wooden house construction within communities and peer groups, as well as the availability of local support networks, including groups or builders who can provide guidance or assistance.

Finally, the analysis of motivation focuses on beliefs and emotions related to wooden house construction. It investigates whether individuals believe that building a wooden house result in a durable, cost-effective, and aesthetically pleasing home, as opposed to concerns about structural integrity or excessive costs. Additionally, it explores people's emotional responses to wooden houses, such as their appreciation for the eco-friendliness of the material.

Table 1.1 *Summary of relevant barriers and enablers for construction with wood in the Netherlands (for abbreviations see glossary)*

	Capability		Opportunity		Motivation	
	Barriers	**Enablers**	**Barriers**	**Enablers**	**Barriers**	**Enablers**
Literature	• Knowledge transfer and collaboration between different stakeholders is scarce • Insufficient time to build a network		• Not enough subsidies • Factories are already producing timber on max. capacity • Dutch houses have regulations on how they should look like • Expensive now that it is an exclusive product • Not all municipalities allow for wooden houses	• Building time is much shorter than with conventional house building; potential to prefab with limited construction time at building site	• Lack of knowledge on the benefits of wooden houses	• Cheaper once standardised
Literature and interviews	• Knowledge about construction with wood is scarce • Architects are not educated to work/design with wood • Not enough professionals who can construct with wood • Education is not aligned with the market • Wood construction sector is small compared to concrete and steel sector	• Lot of knowledge about wooden house building in Scandinavia and some other European countries	• Availability of wood • Price fluctuations of wood • No/not enough suppliers of CLT • No standardisation of wood construction process	• Carbon sequestration • CLT construction becomes cheaper once standardised • Always prefab • Some municipalities assign special lots for wooden house construction • Circular and is some cases recyclable	• Prevailing negative stereotypes around wood construction; e.g. tree felling, 'step backward', rooted in historical shift from wood to stone construction • Common misconceptions about wood properties; e.g. fire hazard, maintenance, wood rot, durability, sound insulation • Origin of wood; perceived challenges and costs related to mixed forests versus monocultures.	• Healthy living environment • Sustainable

	Capability		Opportunity		Motivation	
	Barriers	**Enablers**	**Barriers**	**Enablers**	**Barriers**	**Enablers**
Additions stakeholder interviews	• Common timber knowledge in some EU countries cannot easily translated to the Dutch building practice and regulations.	• Observed increase in investment timber construction • Observed increase in architects designing with wood • Technological improvements (e.g. AI, robotics) that improve efficiency at producers, builders and architects • Observed increase in training and knowledge sharing • Networks of wood builders and architects have led to efficiency improvements	• Technical challenges with wood building; vibrations in construction, fire, noise risks and design constraints • Initial costs of CLT construction are higher • Housing design still with concrete and steel in mind, design not from wood perspective • Lack of initial support from municipalities for CLT construction • Limited general CLT construction knowledge among officials • Risk of monoculture forests in Europe • Fragmented wood trade industry compared to more consolidated industries like steel • Complexity due to multiple partners involved in the supply chain • Regulation complexities for wood building worldwide and existing global fragmentation • Influence of traditional construction parties in decision-making	• Deconstruction and re-use is easier • Current environmental sentiment (eco-consciousness) favouring sustainable construction methods • Increase in environmental regulations, e.g., MPG requirements • Growing forest areas in Europe ensuring the wood's availability • Growing demand (national/international) for wood construction; successful projects advocating for wood construction (economies-of-scale) • Potential for timber construction to increase if integrated into mainstream practices • Questions on prizing and selections by clients challenge architects more to pursue sustainability ambitions.	• Lack of knowledge about material causes concern • Traditional mindset in the construction sector favouring well-known concrete and bricks over wood; Inertia from major builders and housing associations • Previous misconceptions about TFC quality from 20 years ago; unknown qualities of TFC, potential reduction in property value • Perceived cost; especially in terms of initial costs	• Increased recognition of the ecological benefits of timber construction • A growing belief in the market that choosing wood is beneficial • Positive perception among consumers: more than 50% have a favourable view • Recognition of wood's advantages, including its lightweight nature and potential for reuse • When more builders have carried out more work in CLT or TFC, cold feet and incompetence will decrease

2 Barriers and enablers for timber constructions

The findings presented in the following section are based on insights from both literature and expert interviews. The COM-B framework (see Section 1.3) is used to identify key barriers and enablers hampering or aiding the transition towards more timber construction and provides insight in the interventions that are required for this transition. Statements derived from the literature are supported by corresponding references, ensuring the verifiability of the data presented. In parallel, the results also reflect non-attributable insights gained from interviews with industry professionals. These conversations provided perspectives on the barriers and enablers within timber construction, although specific statements from these discussions are not directly cited to maintain confidentiality and the anonymity of the participants.

2.1 Capability

In the context of wooden house construction, capability ensures that a person can physically construct the house and has the necessary knowledge to do so effectively. This section will elaborate on the barriers and enablers shown in Table 1.1.

2.1.1 Barriers

One of the most pressing issues identified by both the literature and the stakeholders is the knowledge gap across the entire chain, starting from wood-quality selection, through commissioning, design, construction, until practical implementation. The knowledge gap stems from decades of reliance on traditional materials such as concrete and steel, leaving wood as a secondary or even tertiary choice for many professionals (Jellema et al., 2022). The concrete and steel sectors have been dominant for so long that their methodologies, expertise, and networks overshadow the wooden construction sector. This historical dominance of concrete and steel poses a challenge to the rise of wood as a primary construction material.

However, experts state that when experience on constructing with wood rises, the knowledge gaps should evaporate. Therefore, more and better education is needed (Jellema et al., 2022). For example, architects, the visionaries behind the design of our built environments, are often educated with a focus on conventional materials. The lack of emphasis on wood means that many architects may not be familiar with its potential or how to incorporate wood into their designs. Various stakeholders emphasised that other materials cannot simply be replaced by wooden materials, the design should be centred around wood instead. Other professionals in the sector, such as builders, may also lack the skills in working with wooden materials in the construction of houses (Cobouw, 2022a). Experts think that this is mainly due to a lack of education, but also experience on using timber and the diverse timber products as a building material. Today, educational institutions are still offering courses in construction and design often following age-old curricula. Experts state that there is an urgent need to align the courses middle and higher education with market needs, emphasising wooden construction's potential benefits and methods. However, a wide range of new courses have been introduced recently, partially bridging the knowledge gap.

Another barrier is the lack of knowledge transfer and collaboration between stakeholders – from architects and engineers to contractors and suppliers, leading to missed opportunities and inefficiencies. Most wooden house construction projects are still stand-alone projects which makes it difficult to scale up and seek collaboration (ED, 2022; Cobouw, 2020). Also, professionals in the wooden construction sector often find themselves with insufficient time to build a robust network, which hampers the exchange of ideas, best practices, and innovations.

2.1.2 Enablers

Both the literature and various experts emphasised a clear advantage in timber construction in Scandinavian countries as well as some other European countries, as compared to the Netherlands (Jellema et al., 2022). Experts stated that the knowledge from these countries could be used as examples if the Netherlands want to build more wooden houses. However, this knowledge is not always directly applicable in the Netherlands due to specific aspects of the Dutch construction sector, including regulatory differences that hinder the seamless integration of this knowledge.

In the interviews with experts, other enablers were mentioned. They state that the financial landscape of construction has seen a notable shift, with stakeholders reporting an enthusiastic increase in investments in timber projects. Simultaneously, architects are breaking new ground by increasingly adopting wood as their material of choice. Next to this the rise of cutting-edge technologies such as artificial intelligence and robotics has brought about a wave of efficiency in the construction process. These technological leaps are not only enhancing precision in wood building but also transforming how architects design and builders construct, leading to smarter, faster, and greener construction methods. Moreover, there has been a significant rise in training programmes dedicated to timber construction, suggesting an industry preparing to sustain and expand its resurgence. Knowledge sharing, which is now happening across digital platforms, also widens access and accelerating innovation in wood-based construction techniques. Lastly, the experts mentioned that the power of networking plays an important role in the timber construction sector; formal and informal alliances between wood builders and architects are leading to collaborative breakthroughs in efficiency and design, fostering a community that is as much about shared learning as it is about competition.

2.2 Opportunity

In the context of wooden house construction, opportunity refers to external factors that obstruct (barrier) or facilitate (enabler) wooden house construction. This section elaborates on the barriers and enablers shown in Table 1.1.

2.2.1 Barriers

The complex nature of the supply chain for wood and wooden building materials impedes the development of wooden house construction. The dependence on a limited range of wood sources poses risks to the availability of timber, as productive timber plantations like the spruce across Europe and larch are being decimated by climate extremes and bark beetles. Climate change is leading to more diverse forests from which sustainable harvesting becomes less feasible, and the species that can be sustainably harvested are becoming more varied, with an increase in hardwood. Moreover, the volatile nature of wood pricing, as evident during the corona pandemic, compounds the difficulty of budgeting and financial planning, placing an additional strain on the economic feasibility of projects.

The capacity constraints of CLT suppliers and timber mills, which are currently at or near maximum capacity, introduce a further barrier, constraining the supply and delaying project timelines. These capacity constraints appear to be largely related to the limited availability of (skilled) personnel. This limitation not only affects the immediate availability of materials but also stifles the potential for innovation and growth within the sector, as the demand for sustainable building materials continues to rise.

Regulatory hurdles further complicate the landscape for wooden house construction. The lack of a unified standard, especially concerning CLT, means that builders and developers face a patchwork of local regulations (ED, 2022). This disparity can discourage investment in wood as a construction material and could mean that wooden house projects are abandoned before they begin, due to the complex approval processes required by different municipalities (ibid.).

Technically, wooden construction contends with inherent challenges that affect the viability and safety of such structures (Cobouw, 2022b). Issues such as structural vibrations, fire susceptibility, and soundproofing need specialised attention and solutions, which can elevate the initial cost of construction. These technical

obstacles are exacerbated by a general lack of industry-wide expertise and a dearth of streamlined processes, which leads to inefficiencies. Stakeholders contend that the environmental impact assessments, such as the Milieu Prestatie Gebouwen (MPG), do not fully account for the environmental benefits of wood as a renewable and biobased material. This includes for instance carbon sequestration. In this way, timber constructions are systematically undervalued with respect to sustainability.

In the realm of design, a predominant barrier is the entrenched mindset that still favours traditional materials like concrete and steel, partly because of experience, for instance if it comes to calculation of strength parameters of the construction. Stakeholders note there is an absence of wood-centric design principles in the early stages of planning. This results in designs that are not optimised for wood, diminishing the material's potential benefits with respect to cost efficiency but also the structural capabilities of wood. Such hesitancy undermines the progress towards more innovative and wood-focused architectural designs, essential for the advancement of wooden house construction.

2.2.2 Enablers

Although there remain some regulatory hurdles, regulation can also expedite the standardisation of wooden house construction when implemented correctly. Once standardised, the process becomes more cost-effective, as seen with building methods based on timber frame constructions (TFC), where standardisation details are already well-established (DvhN, 2020; Jellema et al., 2022). Additionally, some municipalities have allocated special lots for wooden house building, directly promoting this type of construction. The tightening of environmental regulations, including the Dutch MPG (Milieu Prestatie Gebouwen) and European EPD, (Environmental Product Declaration) requirements is progressively favouring the use of wood, given its lower environmental impact. However, improvements are needed in areas such as the completion and accessibility of information available from the NMD (Dutch Environmental Database) as well.From a technical viewpoint, wooden construction can offer advantages. The potential of wood for carbon sequestration highlights its potential in reducing greenhouse gases. The suitability of wood for prefabrication leads to significant time savings and efficiency gains on the construction site, also reducing carbon and nitrogen emissions during the construction phase. Moreover, wooden structures can be more easily deconstructed and recycled compared to traditional building materials, aligning with circular economy principles. Although it is important to realise that wood as a renewable resource is intrinsically circular if produced through sustainable forest management. The inherent benefits of wood for indoor climates, such as its thermal mass and its capacity to absorb water vapour, might also contribute positively to the living environment within homes.

The demand for timber constructions is growing both nationally and internationally, bolstered by profitable projects that demonstrate wood's viability, potentially leading to economies of scale. The current environmental sentiment and eco-consciousness among consumers and builders are steadily tilting the market towards sustainable construction methods. As timber construction integrates into mainstream practices, its adoption is likely to surge further.

Advice from stakeholders underscores the importance of leveraging wood construction's strengths. TFC, for instance, is recommended for residential building up to four stories; beyond this, it becomes less cost-effective. However, in the context of high-rise construction, CLT becomes a more cost-effective choice, as constructing taller buildings with timber frame construction would necessitate additional expenses to achieve structural integrity, making CLT not a cost-increasing option but rather a viable method for erecting tall wooden structures.

2.3 Motivation

In the context of wooden house construction, motivation focuses believes and emotions behind choosing or not choosing wooden house construction. This section will elaborate on the barriers and enablers shown in Table 1.1.

2.3.1 Barriers

Despite the growing enthusiasm for timber construction within the industry, prevailing misconceptions continue to challenge its broader acceptance (ND, 2023). Scepticism around wooden structures often draws from a historical context where the shift from wood to stone was perceived as a move towards greater durability and safety. These biases linger, with wood construction often wrongly associated with excessive tree felling and therefore being unsustainable and a 'step backward', reverting to building practices in the past (Cobouw, 2020; ND, 2023).

Furthermore, perceptions about the properties of wood contribute to its underutilisation. Concerns about wood being a fire hazard, prone to maintenance issues, rot, and poor durability are prevalent (Cobouw 2022b). There is also a widespread belief that wood provides inferior sound insulation compared to other building materials. These perceptions persist despite significant advancements in wood treatment and construction technologies that enhance the natural properties of timber, making modern wooden houses safe, long-lasting, and sufficient in sound dampening. Nevertheless, it has to be acknowledged that wood as bio-based material is more challenging, especially with respect to processing and application to be able to fulfill the current regulations, mainly related to fire hazard. This once more calls for the need for specific expertise when working with timber in the entire construction chain.

Moreover, there is a notable lack of widespread knowledge regarding the benefits of wooden houses. The advantages such as carbon sequestration, biophilic design benefits for occupants, and the overall environmental footprint reduction are often overshadowed by a fear rooted in ignorance — such as the unfounded fear that wooden buildings are more susceptible to collapse compared to those made from other materials. In practice, timber constructions can help to achieve resilient building practices, particularly in areas prone to natural calamities. This is highlighted by the innovative approach in North Groningen, which demonstrates the practical resilience of wooden structures against natural disasters such as earthquakes (SHR, 2015). This aligns with the aforementioned benefits, pushing the narrative beyond traditional misconceptions.

Lastly, the origin of wood as a construction material carries its own set of perceived challenges and costs, especially when considering the ecological impacts of sourcing from mixed forests versus monocultures. Mixed forests are seen as more sustainable but also more complex and expensive to harvest from compared to monocultures, which often raise concerns about the impact on biodiversity while they are economically efficient (Knoke et al., 2005).

Addressing these stereotypes and partly misconceptions is critical for the future of timber construction, requiring concerted efforts to educate and demonstrate the modern capabilities and benefits of wood as a material that is not only historically significant but also future-ready and sustainable.

2.3.2 Enablers

The motivation surrounding timber construction is seeing a positive shift as more stakeholders, ranging from architects to construction companies and housing associations, become aware of its benefits, which go beyond just aesthetics. They also embrace environmental, economic, and health considerations. Central to this shift is the recognition of the healthy living environment provided by wooden structures. Wood has a natural ability to regulate humidity and air quality, creating a living space that stimulates wellness and comfort (Alapieti et al., 2020).

Sustainability is another cornerstone of timber construction's growing appeal. Wood is a renewable resource, but only if it is produced in a sustainably managed forest. This implies that the amount of harvested timber never exceeds the amount of newly produced wood in a given area and moreover other ecosystem functions are maintained (Deal et al., 2007). As wood captures carbon dioxide and stores carbon also if used in timber constructions, this function is maintained also outside the forest, contributing to the reduction of greenhouse gases, when sustainably sourced and managed (Johnston et al., 2019; Lippke et al., 2010; Profft et al., 2009). When the wood construction industry is more standardised, construction wood becomes increasingly cost-effective. With standardised processes and prefabrication, timber can become a more affordable option relative to traditional building materials (VPRO, 2019).

The ecological and environmental benefits of timber are more widely recognised nowadays. This increased awareness is partly due to the concerted efforts of environmental advocates and industry innovators who highlight wood's role in the sustainable development of the building sector. There is a growing belief in the market that choosing wood for construction is not only beneficial for the planet but also for long-term economic planning.

This positive industry trend is reflected in consumer sentiments. The modern consumer is more environmentally conscious and values the eco-friendly nature of the renewable material wood, aligning their purchasing choices with their environmental ethos (Judge et al., 2019).

Moreover, the inherent advantages of wood, such as its lightweight nature, contribute to its popularity. This physical characteristic facilitates easier and quicker construction at the building site, lower transportation costs, and reduced foundation requirements. The potential for reuse and recycling of timber also adds to its credentials as a material of the future, aligning with circular economy principles and reducing construction waste.

3 Transition towards timber constructions – reflection

3.1 Important stakeholder perceptions

The construction industry in the Netherlands is witnessing a significant uptick in more sustainable building practices, with timber construction emerging as a key player. This growing interest is substantiated by the fact that over 60 construction companies have recently created specialised departments to focus on timber construction, particularly with CLT. The nascent nature of these departments, most being less than three years old, signals a swift and enthusiastic move towards wood as a construction material, narrowing the existing knowledge gap in the industry.

The rise in public awareness, partly attributed to the 'Tegenlicht' episode by VPRO in 2019 on timber builders, has played a significant role in the current shift from a niche market to serious player within the construction sector. This change over the last few years has brought more professionals from various fields – contractors, architects, and others – into the fold, enhancing practical experience, fostering professional networks, and dismantling previously noted structural capability barriers (van der Lugt, 2020).

Despite the demand for wooden construction, its execution is still catching up. Analysts and various of the stakeholder interviewed anticipate that the sector is on the brink of a steeper growth trajectory (van de Lugt, 2020). Scaling up operations should reduce the knowledge shortfall, and although several stakeholders indicated that the current costs of timber constructions were between 5 to 10% above the cost for traditional designs, the cost differential is beginning to shrink. Moreover, experts highlight the current challenges inherent in wooden construction, such as increased expenses due to less efficient designs, higher risks for builders, and the complexity of meeting regulatory standards. These factors contribute to a slower adoption rate in the industry. However, there is a growing recognition of these hurdles, and efforts are underway to streamline processes and enhance the efficiency of wood designs. As the industry matures, these initial challenges are expected to diminish, paving the way for more cost-effective and streamlined construction methods. The anticipated improvements in design efficiency and scale economies will likely lead to a reduction in overall costs, making wooden construction more competitive with traditional building methods. This evolution is critical for the sector's growth, as it will not only attract more builders to consider wood as a viable material but also encourage innovations that could further reduce costs and increase sustainability in the long run.

A notable shift in environmental building regulations, particularly the expected decrease in the environmental performance footprint (MPG), is set to propel the growth of Half-Timbered Structures (TFC) construction. The past few years have witnessed a considerable rise in demand for wood-based housing. Public exposure has helped dismantle motivational barriers, eroding negative stereotypes and perceptions about wood as a construction material, leading to greater acceptance among consumers and the wider industry.

Yet, external challenges persist, such as rising raw material costs and stringent nitrogen emission standards, causing a stagnation in construction activities. Currently, commercial construction is outpacing residential construction. Despite national goals, large-scale residential building projects are facing hurdles. The construction industry in the Netherlands is thus expected to encounter challenges over the next years, which may impact overall demand. A key issue is whether the burgeoning interest in timber construction can offset the broader sector's slowdown.

Another challenge concerns the uncertainty on future wood supply related to the effects of changing climate conditions on European forests (Bolte et al., 2009). The drought events in 2018/2019 cause considerable morality in productive Norway spruce forests as well as vitality losses in many other species across Europe (Schuldt et al., 2020).

Despite the uncertainties in supply and developments in the timber construction market, optimism prevails among stakeholders, fuelled by significant investments from major contractors in timber constructions. While TFC is expected to expand more rapidly than CLT due to its efficiency in most projects, the demand for CLT has not waned. Its stability over the years, combined with a significant uptick in demand, positions it well for growth, especially in the residential construction of multi-story buildings. Projects like the Sawa in Rotterdam exemplify the potential for CLT in constructing wooden apartment buildings. With a particular advantage in 3-5 story buildings, modular construction using CLT is also on an upward trend, pointing to a promising future for wood construction in the Dutch market.

3.2 Short-run opportunities – low-hanging fruit

Maintaining momentum in the expansion of wood construction in the Dutch market requires strategic actions to address immediate challenges and capitalise on current trends. A critical action point is bridging the knowledge gaps in the entire chain of timber constructions – acknowledged by many of the industry experts that were interviewed. This does not hold for all stakeholders as many have ample experience on constructing with timber. However, others who also intent to make the switch to more timber constructions might lack expertise and underestimate the differences between building with traditional materials and building with timber. This should also be acknowledged related to, for example, public contracts and other tenders which should not be awarded to companies which lack experience in timber construction. It is expected that these temporary barriers will diminish as builders gain more experience. The scale of many timber construction companies is relatively small, but as they grow, the collective expertise within the sector should continue to increase, leading to a reduction in costs, risks, and construction errors. Stakeholders confirm that this knowledge gap is also evident in the design phase and should be addressed throughout the entire value chain.

To realise more timber constructions a shift in mindset is needed, starting from the initial design stages. Stakeholders emphasise the importance of 'thinking in timber' from day one, as retrofitting a traditional design to timber is not cost-efficient. Maintaining a backup plan in steel or concrete can lead to designs that are not optimised for timber, often resulting in unfavourable dimensions for wood use and potential cost increases. To increase the chance of success for more of timber constructions, it is advised to incorporate a more wood-centric thinking from the outset and to involve engineers with timber expertise as early as possible in the project.

The power of examples and their communication should not be underestimated. Although the focus is often laid on superlatives (high wooden buildings) or special designs, the power of timber constructions is that it can be applied for numerous types of residential and public projects, such as schools, sports hall, but also temporary housing e.g. for students or refugees (Perrucci et al., 2016; Ballinas and Chávez, 2023). The expanding number of builders that have taken up timber construction are a testament to the sector's commitment to growth and improvement. Coupled with a range of educational courses now available to enhance knowledge about constructing with timber, these initiatives are crucial in driving the sector forward.

Strong publicity about timber construction, including competitive insights and stimulating activities such as selections and competitions, has been instrumental in elevating sustainability ambitions across the industry. This has created an impression of a larger movement than currently exists, but it serves as a driver for change.

3.3 Long-term action plan - facilitating the transition

In addition to the immediate challenges and opportunities faced by the timber construction industry, the experts interviewed also identified several key long-term action points that could catalyse the shift towards timber constructions in the Netherlands.

Embracing a more timber-centric approach, the construction industry should leverage the potential of wood as renewable and bio-based building material while also recognising the limitations - e.g. related to supply of required quality and quantity of wooden building materials and specific measures needed to meet the safety regulations. Also, the aspect of substitution should be recognised. This implies that wood as renewable material and if harvested sustainably has a positive environmental footprint whereas non-renewable materials, such as concrete and steel have a negative environmental impact through production of anthropogenic CO_2 and environmental pollution (Hurmekoski et al., 2022). Discussions remain on how to exactly translate the environmental benefits of wood into environmental calculations such as the Dutch MPG (Milieu Prestatie Gebouwen; Howard et al., 2021; Keijzer et al., 2021).

Consequently, the default reliance on concrete and steel in construction needs to be re-evaluated. Wood's advantages could be utilised in various ways:

- Lightweight timber construction methods could solve specific problems such as adding extensions to existing buildings, constructing on soft and unstable soils, or developing circular and temporary building foundations.
- Developing building projects on top of existing infrastructures such as parking garages, again capitalising on the economic and technical (lightweight) benefits from timber constructions, could allow for more housing units in dense urban areas.
- TFC in a building for up to four stories before transitioning to CLT, documenting the process to optimise timber building systems.

The reputed regulating properties of wood in house constructions, such as thermal mass contributing to a healthy indoor climate, require additional empirical validation. Research to substantiate these claims should be a priority.

Investigating the thermal phase shift in timber construction is another important avenue. Learning from Switzerland's example of a 20-40 cm thick CLT house built without insulation (Kung Holtzbau, 2023) could offer insights into creating energy-efficient housing in the Netherlands without the need for traditional insulation.

Addressing the educational gap in timber construction is crucial. The current shortage of qualified personnel in this field points to a need for specialised education and training programmes on all levels of education. But the educational curricula should go well beyond filling gaps in current knowledge. The rapid changes in technology and actual and future environmental challenges ask for expert that can push current initiatives to further innovate the sector through development of new wood(-based) products. Another key issue is to strengthen the collaboration between the forest sector and timber industry to coordinate activities, with respect to e.g. supply of wood for specific needs. This becomes especially important in the context of climate change and the expected shift in wood supply from softwoods towards hardwood species.

Standardisation is also pivotal. Many wood construction projects currently start without a reference framework, making each project a reinvention of the wheel. Standardising regulations and construction details, especially for CLT, informed by the experiences of timber frame construction, can streamline the transition.

4 Conclusion

The construction industry in the Netherlands is experiencing an increase in sustainable practices, with a growing interest in timber construction. This is evidenced by over 60 construction companies establishing departments specialising in timber construction, notably in CLT. This shift from niche to more mainstream over the past few years has broadened the professional base in the sector, reducing the knowledge gap and cost differential, and improving structural capabilities.

Stakeholders remain positive, with significant investments in timber construction indicating potential growth. If it comes to challenges, in the short term, the need for more experts along the entire chain from wood supply through design, commissioning to construction has been indicated. Educational initiatives and robust communication strategies are essential to drive the industry forward and to promote a more wood-centric design philosophy. In the long term, empirical research into wood's beneficial properties, investment in developing new wood products and standardisation of construction practices is critical. Advocating for timber construction's environmental benefits in industry assessments is also necessary to ensure fair competition with traditional materials.

Addressing and dismantling the barriers outlined previously is critical to stimulate the transition to the use of more renewable and bio-based building materials. This transformation will touch every aspect of the supply chain, from sourcing raw materials to the final handover of a wooden house to its owners, backed by supportive policies and regulations at various government levels.

Timber construction's main appeal lies in its sustainability, with its already lower carbon footprint than that of concrete and steel constructions—a gap that could widen with further technological advancements. However, these carbon-related benefits only hold in the case of harvesting in sustainably managed forests. In view of the expected climate-change effects on European forests, special attention has to be given to the reduced availability of conifer species, which are currently dominating the timber market. This is due to the fact that coniferous forest plantations are strongly affected by recent drought events in combination with insect attacks and the related ambition to substitute conifer plantations by more diverse mixed forests.

Additionally, the growing Dutch sector aims to also rely on local resources. This calls for coordinated actions of the forestry and timber industry to ensure that wood production – where possible – will be realised in future. Moreover, it is relevant that the 37,400 ha of newly planned forest will, among providing multiple ecosystem functions, also contribute to sustainable wood production.

So, yes, it 'wood be possible', but effort is needed to use the full potential of wood as construction material, to keep the timber construction sector innovating and strengthen the connection between the forestry and the timber sector to ensure (local) wood supply in future.

5 Acknowledgements

We would like to thank:

- Silke Jacobs and Sven van Baren from Wageningen Environmental Research for sharing their interview data with us
- All people from the following organisations that made time to be interviewed by us:
  - Arcadis
  - Taalkwadratuur
  - MIX architectuur
  - Derix
  - VDM Wonen
  - Woodteq
  - Gooskens hout
- Colleagues Allard Jellema, Anne-Charlotte Hoes, Siet Sijtsema, Marieke Meeusen from Wageningen Economic Research and Emiel Wubben from Business Management and Organisation (Wageningen University) that made time to share knowledge and think along in the process.

We would like to thank Jamal Roskam for the extensive review of our report.

And, finally, we would like to thank the Transformative Bioeconomies programme for funding this research.

Sources and literature

Alapieti, T., Mikkola, R., Pasanen, P., and Salonen, H. (2020). The influence of wooden interior materials on indoor environment: a review. *European Journal of Wood and Wood Products*, *78*, 617-634. https://link.springer.com/article/10.1007/s00107-020-01532-x.

Ballinas, M.B.P., and Chávez, L.G. (2023). Linking the European housing demand to sustainable wood construction materials: Wooden Housing Prototype (No. 2432). Wageningen Food & Biobased Research. https://doi.org/10.18174/632981.

Bolte, A., Ammer, C., Löf, M., Madsen, P., Nabuurs, G.J., Schall, P., ... and Rock, J. (2009). Adaptive forest management in central Europe: climate change impacts, strategies and integrative concept. Scandinavian Journal of Forest Research, 24(6), 473-482. https://doi.org/10.1080/02827580903418224.

Cobouw. (2020). Pablo van der Lugt: gepassioneerd ambassadeur van de houten revolutie. (retrieved: 2023-13-03).

Cobouw. (2022a). Smeed coalities en zet vakmensen en grondstoffen efficiënter in. (retrieved: 2023-13-03).

Cobouw. (2022b). Living Lab 040: proeftuin van de lumineuze bouwinnovaties. (retrieved: 2023-13-03).

Deal, R. L., White, R., and Benson, G. (2007). *Sustainable forestry management and wood production in a global economy*. CRC Press.

DvhN. (2020). Dagblad van het Noorden. 'Natuurlijk bouwen heeft grote voordelen'.(retrieved: 2023-13-03).

ED. (2022). Eindhovens Dagblad. Je droomhuis als een bouwpakket uit Letland. (retrieved: 2023-13-03).

ter Hedde, I.R., Kremer, L.M., Peeters, S.C., Wubben, E.F.M., and Meeusen, M.J.G. (2022). *Baseline Report: Transformative Bioecionomies; The Building Sector*. Wageningen University & Research. https://library.wur.nl/WebQuery/wurpubs/fulltext/585127.

Howard, C., Dymond, C.C., Griess, V.C., Tolkien-Spurr, D., and Kooten, G.C. van (2021). Wood product carbon substitution benefits: a critical review of assumptions. Carbon Balance and Management, 16, 1-11. https://doi.org/10.1186/s13021-021-00171-w.

Hurmekoski, E., Seppälä, J., Kilpeläinen, A., and Kunttu, J. (2022). Contribution of wood-based products to climate change mitigation. In Forest Bioeconomy and Climate Change, 42, 129-149. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-99206-4_7.

Jellema, A., Lauwere, C.C. de, and Hoes, A.C. (2022). *White paper: Verduurzaming van de melkveehouderij: kansen en belemmeringen: Lessen voor de melkveehouderij* (No. 2022-021). Wageningen Economic Research. https://edepot.wur.nl/570768.

Johnston, C.M., and Radeloff, V.C. (2019). Global mitigation potential of carbon stored in harvested wood products. *Proceedings of the National Academy of Sciences*, *116*(29), 14526-14531. https://doi.org/10.1073/pnas.1904231116.

Judge, M., Warren-Myers, G., and Paladino, A. (2019). Using the theory of planned behaviour to predict intentions to purchase sustainable housing. Journal of cleaner production, 215, 259-267. https://doi.org/10.1016/j.jclepro.2019.01.029.

Keijzer, E., Klerks, S., Leeuwen, S. van, Nijman, R., and Fraanje, P. (2021). Een verkenning van het potentieel van tijdelijke CO2-opslag bij houtbouw.

Kung Holzbau. (2023). https://www.kueng-holz.ch/de; https://www.youtube.com/watch?v=4j_UjIshzMc.

Lerink, B.J., Schelhaas, M.J., Schreiber, R., Aurenhammer, P., Kies, U., Vuillermoz, M., ... and Nabuurs, G. J. (2023). How much wood can we expect from European forests in the near future?. *Forestry: An International Journal of Forest Research*, Article: cpad009. https://doi.org/10.1093/forestry/cpad009.

Lippke, B., Wilson, J., Meil, J., and Taylor, A. (2010). Characterizing the importance of carbon stored in wood products. *Wood and Fiber Science*, 5-14.

Lugt, P. van der (2020). Tomorrow's Timber: Towards the next building revolution. MaterialDistrict.

Knoke, T., Stimm, B., Ammer, C., and Moog, M. (2005). Mixed forests reconsidered: a forest economics contribution on an ecological concept. *Forest Ecology and management*, *213*(1-3), 102-116.

Metro. (2008). Hout is in opkomst. (retrieved: 2023-13-03).

Michie, S., Stralen, M.M. van, and West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implementation science, 6(1), 1-12. https://doi.org/10.1186/1748-5908-6-42.

Nederlands Dagblad. (2023). Houtbouw biedt hoop, maar luister naar andere stemmen. (retrieved: 2023-13-03).

Perrucci, D.V., Vazquez, B.A., and Aktas, C.B. (2016). Sustainable temporary housing: Global trends and outlook. Procedia Engineering, 145, 327-332. https://doi.org/10.1016/j.proeng.2016.04.082.

Profft, I., Mund, M., Weber, G.E., Weller, E., and Schulze, E.D. (2009). Forest management and carbon sequestration in wood products. European journal of forest research, 128, 399-413. https://doi.org/10.1007/s10342-009-0283-5.

Programma Woningbouw. 2022. Volkshuisvesting en Ruimtelijke Ordening. https://open.overheid.nl/documenten/ronl-7cf320fe661a5079d9b9c431d6fa3a96c8d558ff/pdf.

Schuldt, B., Buras, A., Arend, M., Vitasse, Y., Beierkuhnlein, C., Damm, A., ... and Kahmen, A. (2020). A first assessment of the impact of the extreme 2018 summer drought on Central European forests. Basic and Applied Ecology, 45, 86-103. https://doi.org/10.1016/j.baae.2020.04.003.

SHR. (2015). Houtbouw oplossingen voor Groningen. https://www.shr.nl/uploads/pdf-files/2015-03-06-aj-houtwereld-houtbouw-oplossing-voor-groningen.pdf.

VPRO. 2019. Houtbouwers. VPRO Tegenlicht. https://www.vpro.nl/programmas/tegenlicht/kijk/afleveringen/2019-2020/houtbouwers.html (retrieved: 2023-04-19).

Appendix 1 Extended method section systematic literature search for scientific and media articles

Three databases (Scopus, Web of Science and Lexis Nexis) were used in April 2023 to search for articles related to our topic. For Scopus and Web of Science we used search terms ("wooden house construction" OR "wooden frame construction" OR "wooden house building" OR "wooden house design" OR "houten huis" OR "bouwen met hout" OR "timber framed houses" OR "timber house construction") AND (europe OR eu OR european OR west) AND (barrier OR challenge OR obstacles OR constraints). However, we found that there are limited articles found about this topic. Therefore, we chose to focus on Dutch newspaper articles which show people's perspective on wooden house building in the Netherlands. Articles were found with Lexis Nexis search terms selecting for Dutch newspapers articles until April 2023 (barrieres OR barriere OR obstakels OR obstakel) AND (houtbouw OR "bouwen met hout" OR kruislaaghout). Also two additional research reports from colleagues were used in our research. Our selection criteria for the articles were that they needed to include barriers or enablers associated with wooden house building preferably in the Netherlands, but we did not exclude articles that talked about other countries.

Wageningen Economic Research
P.O. Box 29703
2502 LS The Hague
The Netherlands
T +31 (0)70 335 83 30
E communications.ssg@wur.nl
wur.eu/economic-research

REPORT 2024-005

To explore the potential of nature to improve the quality of life

Wageningen Economic Research
P.O. Box 29703
2502 LS Den Haag
The Netherlands
T +31 (0) 70 335 83 30
E communications.ssg@wur.nl
wur.eu/economic-research

Report 2024-005
ISBN 978-94-6447-182-3

The mission of Wageningen University & Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 7,600 employees (6,700 fte) and 13,100 students and over 150,000 participants to WUR's Life Long Learning, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.