FWPA
Forest & Wood Products Australia

Project Report

DEVELOPMENT OF A CARBON CREDITING METHOD FOR GREENING CONSTRUCTION WITH SUSTAINABLE WOOD

SEPTEMBER 2024

PROJECT NUMBER
VNA625-2324

Project Report

Development of a Carbon Crediting Method for Greening Construction with Sustainable Wood

Image supplied courtesy of Sumitomo Forestry Australia

Prepared for

Forest & Wood Products Australia

by

B. Freeman, A. Morton, J. Allen, P. Dargusch & J. Gattas

Publication: Development of a Carbon Crediting Method for Greening Construction with Sustainable Wood

Project No: VNA625-2324

IMPORTANT NOTICE

This work is supported by funding provided to FWPA by the Australian Government Department of Agriculture, Fisheries and Forestry.

ISBN: 978-1-922718-87-7

Researcher/s:

Blair Freeman, Andrew Morton, and Jeremy Allen
Indufor Asia Pacific (Australia) Pty Ltd, Level 8 276 Flinders St, Melbourne VIC 3000.

Paul Dargusch
Advanced Timber Hub, School of Engineering, The University of Queensland, St Lucia QLD 4072.

Joe Gattas
School of Civil Engineering, The University of Queensland, St Lucia QLD 4072.
Australian Research Council (ARC) Advance Timber Hub.

Forest & Wood Products Australia Limited
Level 11, 10-16 Queen St, Melbourne, Victoria, 3000
T +61 3 9927 3200 F +61 3 9927 3288
E info@fwpa.com.au
W www.fwpa.com.au

Executive Summary

This Project was established this project to explore the potential development of a carbon emissions reduction methodology ('method') that recognises carbon storage and emissions avoidance in the increased use of wood products in the built environment.

In 2024, the Australian Government established a Proponent-Led Method Development (PLMD) process for the Australian Carbon Credit Unit (ACCU) Scheme, which has provided Australia's forest and wood products sector with an opportunity to develop a new method aimed at incentivizing building project developers of large building constructions to use sustainable wood products as an alternative to the use of other more emissions-intensive building materials and thereby reduce emissions from the construction sector.

This project report outlines the work undertaken by the project team to develop a new carbon crediting method that meets Australia's Offset Integrity Standards (OIS) and would achieve eligible emissions reduction benefits from design and material choices used in large-scale and multi-level building construction projects. The central premise for this new method proposal is that construction project developers in Australia can use an increasing range of innovative mass timber products, for large scale building constructions, which can significantly reduce embodied carbon emissions compared to more conventional methods using non-renewable construction materials, notably reinforced concrete and steel.

The project used a case study construction project located in Melbourne to calculate the embodied upfront carbon emissions in both a conventional reference case design using structural steel and concrete materials with a project design featuring mass timber components. Using Environmental Product Declarations (EPDs) and life-cycle analysis (LCA) tools to contrast the comparative global warming potential emissions of chosen materials, it was shown a typical building construction project of this size could achieve reductions in the order of 5,000 tonnes CO_2 equivalent emissions or 30% reductions in embodied emissions up to construction completion, compared to conventional designs.

Based on the latest industry data, mass timber construction is increasing in Australia, but in 2023 was still less than 2% of building designs in the large-scale (more than 1,000 m^2 floor area) or multi-storey (4+ levels) segments. This suggests significant opportunity to increase the number of overall projects currently dominated by conventional concrete and steel designs. Assuming Australia completes between 600-1,000 new building constructions of this type per year, and the method incentivises a shift from 2% to 10% of project (market) share, prioritising mass timber designs and material choices could achieve CO_{2e} emissions reductions from the sector of up to 250,000 tonnes per year, or 6.7 Mt CO_2e by 2050.

The proposed carbon crediting method aligns with the Australian Government's commitment at COP28 in November 2023 to advancing policies and approaches that support low carbon construction and increase the use of wood from sustainably managed forests in the built environment. This policy driver, coupled with financial incentives such as the potential to generate ACCUs, are expected to encourage investors to give preference to mass timber construction systems where suitable and support additional manufacturing capacity in Australia. This should provide additional demand for Australian grown and manufactured wood products and support a transformational shift towards increased use of renewable wood products that can store sequestered carbon and reduce embodied carbon emissions.

Table of Contents

Introduction

This project was established to explore the potential development of a carbon emissions reduction methodology ('method') that recognises carbon storage and emissions avoidance associated with an increased use of wood products in the built environment.

A Built Environment Working Group was convened with representatives of Australia's forest and wood products sector to oversee and guide the development of this research.

The primary objectives designated for the method development were to:

- determine a preferred pathway for development of a carbon crediting method that will incentivise construction project developers (based on financial and broader sustainability criteria) to use Australian grown and manufactured wood products where suitable, instead of alternative non-wood products with higher emissions intensities; and
- determine approaches to encourage further Government policy support for increased use of timber and other wood products in construction.

Context

During the term of this project, there were two significant national policy developments. Firstly, at COP28 in Dubai in November 2023, the Australian Government joined 16 other countries in committing to increase the use of wood in the built environment by 2030. The signatory countries, under the auspices of the Forest and Climate Leaders' Partnership Coalition on *Greening Construction with Sustainable Wood*, stated the following[1]:

"Recognizing that wood from sustainably managed forests provides climate solutions within the construction sector, we commit to, by 2030, advancing policies and approaches that support low carbon construction and increase the use of wood from sustainably managed forests in the built environment. Such policies and approaches will result in reduced GHG emissions, and an increase in stored carbon."

COP28, Dubai – Forest and Climate Leaders Partnership announcement on the Coalition on greening construction with sustainable wood.

With this statement, the Australian Government committed to advancing policies and approaches that support low carbon construction and increase the use of wood from sustainably managed forests in the built environment.

This policy position provided additional impetus for the development of a carbon crediting method to incentivise this segment of Australia's construction sector to use Australian timber products where suitable.

[1] FCLP 2023, *Initiative for Greening Construction with Sustainable Wood*. FCLP Public Announcement. Refer online: https://forestclimateleaders.org/wp-content/uploads/2023/12/FCLP-COP28-Release-Buildings-06122023.pdf.

The second significant national development was the announcement in May 2024 of Australia's interim Proponent Led Method Development (PLMD) process for the Australian Carbon Credit (ACCU) Scheme[2]. Under this interim process, the Australian Government called for Expressions of Interest (EOIs) in submitting method ideas for new methods (or variations of existing methods) to deliver eligible carbon abatement through carbon sequestration or emissions avoidance.

The PLMD interim process became the focus for latter stages of this project, with the Built Environment Working Group providing guidance to the project team to focus on preparing an EOI for developing a carbon crediting method under the ACCU Scheme.

Overview of report

This report sets out the key components of the EOI, including an analysis of a case study, and relevant conclusions for Australia's forest and wood products sector.

This report comprises the methodology (section 2), which discusses the approach and key components of this research, including literature review and stakeholder engagement.

Results from a review of relevant industry data and published literature, and analysis of a case study in Melbourne, are presented.

A discussion follows, encompassing consideration of a broad range of design issues in the development of a new carbon crediting method for the ACCU Scheme.

This report concludes with conclusions and recommendations, based on the development work to date and a proposal to the Australian Government to further develop a new ACCU Scheme method focused on 'greening construction with sustainable wood'.

Through this research, the project team worked closely with AFPA, FWPA and the Built Environment Working Group to submit an EOI to the Australian Government in July 2024, under the first round of the interim PLMD process for the ACCU Scheme. The EOI sets out an outline for a new carbon crediting method under the ACCU Scheme, titled '*Greening Construction with Sustainable Wood*'.

The Australian Government has advised its intent to prioritise selected EOIs from the first round of this process by the end of 2024.

Methodology

Project governance

FWPA and AFPA (Australian Forest Products Association) established and jointly managed this research project under the umbrella of a sectoral initiative focussed on 'Carbon in the Built Environment'. Under this initiative, a Built Environment Working Group was convened, comprising representatives from a broad range of leading companies in the Australian forest and wood products sector. The working group served as a Steering Committee for the research, providing guidance and feedback to the project team through a series of workshop

[2] Australian Government (2024) *Developing new ACCU Scheme methods*. Online: https://www.dcceew.gov.au/climate-change/emissions-reduction/accu-scheme/developing-new-methods

meetings (three in total) and progress updates (six in total) delivered over a period of 12 months between August 2023 and July 2024.

The working group provided the project team with direct industry experience with contemporary building construction designs; innovative timber products and engineered wood products; construction project development and standards; and construction trends. The Working Group also reviewed all method development documents prior to submission of project deliverables; most notably, an EOI for a new method under the ACCU Scheme.

In addition, the project team engaged with external experts to peer review inputs on formative descriptions of the method proposal. This included researchers with extensive experience in the development and implementation of novel methods to more accurately estimate carbon in forest systems and in wood products, including the dynamics of decomposition of wood and paper products in end-of-life settings, as well as carbon project developers with a high level of familiarity with Australia's Offset Integrity Standards (OIS) for new methods.

Definition of eligible projects

The central premise for this method was that construction project developers in Australia can use an increasing range of innovative mass timber products, for large scale building constructions, which can significantly reduce embodied carbon emissions compared to more conventional methods using non-renewable construction materials, notably reinforced concrete and steel. The concerted use of mass timber construction is described as 'MTC'.

In this context, the research was directed towards developing a carbon crediting method to cover the following project activities:

- The design of large-scale construction building projects in Australia that feature consideration of the scope to preferentially select and use domestically produced timber products over alternative construction materials with higher emissions intensity (i.e. higher embodied carbon values) where suitable for the design and purpose of the building.
- The demonstration of the emission reduction benefits from 'greening construction' approaches, using credible embodied carbon assessment tools to compare the embodied carbon profile of the reference case with the embodied carbon profile of the project case, within a defined project boundary.
- The generation of ACCUs based on the difference between the modelled emissions for the reference case and the modelled/actual emissions for the project case - which will in turn encompass consideration of both the carbon sequestered and stored in timber products (biogenic carbon storage) and the substitution benefit of using timber products compared to performance-equivalent quantities of more emissions-intensive building materials produced in Australia (note: ACCUs cannot be issued for emission reductions associated with imported products).

In this way, projects using the method would remove and avoid CO_2 emissions, by combining the abatement benefits of preferencing timber products that store carbon sequestered from the atmosphere and reducing emissions associated with more emissions-intensive materials.

Over the past 10-20 years, there has been increasing interest in the use of glulam, cross-laminated timber (CLT) and other engineered wood products, to meet the growing demand for more sustainable buildings, and increasing recognition of other favourable features including structural properties and reduced construction timelines. Over this period, there has been significant advances in these products and systems, and the MTC technology is now mature.

There are extensive reports now pointing to the growing extent of multi-storey timber buildings worldwide[3,4,5]. Furthermore, there are some leading examples of these types of buildings in Australia – for example, the Forte building (2012) and the T3 Collingwood Project (2023) in Melbourne (Figure 1 and Figure 2); International House at Barangaroo (2016) in Sydney; 25 King (2018) in Brisbane; the Adelaide Oval Hotel (2020) in Adelaide; and the proposed C6 Project (under design) in South Perth. Some of these projects are illustrated in **Appendix 1**.

Case study analysis

This method development benefited directly from access to a case study featuring the use of innovative mass timber construction in a mid-rise building in Melbourne. 'T3 Collingwood' is a 15-storey prime-grade office tower developed by Hines, a global real estate group, and built by the construction company ICON. The project investment partners in Australia comprised Hines Australia, Sumitomo Forestry Australia and NTT UD Australia.

Figure 1 Building view of T3 Collingwood in Melbourne

Source: Hines

Figure 2 Construction of T3 Collingwood in Melbourne, featuring the use of mass timber materials manufactured in Australia

Source: image supplied courtesy of Sumitomo Forestry Australia

The T3 building in Melbourne was designed to be highly sustainable, using mass timber as the main structural material and aiming for a 6 Star Green Star Rating. Hines' T3 projects ('Timber, Transit and Technology') replace traditional structural systems like concrete and steel with prefabricated solid wood systems.

Ten of the 15 levels of T3 Collingwood were constructed primarily of timber products, utilising glulam posts and beams and cross-laminated timber floor panels. Based on the *Issued for Construction* (IFC) documentation, Hines anticipated the predominant use of mass timber as a construction material would decrease embodied carbon levels by up to 34% compared to conventional concrete and steel construction.

---

[3] Nepal et al. (2024) The potential use of mass timber in mid-to high-rise construction and the associated carbon benefits in the United States. *PLoS ONE* 19(3): e0298379. https://doi.org/10.1371/journal.pone.0298379.
[4] Wood Central (2024*) Faster & Greener: Canada's Top Bank Says 'Yes' to Mass Timber*. Article published May 2024: https://woodcentral.com.au/faster-greener-canadas-top-bank-says-yes-to-mass-timber/
[5] Arup (2019) *Rethinking Timber Buildings: Seven perspectives on the use of timber in building design and construction*.

In June 2024, the T3 Collingwood Project was named as the winner of the Australian Institute of Architects' 2024 Victorian Chapter Awards: Commercial Architecture category; with the notes "*T3 is applauded for its critical position in commercial design moving towards a post carbon future*"[6].

Sumitomo Forestry Australia Pty Ltd kindly provided construction materials data and carbon emissions data for this project, specifically and exclusively to support the development of this proposed method. This data was derived from the use of LCA modelling based on the 80% design stage of construction development, i.e., advanced stages of construction.

Further details on the case study findings from the T3 Collingwood data are set out under the '*Results*' section of this report.

Literature review

This research project also incorporated a literature review to considered published material on the emissions reduction benefits arising from the use of wood products in the construction sector and associated research analyses in relation to carbon emissions reduction and crediting schemes associated with the built environment. The scope of the literature review and key observations are set out in **Appendix 2**.

Key method design considerations

Building upon the case study observations and the broader literature review, the project team then addressed a range of key method design considerations through a series of workshop sessions with the Steering Committee. These method design considerations included addressing the following key questions:

- *Primary objective*: Should the method be focused on incentivising construction project developers to use more timber products, or a more holistic, project-based method to maximise emission reductions through 'green' or 'clean' buildings?
- *Scheme focus*: Should the project focus mainly on the ACCU Scheme, or explore other options under international, non-government led schemes?
- *LCA scope*: Should the Life Cycle Analysis be conducted based on A1 – A5 life cycle stages only (upfront embodied carbon), or whole of life carbon (encompassing end of life and beyond systems boundaries), or another subset?
- *Product scope*: Should the methodology be based on preferential use of Mass Timber Construction (MTC) products only, or all Timber Products (long-term to very long-term wood products)?
- *Sectoral scope*: Should the methodology be based on the commercial construction sector only, or residential construction as well, or all construction sectors that may choose to use timber products over non-timber products?
- *Tools scope*: Should the methodology be based on use of a select suite of existing LCA tools in use by the construction sector, or consider developing a method-specific tool based on ISO standards?

[6] Australian Institute of Architects 2024 National Architecture Awards Program. Online: https://www.architecture.com.au/archives/awards/t3-collingwood-jackson-clements-burrows-architects

These types of method design issues were discussed with reference to the case study data, literature review findings, and the expertise and experience of the Steering Committee members.

The design principles agreed to with the Steering Committee, and subsequently endorsed by the broader Built Environment Working Group, are discussed below under the '*Results*' and '*Discussion*' sections of this report.

Development of method proposal for ACCU Scheme

The final stages of this project were focused on the preparation of a proposed outline for a carbon crediting method under the ACCU Scheme in Australia. This focus on developing a proposed method outline for the ACCU Scheme was based on the Australian Government's guidance in the second half of 2023 of its intent to implement a proponent-led method development process and, subsequently, the call for EOIs in May 2024 under interim PLMD process arrangements.

Between January and April 2024, the project team prepared a method proposal in preparation for the Australian Government to receive these proposals. Drafts of the proposal were based on the method design principles agreed to with the Steering Committee and were circulated for comment and feedback.

Following the Government's call for EOIs in late May, the method proposal was revised and updated to align with the specific requirements for EOIs. A project submission was made by the due date in early July 2024.

At the time of project completion, the Government is considering the EOI submission for a new carbon crediting method titled Greening Construction with Sustainable Wood, along with all other submissions received under the interim PLMD process.

--

Results

Following are the results of a review of industry data and the T3 Collingwood case study data, which were used to inform the design of a proposed method under the ACCU Scheme.

Industry data review

The examples of mid-rise and other large-scale buildings shown in **Appendix 1** present an exciting range of architectural designs incorporating MTC designs and material choices. However, these examples are pioneering in nature. MTC continues to be used in only a small proportion of large-scale or multi-storey building construction projects across Australia.

The latest available construction sector data shows that timbers' share of the mid-rise and above construction market is generally less than 2% (Table 1). This suggests significant opportunity to increase the number of overall projects currently dominated by conventional concrete and/or steel design.

Table 1 Timber market share of mid-rise+ building construction projects between 2015-16 to 2022-23

Market share	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Total no. 4-20 storey projects reported, nationally	412	756	669	399	335	265	276	389
Total no. 4-20 storey projects featuring mass timber	4	3	4	6	11	4	4	7
% total projects featuring timber	**0.97%**	**0.40%**	**0.60%**	**1.50%**	**3.28%**	**1.51%**	**1.45%**	**1.80%**

Source: FWPA Mid-rise Market Analysis (2024)

Published literature, summarised in **Appendix 2**, also indicates that the use of mass timber in Australia's construction sector is not yet mainstream. Recent studies have noted the use of MTC is growing, but it is still used in only a very small proportion of construction projects; and the reason for this may be due to a lack of a detailed understanding about how it performs[7,8,9]. While this situation has led to substantial research worldwide, it means that the use of MTC in Australia's mid-rise buildings, specifically to reduce greenhouse gas emissions, can be considered 'additional'; i.e., not business as usual.

T3 Collingwood case study data

Sumitomo Forestry Australia Pty Ltd kindly provided life-cycle assessment (LCA) data for T3 Collingwood, specifically and exclusively to support this research project and the development of a carbon crediting method for use of wood products in the built environment. The T3 Collingwood data is derived from LCA modelling based on the 80% design stage of construction development, i.e., advanced stages of construction, but not yet at completion.

This data encompasses a whole life cycle analysis, which takes into consideration the *carbon storage in wood products* and *avoidance of emissions* that would be emitted if more emissions-intensive building designs and materials were used. To do this, T3 Collingwood compared a *Reference Case* with a performance equivalent *Project case*. These two designs comprise:

[7] Crawford & Cadorel (2017) *ibid*.
[8] WBCSD (2021) *Net-zero buildings – Where do we stand?* Report prepared by ARUP for the WBCSD.
[9] World Green Building Council (2019) *Bringing embodied carbon upfront - coordinated action for the building and construction sector to tackle embodied carbon*. Available online: www.worldgbc.org/embodied-carbon

A. *Reference case*: The building design reflecting 'business as usual' conventional construction practices and material choices.

B. *Project case*: The proposed alternative design featuring MTC and increased use of wood products, specifically to reduce the emissions associated with the construction and embodied carbon; but otherwise aligning with and meeting the structural performance requirements for the building.

As part of the construction project management, two sets of upfront carbon emissions calculations (across the A1-A5 life-cycle stages) were prepared: one for the Reference case and another for the Project case ('Greening Construction' case). This comparison is based on the Global Warming Potential (GWP) in kg per CO_{2e} between the Reference case and the Project case, as shown below. This summary highlights the use of mass timber products (comprising CLT, glulam, and laminated veneer lumber) in the Project case, in contrast to the Reference case which has no mass timbers, relying on steel and concrete components.

Table 2 Illustration of LCA comparison of Reference case and Project case for construction project featuring mass timber products

Embodied carbon emissions: A1-A5	**Reference Case building** (*Reinforced concrete design*)				**Project Case building** (*Timber design*)			
Material	Quantity		Embodied Carbon		Quantity		Embodied Carbon	
Concrete	11,189	m^3	6,270,874	kg-CO_{2e}	7,545	m^3	3,463,308	kg-CO_{2e}
Steel	1,633,360	kg	1,763,465	kg-CO_{2e}	1,074,362	kg	1,171,738	kg-CO_{2e}
Mass timber products	-	m^3	-	kg-CO_{2e}	3,226	m^3	1,299,773	kg-CO_{2e}
Other materials	*Unspecified*	m^3	4,912,949	kg-CO_{2e}	*Unspecified*	m^3	4,912,949	kg-CO_{2e}
Net emissions excluding carbon sequestration			12,947,288	kg-CO_{2e}			10,847,768	kg-CO_{2e}
Carbon sequestration*	-		-127	kg-CO_{2e}	3,226	m^3	-3,200,269	kg-CO_{2e}
Net emissions including carbon sequestration			12,947,161	kg-CO_{2e}			7,647,499	kg-CO_{2e}

Net difference in embodied carbon	*(Amount eligible for abatement claim)*	**5,299,662**	**kg-CO_{2e}**

Source: Illustrative example courtesy of Sumitomo Forestry Australia, based on LCA analysis for T3 Collingwood at 80% design stage. Carbon sequestration in timber products calculated based on -621 kg-CO_2-e/m^3, from approved EPDs.

Proponents would then calculate the net abatement as the *net difference in embodied carbon,* including carbon sequestration, based on the use of LCA tools.

Table 3 below shows the breakdown of global warming values (effectively emissions associated with the construction that are incorporated as embodied carbon) and the biogenic carbon storage (the CO_2 sequestered by trees and stored within harvested wood products), which features in the A1 life cycle section. The global warming values for the Reference case are significantly higher than in the Project case; and the Project case enjoys the benefit of significantly higher biogenic carbon storage, attributable to the use of around 3,266 cubic metres (m^3) of timber products (predominantly CLT, glulam and laminated veneer lumber).

In this analysis, it should be noted the largest contributor to emissions, and emission reductions, is LCA section B6, which covers the operational energy use of the building or infrastructure, such as the operation of the heating system and other building-related installed services. This stage also includes the provision and transport of all materials, products, energy and water used during this part of the use stage. This section, and other B sections, are typically not impacted significantly by construction material choices, i.e. choice of timber compared to concrete or steel. Therefore, for the purposes of methodology development relating to the use of wood products in the built environment, it is proposed the LCA stages encompassing operational emissions (B1-B7) be excluded from the analysis.

Table 3 LCA modelling outputs from the 80% design stage of T3 Collingwood

	Reference case (reinforced concrete design)		Project case (timber design)	
Life cycle stages	**Global warming values (kg CO_{2e})**	**Biogenic carbon storage (kg CO_{2e})**	**Global warming values (kg CO_{2e})**	**Biogenic carbon storage (kg CO_{2e})**
A1-A3	11,142,550	127	9,346,410	3,200,269
A4 *(new)*	764,816	0	598,938	0
A5 *(new)*	1,039,921	0	902,420	0
B3	0	0	0	0
B4-B5	2,196,828	0	2,196,828	0
B6	83,173,049	0	49,882,255	0
B7	217	0	162	0
C2	177,724	0	138,400	0
C3	49,360	0	70,876	0
C4	160	0	160	0
D	-2,048,788	0	-1,549,510	0
Total	**96,495,838**	**127**	**61,586,940**	**3,200,269**

Source: Sumitomo Forestry Australia, December 2023. Data provided specifically and exclusively for this project and method development. Please note this data is presented in kilograms of CO_{2e}, not tonnes. (Shading indicates the primary focus on the A1-A5 life cycle stages and secondary focus on C2-C4 and D stages).

Table 4 shows, for T3 Collingwood that an LCA analysis covering the A1-A5 life cycle stages would result in total emission reductions of approx. 5,300 tCO_{2e}, which represents a reduction of around 41% in modelled emissions from the Reference case.

Table 4 Comparative analysis of LCA modelling from the 80% design stage of T3 Collingwood

Summary	**Reference case (reinforced concrete)**	**Project case (Timber)**	**Modelled carbon benefit**	**Modelled carbon benefit**
Life cycle stages	**(kg CO_{2e})**	**(kg CO_{2e})**	**(kg-CO_{2e})**	**(t-CO_{2e})**
A1-A3	11,142,550	9,346,410		
Biogenic carbon storage	-127	-3,200,269		
A1-A3 total	11,142,424	6,146,141	4,996,283	**4,996**
A1-A5	12,947,288	10,847,768		
Biogenic carbon storage	-127	-3,200,269		
A1-A5 total	12,947,161	7,647,499	5,299,662	**5,300**
A, B, C & D stages	96,495,838	61,586,940		
Biogenic carbon storage	-127	- 3,200,269		
A1-D total	96,495,712	58,386,671	38,109,041	**38,109**
C2-C4	227,244	209,436	17,808	**18**
D	-2,048,788	-1,549,510	-499,278	**-499**

Source: Sumitomo Forestry Australia, December 2023. Data provided specifically and exclusively for this project and method development.

Other observations from this case study analysis were:

- An LCA analysis that incorporates the C2-C4 life cycle stages would not add much to the total emission reductions or the financial value of carbon credits. This indicates that the timber products used in construction will store carbon for longer in the end-of-life stages, but the benefit of this is subdued by the large volume of construction materials used and the differential in end-of-life impacts on emissions is not so large.
- An LCA analysis that incorporates the D life cycle stage would see some minor diminishment of the value of increasing the use of wood products; although overall, across sections A1-A5, C and D, the emission reduction benefits of the timber case still outweigh those of the Reference case, by a significant extent. The diminishment seen in the D life cycle stage is attributable in large part to assumptions based on the superiority of some non-timber products such as steel in the capacity for recovery, reuse, and recycling of these products.

More broadly, this case study highlights, as a set of observations:

- There is clearly capacity for projects such as T3 Collingwood to present a robust breakdown of LCA data and embodied carbon emissions data across multiple life cycle stages.
- The B life cycle stages (operational emissions) account for the largest sources of emissions overall; but can be readily excluded from an analysis that focusses on the impacts of the use of wood products in construction design and material choices.
- The A1-A3 life cycle stages (production) capture the biogenic carbon storage, which complements and adds to the benefits arising from substitution of timber products for more emissions-intensive products.
- Inclusion of the C life cycle stages (end of life) has not added much difference to the emission reduction outcomes. Further consideration of this would require additional case study data for comparison.
- Likewise, inclusion of the D life cycle stage (beyond the system boundary) may not add much difference to the emission reduction outcomes and would add further complexity and uncertainty to the analysis.

These results and the implications for the proposed method design are discussed further under the ‘Discussion’ section.

Discussion

Key elements of the method development process are discussed below.

Scheme focus for method development

A key consideration during the initial stages of this project was whether there were any existing methods under carbon crediting schemes in other countries that could be applied or adapted for application in Australia.

An international review of methods currently under development, including those recognised within voluntary carbon offset and crediting schemes, indicated there is a '*Methodology for Mass Timber Constructions*' under development for the Verified Carbon Standard (VCS), administered by Verra[10]. However, this methodology development is not yet at a stage where it can be shared externally for consideration, and therefore, there has been no opportunity to date to compare and align the details of the proposals. Furthermore, it is not yet known if this VCS standard would be applicable in Australia – and if so, it is not yet known if it would constitute 'eligible carbon abatement' for the purposes of Australia's national inventory.

Noting these limitations of the VCS method, while currently under development, and the announcement by the Australian Government to commit to increasing the use of wood from sustainably managed forests in the built environment, the project team and the Built Environment Working Group decided to focus further efforts on method development under the ACCU Scheme. This prioritisation for the research was consolidated following the Australian Government's launch of the interim PLMD process and call for EOIs.

Construction sector emissions

A key finding from the literature review was the construction sector in Australia represents a substantial proportion of the national carbon footprint, with authoritative data from 10 years ago showing it accounted for over 18%. The largest contributors to the construction carbon footprint continue to be electricity, gas and water (utilities), and construction materials.

Over the past decade, there has been considerable focus on achieving emission reductions through the transition to use of renewable energy sources and other energy efficiency programs. While this focus is ongoing, the energy efficiency gains are such that there is now increasing focus on other factors including material use, and measures such as replacing carbon-intensive materials, and reducing, reusing and recycling construction materials. New low-carbon materials, such as engineered wood products (EWPs) or geopolymer concrete, have the potential to replace the traditional materials of steel and concrete, both of which are carbon-intensive.

Engineered wood products have significant potential as a sustainable alternative for concrete and steel in construction. A large proportion of studies on this topic over the past decade have focused on Cross Laminated Timber (CLT) and have generally shown that CLT can add value to conventional timber products due to its high strength-to-weight ratio, simple installation, aesthetic features and environmental benefits. Some of these and other studies recognise the broader suites of engineered wood products, e.g., glulam and laminated veneer lumber.

[10] Verra (2024) *Methodology for Mass Timber Constructions*. Accessed 30 June 2024, online: https://verra.org/methodologies/methodology-for-mass-timber-constructions/

Notwithstanding this, published literature indicates that the use of mass timber in Australia's construction sector is not yet mainstream. Recent studies have noted the use of MTC is growing, but it is still used in only a very small proportion of construction projects; and the reason for this may be due to a lack of a detailed understanding about how it performs.

While this situation has led to substantial research worldwide, it means that the use of MTC in Australia's mid-rise buildings, specifically to reduce greenhouse gas emissions, can be considered 'additional'; i.e., not business as usual.

Eligible project activities

The proposed new method has been designed for large scale building projects featuring mass timber construction design and materials, with four or more storeys, or an indicative minimum threshold limit of using at least 200 m^3 of timber products in the building structure, or a gross floor area (or 'net lettable area' of at least 1,000 square metres (m^2)) to realise the scale of opportunity required for ACCU consideration. Generally, the method to report embodied emissions savings will be easier to implement on a single-building basis.

The building projects may be 'mixed use' buildings under the National Construction Code, comprising multiple building classes – and may incorporate multi-residential uses as well as commercial and industrial uses.

The proposed approach is to *exclude class 1 buildings* (detached or attached single dwellings of a domestic or residential nature) from this method development; while noting there is significant potential for increased substitution of non-timber products with timber products in the residential sector, and the scope for this to be considered further in the future.

The primary reason for this focus on large scale construction projects, including mid-rise and tall buildings, is the clear argument and level of evidence for 'additionality' in the increased use of wood products in these buildings compared to a conventional reference case design. There is a high level of recognition of the way in which MTC design can replace the use of more emissions-intensive building materials, whereas class 1 residential buildings continue to feature a significant use of timber framing as part of conventional construction systems.

In addition, through consultation with the Australian Research Council (ARC) Advance Timber Hub, and Master Builders Associations, the Australian forest and wood products industry has observed the benefits of focusing on large scale construction projects with a single building, single footprint, which can generate substantial emission reduction benefits for each building project. In contrast, scaling up low-rise residential development would require extensive aggregation and working with an entirely different building sector, with different types of tools and systems.

Furthermore, the proponents recognize this is a new type of method for the ACCU Scheme, which elevates the importance of a clear and simple method proposition. In this context, it is proposed that containing the method scope to large scale construction projects featuring MTC is relatively clear and simple, with large scale projects situated on single footprints. Examples of these project types are set out in **Appendix 1**.

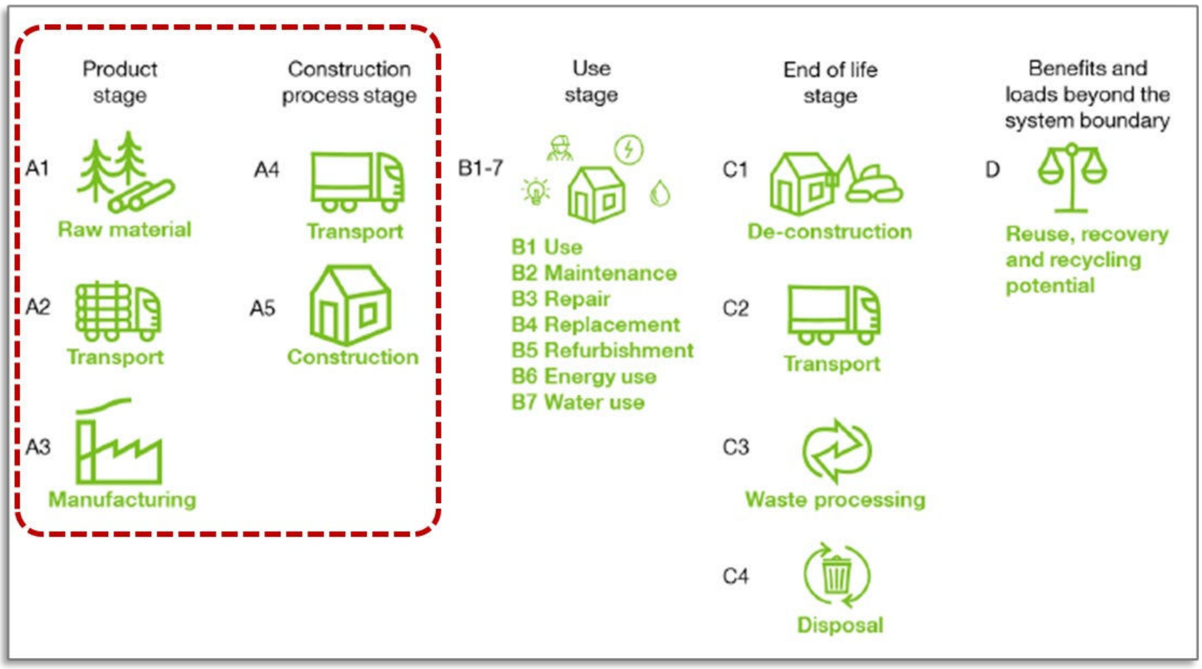
Project boundaries

The project boundaries for this method were defined with reference to European standards guidance on system boundaries for assessing the sustainability of construction works (EN

15978:2011). The EN standard describes the system boundary that should be applied at the building level and provides LCA calculation methods and reporting requirements for new and refurbished buildings, across all life cycle stages. It also provides guidance on defining the building life cycle, selecting environmental data and other information, the calculation of the environmental indicators, and reporting the assessment and comparison of LCA results[11].

Using the EN standard guidance, it is proposed the new method will calculate and compare the embodied carbon in the two alternate building designs, based on the 'Production' (A1-A3) life cycle stage and 'Construction process' (A4-A5) stage (Figure 3). This system boundary will encompass the biogenic carbon storage in the raw materials, i.e. wood from forests (A1) and the embodied carbon in construction materials including timber, concrete, steel, and aluminum. Emissions associated with construction materials (products) and processes within this system boundary will be derived from LCA databases and published Environmental Product Declarations (EPDs) that provide validated data on embodied carbon emissions for a broad range of construction products and processes.

Figure 3 System boundary for projects under the proposed carbon crediting method



Source: Stora Enso EPD for CLT. Derived from 15978:2011 EN standards guidance on system boundaries for building assessments.

Following deliberations by the project team and the Built Environment Working Group, it was decided the method should exclude consideration of operational emissions in the building 'use' stage (B1-B7), 'end of life' stages (C1-C4) and the 'benefits and loads beyond the system boundary' (D). The main reason for focusing on the A1-A3 and A4-A5 stages were:

- Focusing on the embodied carbon in construction projects, up to project completion; and
- Incentivizing the use of wood products where suitable, instead of alternative non-wood products with higher emissions intensities, specifically to realise net abatement benefits.

These decisions on design and material choices are made and reflected in the Product (A1–A3) and Construction process (A4-A5) stages and are therefore decisions made by the project developer and building designer.

[11] *EN 15978 Sustainability of construction works*. Online: https://standards.globalspec.com/std/1406797/EN%2015978

The exclusion of the operational 'use' stage emissions in the proposed carbon method differentiates it from the existing 'Commercial buildings' method and the coverage of the NABERS programs, which relate mainly to energy use and energy efficiency ratings. In the building 'use stage' (B1-B7), significant gains in emission reductions can be achieved without timber substitution, e.g. progressive use of renewable energy. This decision making is typically completed by the long-term building owner and building manager.

For these reasons, it was proposed the project boundary encompass all the stages leading up to the completion of construction projects but *excludes* the Use life cycle stage and all subsequent life cycle stages. The A1-A5 stages encompasses the aspects for which construction project developers have direct responsibility and control.

Furthermore, the proposed project boundary recognises the potential issues of overlap with the 'Commercial buildings' method and NABERS and that significant gains in emission reductions can be achieved without timber substitution. The subsequent C & D life cycle stages beyond the Use stage have also been excluded, as it would be inconsistent to exclude the B life cycle stage but then include subsequent stages in the abatement calculations.

Baseline scenario for use of wood products in construction

Current industry practice for mid-storey building construction and design in Australia predominantly utilises reinforced concrete and steel structures[12, 13, 14].

Timber and wood products have been used in construction for many centuries but are less common in larger buildings due to preexisting concerns over structural performance, durability, fire resistance and acoustics[15]. As a result, buildings have tended to be constructed of steel and concrete due to their suitability and proven performance in medium to high-rise construction, and the economies possible at this scale have made these materials even more competitive.

Notwithstanding this, over the past 10-20 years, there has been increasing interest in the use of wood products, especially CLT and other engineered wood products, to meet growing demand for more sustainable buildings, and increasing recognition of other favourable features including structural properties and reduced construction timelines. These advances in MTC product development, and the relatively mature state of the technology now in Australia, was discussed above.

However, the uptake of these designs and materials is still expected to be gradual compared to traditional design and material choices without more targeted policies and incentives accompanied by more detailed information on how these timber-based systems perform. The constraining factors (prior to the introduction of policy drivers and financial incentives such that the ACCU Scheme may offer).

---

[12] Abed et al. (2022) A Review of the Performance and Benefits of Mass Timber as an Alternative to Concrete and Steel for Improving the Sustainability of Structures. *Sustainability*, 14, 5570

[13] Jayalath et al. (2020) Life cycle performance of Cross Laminated Timber mid-rise residential buildings in Australia. *Energy and Buildings*, Vol. 223, 2020,110091, ISSN 0378-7788.

[14] Yu et al. (2017) The carbon footprint of Australia's construction sector. *Procedia Engineering*, Vol. 180, 211 – 220.

[15] Crawford & Cadorel (2017) A framework for assessing the environmental benefits of mass timber construction. *Procedia Engineering*, Vol 196, 838 – 846

In relation to policy drivers and construction industry trends, it should be noted there is a range of national-level policies and programs that have focussed largely on reducing the operational emissions and energy efficiency in residential and commercial buildings, such as changes to the National Construction Code (NCC), a national plan for the 'Trajectory for Low Energy Buildings', the National Australian Built Environment Rating System (NABERS) and the Commercial Building Disclosure (CBD), which uses NABERS to provide energy efficiency information to buyers and tenants.

Most of these policies and programs are expected to realise further improvements in reducing operational emissions of buildings once constructed. However, until recently, there has been less focus on reducing embodied carbon emissions associated with the production of materials used in the construction sector. Embodied carbon emissions comprise the carbon dioxide emissions released into the atmosphere before and during construction – including any emissions concerning manufacturing and transportation of the materials used for construction.

Recent developments have seen an increasing focus on reducing embodied carbon emissions. In NSW, the State government has established the State Environmental Planning Policy (Sustainable Buildings SEPP) 2022 (SB SEPP) as a policy framework aimed at promoting sustainable building practices and reducing the environmental impact of the built environment in NSW. This specifically includes through the introduction of embodied emissions measurement and reporting for all building types and associated materials[16]. From October 2023, all new residential and all non-residential developments must report on embodied emissions under the SB SEPP.

This policy position in NSW was formulated based on research commissioned in 2021, which found embodied emissions made up 16% of Australia's built environment footprint in 2019; and concluded that without deliberate action, this could increase to 85% by 2050 as buildings become more efficient and the power grid decarbonises through increased renewables[17].

In addition to these policy shifts, over the next decade, the construction sector in Australia (and globally) will likely see progressive improvements in lowering the emissions intensity associated with the manufacturing of traditional materials including steel and concrete (e.g. 'green steel' and low carbon concrete') with an increasing range of global and national initiatives underway for 'bringing embodied carbon upfront'[18,19].

These initiatives will mean the baseline scenario will be dynamic over time (not static) and will incorporate progressive improvements in reducing construction sector emissions on a unit basis. However, the baseline scenario will continue to reflect the predominant focus to date on operational emissions, more so than embodied carbon emissions; and will not feature the financial incentive provided by the capacity to generate ACCUs from shifts in the construction sector to increase the use of wood products in the built environment by 2030.

---

[16] NSW Government (2023) *Embodied Emissions Reporting*. An Embodied Emissions Technical Note, published by the Department of Planning and Environment.
[17] Green Building Council of Australia (2021) *Embodied Carbon & Embodied Energy in Australia's Buildings.*
[18] World Green Building Council (2019) *Bringing embodied carbon upfront - coordinated action for the building and construction sector to tackle embodied carbon*. Report by the World Green Building Council and Ramboll.
[19] World Business Council for Sustainable Development (2021) *Net-zero buildings – Where do we stand?* Arup Report.

Calculating net abatement

The method will incorporate and provides crediting for both the *carbon storage in wood products* and *avoidance of emissions* that would be emitted if more emissions-intensive building designs and materials were used. The method will do this by requiring proponents to construct and compare two designs:

C. *Reference case*: The building design reflecting 'business as usual' conventional construction practices and material choices.

D. *Project case*: The proposed alternative design featuring MTC and increased use of wood products, specifically to reduce the emissions associated with the construction and embodied carbon; but otherwise aligning with and meeting the structural performance requirements for the building.

Project proponents will need to prepare two sets of upfront carbon emissions calculations (across the A1-A5 life-cycle stages): one for the Reference case and another for the Project case ('Greening Construction' case). This comparison will need to be done using credible LCA tools to model the comparative Global Warming Potential (GWP) in kg per CO_{2e} between the Reference case and the Project case.

The net abatement would be calculated as the *net difference in embodied carbon,* including carbon sequestration, based on the use of LCA tools and the refinement of estimates through the design stages.

This approach, using LCA models to compare a Reference case with a Project case incorporating more use of wood products, is an established method that features prominently in published research[20] and the literature review for this EOI (**Appendix 2**). Both cases must share the same aspects for the comparison of the following:

- Life cycle stages and system boundary (A1 – A5)
- Size, scale, volume, and function of the building
- Calculation methodologies
- Data sources and data hierarchy including consistent use of EPDs
- Declared units
- Site work boundary
- Building elements boundary
- Cut-off rules
- Assumptions on carbon sequestration, carbon neutral products, and carbon offsets used in the project.

Having aligned these aspects of the LCA, the Reference case can differ from the Project case in respect to:

- Building material choices and quantities
- Transport emissions, which factor the distance and type of transport required for different materials
- Construction emissions, which factor the type of construction required for various construction designs.

[20] Refer Ximenes & Grant, 2013; Liu et al, 2016; Skullestad et al. 2016; Jayalath et al., 2020; Hart et al. 2021.

Abatement calculation tools

The building construction sector uses a range of LCA tools to calculate and validate embodied emissions and other sustainability metrics associated with construction designs and completed projects. Leading examples of tools used in Australia include *One Click LCA*, *eTool*, *Sphera* (a rebrand of the former *GaBi*) and *SimaPro*.

Australia's forest and wood products industry has identified these as the leading examples of LCA tools based on consultation with ARC Advance Timber Hub and a review of systems and tools used by construction companies involved with MTC projects.

It is proposed the new method will enable construction project developers to use their preferred LCA modelling tools, *provided that* the tool complies with a defined set of principles and criteria specified in the method. These principles and criteria will need to be defined and agreed through further work on method development. However, it is proposed that LCA tool requirements are to:

- comprise a certified product database incorporating data from the AusLCI and EPD Australasia databases, and a broader range of datasets for materials, including generic and manufacturer-specific data
- be compliant with ISO standards for management systems
- be aligned with Australia's NCAS and the latest National Greenhouse Accounts (NGA) Emission Factors
- be transparent, verifiable, and peer reviewed.

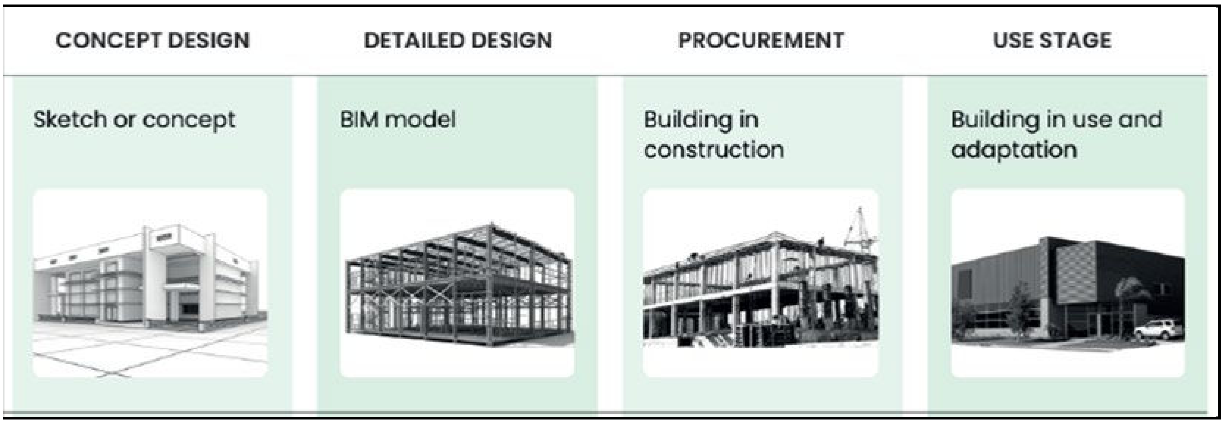
This approach of providing guidance and requirements for the use of LCA modelling tools, rather than endorsing specific LCA tools, is considered appropriate given the range currently used by the industry, and it will reduce undue constraints on project developers and administrative requirements (burdens) on the scheme administrators or the regulator, to be assessing and endorsing tools.

Under the proposed method, project proponents would be requested to document the main assumptions incorporated in the LCA tools, e.g. key databases, specific standards applied, specific design elements incorporated (e.g. types of floor plates and connector components).

Timing for abatement calculations

The new method will need to specify the stage or stages of the building design at which net abatement can be calculated, to determine the ACCUs that will be generated. The building design commences with initial sketch and concept models, and progresses through to the detailed design, then procurement and construction (Figure 4). As the design progresses through these stages, there is increasing levels of accuracy and precision in the design elements, including construction systems and material choices.

Figure 4 Stages of building design with increasing levels of accuracy and precision in design elements



For the new method, there is a need to balance this recognition of increasing detail and design accuracy and precision through the construction planning processes with the need to provide incentives for project developers at the early stages of the project, when investment decisions are being made, including in respect to the selection of construction systems and material choices such as those relating to mass timber products.

Therefore, it is proposed that project proponents be able to make a project application using the new method based on the 'detailed design' stage development, and then conduct or engage a near-completion review and calculation adjustment as required, in the final stage of the project design (Figure 5). This would enable project proponents to factor the consideration of ACCUs into investment decisions and subsequent design decisions, while balancing this with assurance of real abatement when the project is near completion and post-completion.

Figure 5 Proposed alignment of ACCU Scheme project applications with building design stages

Construction stage	Application of proposed new method	Roles for proponent
Concept design	Preparatory development	Insufficient detail to submit application for project registration under ACCU Scheme.
Detailed design, with BIM, prior to construction	Project application incorporating net abatement calculated from detailed design LCA	Project registration under ACCU Scheme. Commence ACCU accounting and reporting obligations. Pursue ACCU sales and revenue (optional), subject to prudent risk buffers for subsequent adjustment requirements.
Procurement stage	Annual reporting obligations under ACCU Scheme and project contracts, with any adjustments and reconciliations required	Regular reporting in accordance with the specified reporting period; proposed as annually for this method. At the end of each reporting period, a report must be submitted to the Clean Energy Regulator detailing the amount of greenhouse gas emissions the project avoided or removed.
Use stage	Annual reporting obligations under ACCU Scheme and project contracts, with any adjustments and reconciliations required	Regular reporting in accordance with the specified reporting period; proposed as annually for this method. At the end of each reporting period, a report must be submitted to the Clean Energy Regulator detailing the amount of greenhouse gas emissions the project avoided or removed.

Ensuring no double counting

A key issue considered in the preparation of this EOI is the potential risk of double counting, such as if the carbon storage in the timber products used for construction has already been accounted for by forest owners, e.g. timber produced from plantations grown under the 'Plantation Forestry' method under the ACCU Scheme.

Clearly this new method will need to incorporate the requirement for due diligence, disclosure, and exclusion of carbon credits for any timber products for which ACCUs may already have been issued. However, the risk of this occurring in the next 10-15 years is effectively nil, as no plantations established under the Plantation Forestry method will have reached maturity, and therefore be providing harvest products in this time.
This position is based on the premise that wood products used in construction projects are manufactured from sawlogs rather than pulp logs; and the timeframe for growing sawlogs is typically at least 15-20+ years (as illustrated in Table 5).

ABARES data shows that softwood timber plantations are typically grown on rotations of around 30 years to produce sawlogs, with some limited sawlog production from age 18-20 years; while hardwood plantations grown for sawlog timber production are typically grown on rotations of between 25 – 45 years, and the earliest sawlog products would similarly arise around 20 years[21]. Based on this guidance, the following analysis shows the earliest year in which plantation timber grown with support from the ACCU Scheme through Plantation Forestry method could produce timber for construction projects is circa 2032 and beyond; and across the current schedules, the earliest production of sawlogs from most projects will be after 2040.

Table 5 Indicative guidance on earliest production of timber from plantations established under the Plantation Forestry Method

Plantation Forestry Method Determination 2022[1]	Indicative timeline for sawlog production[2]		Indicative earliest year from Method approval in 2022[1]	
	Softwood	*Hardwood*	*Softwood*	*Hardwood*
Schedule 1: Establishing a new plantation forest	20 years	20 years	2042	2042
Schedule 2: Converting from short-rotation to long-rotation plantation	~20 years (from hardwood to softwood)	~10-12 years (from pulpwood to sawlog regime)	2042	2032 - 2035
Schedule 3: Continuing rotational harvest cycles in a plantation forest	20 years	20 years	2042	2042
Schedule 4: Transitioning a plantation forest to a permanent forest	No timber production	No timber production	-	-

Source: Indufor indicative estimates. Notes: 1. This indicative guidance is centered on the Methodology Determination 2022 and, for simplicity, overlooks the Methodology Determination 2017, which has been superseded. 2. Indicative timeline for sawlog production reflects the expectation of some sawlog production from the 2nd or 3rd thinning of plantation forests, with recognition the substantive proportion of volumes are expected upon clearfell at the end of full rotations.

[21] Gavran, M, Frakes, I, Davey, S & Mahendrarajah, S, 2012, *Australia's plantation log supply 2010–2054*, ABARES, Canberra, March.

Therefore, there is negligible scope for double counting of emission reductions associated with the ACCU Plantation Forestry method and the proposed method, until well beyond 2032. Thereafter, this risk can be addressed by a requirement in the new method for proponents to incorporate the requirement for due diligence, disclosure, and exclusion of carbon credits for any timber products for which ACCUs may already have been issued.

Looking beyond the risk of double counting ACCUs, there is also the risk of double counting the biogenic carbon storage in timber and wood products. The NGGI accounts for carbon sequestration and storage in the Harvested Wood Products pool within the LULUCF sector, and therefore, to an extent, most if not all carbon stored in timber and wood products from existing forest estates in Australia will be accounted for the NGGI. This pool would increase in two cases: firstly, if more plantation forests were established to produce timber and wood products; and secondly, if forest products designated for short term uses (e.g. pulp and paper fibre) are redirected to long term uses (e.g. manufacturing of engineered wood products), whereby the life cycle of carbon sequestration and storage would be extended.

In this context, the proposed new method recognises the role of harvested wood products in storing carbon within building projects, while also noting the national accounts may already account for the carbon sequestered and stored in wood products, unless there is an increase in supply. Over time, this recognition of the role of wood products in storing carbon for the long term, and the preferential use of more sustainable timber in construction – through the incentives provided by this method and other drivers - may lead to increased carbon sequestration and storage in the national accounts.

Treatment of imports

Another key consideration for the new method is the treatment of imported construction materials, including both non-timber products (featuring in the Reference case) and timber products (featuring in the Project case). This is an important consideration because emissions associated with the production of all imported products, and the biogenic carbon storage of timber products, are not accounted for by Australia in its greenhouse gas inventory reporting under the Paris Agreement. Inconsistent treatment of imports could therefore skew the abatement calculations and comparisons between the Reference case and the Project case.

To address this, it is proposed the new method would incorporate the conditional requirement that abatement calculations can only incorporate construction materials produced from domestic supply, manufacturing and transport. Furthermore, ACCUs can only be generated from the net difference in embodied carbon emissions derived from the quantities of timber (and other materials) used in the project that are supplied from domestic sources. This requirement would have two benefits:

1. It will encourage the construction sector to preference sustainable wood products that are grown and produced in Australia and therefore can be accounted for in the national inventory reporting under the Paris Agreement; and
2. It will also mitigate the risk of inconsistencies in the treatment of imports across the comparison between the Reference case and Project case, and net abatement calculations.

The assurance by project proponents of this treatment of imports would need to be addressed as part of the project registration at the detailed design phase of the construction project; and reconfirmed in subsequent reporting, including at the post-construction ‘Use’ stage.

Alignment with Offset Integrity Standards

A summary of the alignment of the proposed new method with Australia's OIS is set out below in Table 6.

Table 6 Summary of alignment of proposed new method with Offset Integrity Standards

OIS	Proposed new method position
Additionality *A method should result in carbon abatement that is unlikely to occur in the ordinary course of events.*	✓ The method will support carbon abatement that is unlikely to occur at scale in the ordinary course of events. ✓ While there are some examples of innovative building designs across Australia, MTC is still used in only a very small proportion of construction projects (with the latest industry data indicating <2%), and additionality tests can be applied based on evidence and observable common practice. ✓ The proposed method is expected to provide direct support for projects that are new or better than industry average: i.e. examples of innovative technology or practices reducing or sequestering more emissions than the average in the sector.
Measurable and verifiable *A method involving the removal, reduction or emissions should be measurable and capable of being verified.*	✓ The abatement will be measurable, specifically using LCA tools that incorporate extensive existing data from EPDs and other datapoints on embodied carbon across a broad range of construction materials. ✓ The measurement of abatement benefits in this way is well established, as reflected in the case study and literature review (**Appendix 2**). ✓ The abatement is verifiable, through the engagement of independent and qualified experts to review the LCA calculations, and progressive reporting, using internationally recognised LCA modelling tools.
Eligible carbon abatement *A method should provide abatement that is able to be used to meet Australia's international mitigation obligations.*	✓ Abatement will be realised from reducing emission *sources* (through avoided use of relatively high emissions intensive products and emissions in the Industrial processes and product use sector), and substitution with products that are effectively *sinks* (in the Harvested Wood Products pool in the LULUCF sector), which are accounted for by Australia in its NGGI reporting under the Paris Agreement. ❖ The method recognises the role of harvested wood products in storing carbon within building projects, noting carbon sequestered and stored in these products may already be accounted for in the NGGI, unless there is an increase in supply. ✓ Over time, this recognition of the role and the preferential use of more sustainable timber in construction – through the incentives provided by this method and other drivers – is expected to lead to increased carbon sequestration and storage.
Evidence-based *Supported by clear and convincing evidence.*	✓ The proponents have conducted a literature review to consider the extent to which the anticipated abatement is supported by clear and convincing evidence. The literature review (**Appendix 2**) provides a clear and convincing evidence base to support the expectation of real, net abatement from the proposed project activity.
Project emissions *Material emissions emitted as a direct result of the project activities should be deducted.*	✓ Abatement calculations will be based on the use of credible, industry leading LCA tools for construction projects to capture all sources of project emissions, as well as sinks, for construction material choices across the A1-A5 life cycle stages. ✓ The use of credible, industry leading LCA tools, and consistent use of data sources and data hierarchy, including consistent use of EPDs will ensure all sources of emissions are deducted in a systematic way. ❖ Concurrent work to liaise with industry leading LCA tool providers to develop and strengthen methodologies and establish additional EPDs for a broader range of products

OIS	Proposed new method position
Conservative *Where a method involves an estimate, projection, or assumption, it should be conservative*	✓ Calculated GWP and biogenic carbon storage contributions would only be based on internationally recognised product component EPDs and life-cycle assessment tools adhering to key principles, conservative emissions factors and common assumptions. ✓ All design choices for the Reference case must be conventional, not worst case. ✓ It is proposed the system boundary purposefully excludes life-cycle areas of uncertainty, which would not only add complexity if included, but they are also acknowledged in literature review to derive varying impacts to whole of life emissions for products and projects. The decisions influencing the specific outcomes and assumptions in these end-of life parts of the system are also generally outside control of the project developer. ✓ Abatement can only be claimed for domestically sourced and produced materials, with any potential gains in emissions benefit from imports to be excluded.

Conclusions

This research project led to the conclusion that the most prospective opportunity for Australia's forest and wood products sector to develop a carbon crediting method that incentivises construction project developers to use Australian grown and manufactured wood products where suitable, instead of alternative non-wood products with higher emissions intensities, is under the ACCU Scheme through the new PLMD process.

This conclusion is largely attributable to the two significant Australian Government policy developments that were announced during this research project, i.e.

- Firstly, at COP28, the commitment to advancing policies and approaches that support low carbon construction and increase the use of wood from sustainably managed forests in the built environment – with specific recognition that such policies and approaches will result in reduced GHG emissions and an increase in stored carbon within the construction sector.
- Secondly, in May 2024, the launch of Australia's interim PLMD process for the ACCU Scheme; with the call for EOIs in submitting method ideas for new methods (or variations of existing methods) to deliver eligible carbon abatement through carbon sequestration or emissions avoidance.

In this context, the development of a carbon crediting method proposal for the ACCU Scheme became compelling and the research became specifically focussed on this scheme.

Furthermore, this research project demonstrated that a method proposal can be prepared to respond to the requirements of the PLMD process. Having worked through a broad range of method design issues, discussed above, the project team then worked closely with AFPA, FWPA and the Built Environment Working Group to submit an EOI to the Australian Government in July 2024, under the first round of the interim PLMD process for the ACCU Scheme. The EOI sets out an outline for a new carbon crediting method under the ACCU Scheme, titled '*Greening Construction with Sustainable Wood*'. Through this EOI, Australia's forest and wood products sector can actively encourage further Government policy support for increased use of wood products in the construction sector.

While acknowledging this primary focus on development of a carbon crediting method under the ACCU Scheme, it would be prudent for the sector to continue to monitor the development of the '*Methodology for Mass Timber Constructions*' for the Verified Carbon Standard (VCS). This methodology is under development but expected to progress to a public consultation phase by the end of 2024.

Another key conclusion is that Australia's forest and wood products sector has demonstrated capacity to bring together a broad range of expertise to support method development processes under schemes such as the ACCU Scheme. This demonstrated capacity and experience can be built upon through subsequent rounds of calls for new methods under the ACCU Scheme and its PLMD process; and potentially other schemes such as the formative Nature Repair Market, which is an Australian Government initiative to incentivises actions to restore and protect the environment. It encourages nature positive land management practices that deliver improved biodiversity outcomes. The Nature Repair Market will establish a marketplace where individuals and organisations can undertake nature repair projects to generate a tradable certificate.

Recommendations

This research project has delivered an EOI to the Australian Government for the development of a carbon crediting method to incentivise construction project developers to use Australian grown and manufactured wood products where suitable, instead of alternative non-wood products with higher emissions intensities. The Australian Government has advised its intent to prioritise selected EOIs from the first round of this process by the end of 2024.

The additional work required to further develop this method comprises predominantly stakeholder engagement, especially with the following groups:

- *Construction sector*: Through the BEWG, there has been a range of engagement already, most notably within Australia's wood products sector, companies involved directly in construction projects, and ongoing engagement with the Master Builders Association. Having conceptualised this method proposal, it would be beneficial to engage further with the construction sector, including leading construction companies, as well as Engineers Australia, to test further this method proposal and obtain further feedback on likely levels of uptake, relative to a baseline projection over the next 10+ years.
- *Timber Building Sustainability programs*: This method proposal has been developed with direct reference to the complementarity with the NABERS program and sustainability programs and initiatives of the Green Building Council of Australia (GBCA). NABERS is soon to release a new Embodied Carbon rating tool which will enable new buildings and major refurbishments to measure, verify, and compare their upfront embodied carbon with similar buildings[22]; which would likely provide consistent method for measuring embodied carbon in the construction sector. This tool is expected to become a leading resource for architects, engineers and construction companies, in providing a credible tool for embodied carbon assessments.

  The method development team for this EOI have sought to engage with NABERS and the GBCA but there has been limited opportunity to do so prior to the EOI submission date. Follow up engagement would be pursued with support from the ERAC for further work on this method development.
- *First Nations*: As noted in Section 3.1, the proponents of this EOI see First Nations Opportunities, including the scope for Aboriginal or Torres Strait Islander participation, including the method development process as well as benefit sharing. The method development team have made preliminary contact with selected First Nations organisations, and their corporate enterprises, for initial feedback on this EOI, with generally favourable feedback. However, it would be beneficial to conduct further engagement with these and other First Nations groups over a period of 3-4 months.
- *Verra*: As noted in Section 4.1, the proponents are aware that under the Verified Carbon Standard administered by Verra, there is a voluntary carbon method under development with the working title of '*Methodology for Mass Timber Constructions*'. However, no details of this method have been made public to date, nor its timeline for completion, and its applicability in Australia is unknown. Furthermore, as a voluntary carbon scheme method, it will not necessarily reflect the Australian Government's policy positions relating to 'greening' the construction sector with increased use of wood products. Nonetheless, the method development team for this EOI have contacted Verra and requested the opportunity for further engagement as these two initiatives progress further.

[22] *NABERS Embodied Carbon*. Online: https://www.nabers.gov.au/ratings/our-ratings/nabers-embodied-carbon

In addition, there is some further method development work around specifying the criteria-based requirements for tools to be used for calculating and comparing embodied carbon emissions in construction materials associated with the reference case and the project case. It is proposed that this be addressed principally through the further engagement with the construction sector, as outlined above, to discuss the sector's use of existing tools, with further expert input from the ARC Advance Timber Hub.

Concurrently, the ARC Advance Timber Hub is now working to address construction data requirements, with the aim to establish publicly available datasets over coming years that could be used to provide the total number of large-scale buildings in Australian and the proportion of different construction systems and key material choices.

To address the consultation requirements and key requirements for LCA modelling tools, AFPA and FWPA consider the time needed to undertake further method development work is approximately 3-4 months from notification of selection by the Australian Government as a method idea for further development.

This timeline is based on the time required to consult further with leading construction companies in Australia, representatives of the NABERS program, the GCBA, selected First Nations groups, and representatives of Verra and the Verified Carbon Standard - and to make refinements to the method proposal accordingly. This work will require direct engagement, through meetings, briefing sessions, sharing of the EOI for feedback, and compiling feedback into subsequent versions of the method proposal.

Following further work over this period, the method proposal would be strengthened by this additional consultation and be ready for further consideration by the ERAC.

With this focus predominantly on further stakeholder engagement, there are the risks that:

- The organisations nominated for further consultation are unavailable or otherwise not in a position to be consulted in the near term.
- The organisations nominated for further consultation raise substantial concerns about the method idea and its alignment with the Offset Integrity Standards for carbon abatement.

The project team and Built Environment Working Group consider these risks to be low or manageable, for the following reasons.

Firstly, the method idea is directly aligned with Australian Government's commitment to *'advancing policies and approaches that support low carbon construction and increase the use of wood from sustainably managed forests in the built environment'* – per its announcement at COP28 in Dubai, under the auspices of the Forest and Climate Leaders' Partnership Coalition on Greening Construction with Sustainable Wood.

Secondly, the method idea is based on accelerating adoption of demonstrable technical capability to design and construct large scale buildings that can realise lower embodied carbon emissions, with case study examples around Australia that showcase the potential, if further drivers or incentives (such as ACCUs) are available to increase the uptake.

Thirdly, BEWG engagement with construction companies indicate there is increasing interest and willingness to consider innovative construction systems that will reduce embodied carbon, provided it can address other investment requirements – most notably, being competitive on total construction costs and on delivery within project timelines. This method proposal is intended to contribute favourably to the benefit-cost analysis for construction companies, by providing ACCU for carbon abatement benefits.

References

Abed, J., Rayburg, S., Rodwell, J., Neave, M. (2022) A Review of the Performance and Benefits of Mass Timber as an Alternative to Concrete and Steel for Improving the Sustainability of Structures. *Sustainability*, 14, 5570.

Arup (2019) *Rethinking Timber Buildings: Seven perspectives on the use of timber in building design and construction*.

Australian Government (2024) *Developing new ACCU Scheme methods*. Online: https://www.dcceew.gov.au/climate-change/emissions-reduction/accu-scheme/developing-new-methods

CEFC (2021) Australian buildings and infrastructure: Opportunities for cutting embodied carbon. Industry Report.

Crawford, R.H., Cadorel, X. (2017) A framework for assessing the environmental benefits of mass timber construction. *Procedia Engineering*, Vol 196, 838 – 846.

DCCEEW 2023, *Attachment A: Method and module EOI interim guidelines*, Department of Climate Change, Energy, the Environment and Water, Canberra, September. CC BY 4.0.

Duan, Z., Huang, Q., Sun, Q., Zhang, Q. (2022) Comparative life cycle assessment of a reinforced concrete residential building with equivalent cross laminated timber alternatives in China. *Journal of Building Engineering*, Vol. 62, 105357.

FCLP 2023, *Initiative for Greening Construction with Sustainable Wood*. FCLP Public Announcement. Refer online: https://forestclimateleaders.org/wp-content/uploads/2023/12/FCLP-COP28-Release-Buildings-06122023.pdf.

Green Building Council of Australia (2021) Embodied Carbon & Embodied Energy in Australia's Buildings.

Green Building Council of Australia (GBCA) and Thinkstep-ANZ (2021) *Embodied Carbon and Embodied Energy in Australia's Buildings*. Sydney: Green Building Council of Australia and Thinkstep-ANZ.

Hart, J., D'Amico, B., Pomponi, F. (2021) Whole-life embodied carbon in multi-story buildings - Steel, concrete and timber structures. *Journal of Industrial Ecology* 2021, Vol 25, 403–418.

Hawkins, W., Cooper, S., Allen, S., Roynon, J., Ibell, T. (2021) Embodied carbon assessment using a dynamic climate model: Case-study comparison of a concrete, steel and timber building structure. *Structures*, Vol. 33, 2021, Pages 90-98, ISSN 2352-0124, https://doi.org/10.1016/j.istruc.2020.12.013.

Jayalath, A., Navaratnam, S., Ngo, T., Mendis, P., Hewson, N., Aye, L. (2020) Life cycle performance of Cross Laminated Timber mid-rise residential buildings in Australia. *Energy and Buildings*, Vol. 223, 2020,110091, ISSN 0378-7788, https://doi.org/10.1016/j.enbuild.2020.110091.

Kremer, P. D., Symmons, M.A. (2015) Mass timber construction as an alternative to concrete and steel in the Australia building industry: a PESTEL evaluation of the potential. *International Wood Products Journal*, 2015, Vol. 6, No.3, 138-147.

Kuittinen, M., Zernicke, C., Slabik, S., Hafner, A. (2021) How can carbon be stored in the built environment? A review of potential options. *Architectural Science Review*, 2021, DOI: 10.1080/00038628.2021.1896471.

Liu, Y., Guo, H., Sun, C., Chang, W.S. (2016) Assessing cross laminated timber (CLT) as an alternative material for mid-rise residential buildings in cold regions in China - A life-cycle assessment approach. *Sustainability*, Vol. 8, 1047; doi:10.3390/su8101047.

Lukić, I., Premrov, M., Passer, A., Leskovar, V A. (2021) Embodied energy and GHG emissions of residential multi-storey timber buildings by height – A case with structural connectors and mechanical fasteners. *Energy and Buildings*, Vol. 252, 2021, 111387, ISSN 0378-7788, https://doi.org/10.1016/j.enbuild.2021.111387

Nepal et al. (2024) The potential use of mass timber in mid-to high-rise construction and the associated carbon benefits in the United States. *PLoS ONE* 19(3): e0298379. https://doi.org/10.1371/journal.pone.0298379.

Perry, M., Peachey, L., Lam, B., Binney, J. (2021) Estimating the benefits of an emissions reduction fund method for the use of timber products in buildings. Report prepared for Forest and Wood Products Australia (FWPA), Australia, PRA541-2021.

Skullestad, J L., Bohne, R A., Lohne, J. (2016) High-rise Timber Buildings as a Climate Change Mitigation Measure – A Comparative LCA of Structural System Alternatives. *Energy Procedia,* Vol. 96, 2016, Pages 112-123, ISSN 1876-6102, https://doi.org/10.1016/j.egypro.2016.09.112

Wood Central (2024*) Faster & Greener: Canada's Top Bank Says 'Yes' to Mass Timber*. Article published May 2024: https://woodcentral.com.au/faster-greener-canadas-top-bank-says-yes-to-mass-timber/

World Business Council for Sustainable Development (2021) *Net-zero buildings – Where do we stand?* Report prepared by ARUP for the WBCSD.

World Green Building Council (2019) *Bringing embodied carbon upfront - coordinated action for the building and construction sector to tackle embodied carbon*. Report by the World Green Building Council (WGBC) and Ramboll. Available online: www.worldgbc.org/embodied-carbon

Ximenes, F. & Grant, T. (2013) Quantifying the greenhouse benefits of the use of wood products in two popular house designs in Sydney, Australia. *International Journal of Life Cycle Assessment*, Vol. 18, No. 4, 891-908.

Ximenes, F. & Thinkstep-ANZ (2023) *Forests, plantations, wood products & Australia's carbon balance*. Report prepared for Forest & Wood Products Australia (FWPA), Australia.

Yu, M. et al. (2017) The carbon footprint of Australia's construction sector. *Procedia Engineering*, Vol. 180, 211 – 220.

Yu, M., Widmann, T., Crawford, R., Tait, C. (2017) The carbon footprint of Australia's construction sector. *Procedia Engineering*, Vol. 180, 211 – 220.

Acknowledgements

This research project was prepared with strong support from the Built Environment Working Group (BEWG) facilitated by AFPA and FWPA. The BEWG comprised leading companies in the Australian forest and wood products sector, as well as companies that have direct investments in large scale construction projects, notably Sumitomo Forestry Australia, and representatives of master builders that are intent on raising standards within the industry, specifically Master Builders Australia.

The authors gratefully acknowledge this support including participation in project workshops and reviewing draft documents to provide feedback and guidance.

The authors especially acknowledge the support from Sumitomo Forestry Australia for the preparation of the case study incorporated in this project report. The case study provided highly relevant data to inform the comparative assessment of embodied carbon emissions in alternative designs for large scale buildings and valuable insights to key considerations in contemporary building designs and construction material selections.

The authors also gratefully acknowledge all the support of the Australian Research Council Industry Transformation Research Hub to Advance Timber for Australia's Future Built Environment (ARC Advance Timber Hub, IH220100016), with whom some of the authors are directly affiliated. The Hub provided ready access to a broader network of academic expertise and other stakeholders with specialist expertise in fields relating to construction design and material choices for the built environment. In addition, Research Hub Director Professor Keith Crews and Hub Manager Kelly Rischmiller provided invaluable support for the setup of the project as well as assistance and guidance throughout the multiple stages and the dissemination of findings.

Appendix 1 Photo gallery of large-scale timber constructions

The following is a selection of examples of the types of construction projects featuring mass timber construction that would be considered, as ‘new builds’, for application under the proposed new method.

25 King St Timber Tower, Brisbane

Source: Wood Solutions

Aveo Bella Vista, Norwest, Sydney

Source: Wood Solutions

Gilles Hall, Monash University, Frankston

Source: Wood Solutions

The Bond, Norwest, NSW

Source: Wood Solution

Ballarat Gov Hub

Source: Wood Solutions
Photography: JWA and Kane Constructions

Monterey Apartments, Kangaroo Point, Qld

Source: Wood Solutions
Photography: Callum Lillywhite

Adelaide Oval Hotel, Adelaide, SA

Source: Wood Solutions
Photography: David Sievers

Stromlo Leisure Centre, ACT

Source: Wood Solutions
Photography: Cox Architecture

Meyer Timber Warehouse, NSW

Source: Wood Solutions
Photography: TGA Engineers

Hyne Timber Processing Facility, Qld

Source: Wood Solutions
Photography: Badge & Tungsten Structures

Macquarie University Innovation Hub, NSW

Source: Wood Solutions

The Hedberg Performing Arts Precinct, Hobart

Source: Wood Solutions
Photography: Natasha Mulhall

Appendix 2 Literature review

Review scope

Indufor and the ARC Advance Timber Hub have observed extensive published literature relating to whole-life embodied carbon in multi-story buildings and comparisons between the use of wood products and non-timber products. A select list of relevant publications reviewed specifically for the preparation of this method is set out below. Summary data from this review is also provided, as representative of the evidence base of relevant literature that supports the underlying principles and carbon benefits arising from the proposed method.

Summary of findings

The following summary addresses the main points arising from the literature review in relation to mass timber construction, its environmental benefits, comparisons with other materials, and considerations for the Australian construction sector.

The construction sector represents a substantial proportion of Australia's carbon footprint, with authoritative data from 10 years ago showing it accounted for over 18%[23]. The largest contributors to the construction carbon footprint continue to be electricity, gas and water (utilities), and construction materials. Over the past decade, there has been considerable focus on achieving emission reductions through the transition to use of renewable energy sources and other energy efficiency programs. While this focus is ongoing, the energy efficiency gains are such that there is now increasing focus on other factors including material use, and measures such as replacing carbon-intensive materials, and reducing, reusing and recycling construction materials. New low-carbon materials, such as engineered wood products (EWPs) or geopolymer concrete, have the potential to replace the traditional materials of steel and concrete, both of which are carbon-intensive[24].

Engineered wood products have significant potential as a sustainable alternative for concrete and steel in construction. A large proportion of studies on this topic over the past decade have focused on Cross Laminated Timber (CLT) and have generally shown that CLT can add value to conventional timber products due to its high strength-to-weight ratio, simple installation, aesthetic features and environmental benefits[25]. Some of these and other studies recognise the broader suites of engineered wood products, e.g., glulam and laminated veneer lumber.

Notwithstanding this, published literature indicates that the use of mass timber in Australia's construction sector is not yet mainstream. Recent studies have noted the use of mass timber construction (MTC) is growing, but it is still used in only a very small proportion of construction projects; and the reason for this may be due to a lack of a detailed understanding about how it performs[26,27,28].

While this situation has led to substantial research worldwide, it means that the use of MTC in Australia's mid-rise buildings, specifically to reduce greenhouse gas emissions, can be considered 'additional'; i.e., not business as usual.

Another prominent theme arising in the literature review is the importance of conducting comprehensive life cycle analyses to demonstrate the environmental benefits of alternative construction designs and material choices.

---

[23] Yu et al. (2017)
[24] *Ibid*.
[25] Jayalath et al. (2020)
[26] Crawford & Cadorel (2017)
[27] WBCSD (2021)
[28] WGBC (2019)

There are multiple studies advocating that whole life carbon assessment is critical to enabling society to achieve net zero goals[29]; while others emphasise the need for using a systematic framework to assess the environmental benefits of mass timber construction and inform sound decision making.[30,31,32,33] Other studies have adopted this approach, but excluded or separated operational emissions from the analysis, to focus specifically on the life cycle impacts of construction material choices[34,35].

While recognising the importance of conducting or considering comprehensive life cycle analyses, it has also been observed that end-of-life processes are fraught with uncertainty and often ignored, despite the potentially large associated carbon fluxes[36]. This may present challenges for construction project proponents, to conduct robust life cycle assessments for construction projects that incorporate end-of-life scenarios that address the uncertainty associated with the scenarios over a 50 - 60 years period.

However, robust research data is available for the end-of-life outcomes for engineered wood products in Australia[37]; which indicates effectively all the carbon in EWPs commonly disposed of in landfills in Australia can be retained in storage indefinitely. This result, confirmed by an independent study, has two major implications for EWPs:

- Use of EWPs has a beneficial impact on greenhouse gas mitigation efforts, as a high proportion of the carbon contained in those products can be deemed to be retained in long-term storage in Australia. This will directly benefit the industry as its greenhouse credentials are demonstrated and can be expected to compare favourably against most current alternatives; and

- Factors used to determine greenhouse gas emissions from wood and EWPs in landfills should be drastically reduced to reflect the findings of this study and recently published international data.

[29] WBCSD (2021)
[30] Crawford & Cadorel (2017)
[31] Duan et al. (2022)
[32] Hart et al. (2021)
[33] GBCA & Think-Step (2021)
[34] Ximenes & Grant (2013)
[35] Hart et al. (2021)
[36] Hawkins (2021)
[37] Ximenes F., Brooks P., Wilson C. and Giles, D. (20130 *Carbon Storage in Engineered Wood Products in Landfills*. Report prepared for Forest & Wood Products Australia. Project No: PRB180-0910.

Key points

Following is a summary of the selected set of literature, with key points focusing on comparative assessments of the environmental performance of mass timber construction and the importance of whole life cycle assessment in evaluating the environmental impacts.

1. Abed et al. (2022) A Review of the Performance and Benefits of Mass Timber as an Alternative to Concrete and Steel for Improving the Sustainability of Structures. *Sustainability*, 14, 5570.
    - ***Mass timber outperforms concrete and steel in structural and environmental aspects.***
    - Reduced carbon emissions and comprehensive review underscore its sustainability.
    - ***Emphasizes the importance of thorough analysis for evaluating mass timber's benefits.***
    - Structural and performance-related advantages of mass timber are explored in-depth.
2. ARUP (2019) *Rethinking Timber Buildings - Seven perspectives on the use of timber in building design and construction*. London.
    - The report discusses timber's adaptability in various architectural designs and showcases its versatility and sustainability, offering unique design possibilities.
    - ***Presents the case for the environmental superiority of timber products, which contributes to increased adoption in modern construction.***
    - Innovative approaches underscore timber's flexibility and superior design.
3. Crawford and Cadorel (2017) A framework for assessing the environmental benefits of mass timber construction. *Procedia Engineering*, Vol 196, 838 – 846.
    - Mass timber construction (MTC) is seen as a potentially viable alternative for dealing with these issues while at the same time meeting the demands of modern buildings, such as increasing height, speed of construction and fire resistance.
    - ***The use of MTC is growing, but it is still used in only a very small proportion of construction projects. Part of the reason for this may be due to a lack of a detailed understanding about how it performs.***
    - This study introduces a systematic framework for assessing mass timber's environmental benefits, based on a life cycle approach, using the EN 15978 standard which separates the building life cycle into four phases: production (including biogenic carbon storage); construction; use; and end-of-life.
4. Duan et al. (2022) Comparative life cycle assessment of a reinforced concrete residential building with equivalent cross laminated timber alternatives in China. *Journal of Building Engineering*, Vol. 62, 105357.
    - The study compares residential buildings, highlighting the eco-friendliness of CLT.
    - ***Life cycle assessment validates cross laminated timber's environmental superiority compared to other products.***
    - ***Demonstrates quantifiable metrics supporting the importance of whole life cycle analysis.***
    - Emphasizes sustainability and reinforces the need for a life cycle approach.

5. GBCA and Thinkstep-ANZ (2021) *Embodied Carbon and Embodied Energy in Australia's Buildings*. Sydney.

   - Focuses on embodied carbon and energy, showcasing timber's contribution to sustainability.
   - ***Highlights the importance of considering the entire building life cycle for accurate analysis.***
   - Provides insights into timber's embodied carbon reduction potential.

6. Hart et al. (2021) Whole-life embodied carbon in multi-story buildings - Steel, concrete and timber structures. *Journal of Industrial Ecology*, 2021, Vol 25, 403–418.

   - ***Investigates embodied carbon in multi-story buildings, showcasing timber's lower impact.***
   - Compares steel, concrete, and timber structures, highlighting timber's benefits.
   - The study recognises the whole life embodied carbon (WLEC) of a building structure potentially includes greenhouse gas emissions from all life cycle stages from A to D, except for B6 and B7 (operational energy and water use). All the modelling assumed a 50-year design life consistent with typical building LCA practice.
   - Highlights the importance of a whole-life cycle perspective for understanding long-term benefits. Failure to include stages up to and including construction would result in a significant understatement of the true impacts for all systems, and it is also particularly important to consider the end-of-life stages for timber products.
   - ***In terms of WLEC, the study found on average the timber frame system is substantially better than the other two options, although there is some overlap in the results distribution***. Timber frames also have, by a wide margin, the lowest mass, and this can also lead to lower mass and WLEC of foundations.

7. Hawkins et al. (2021) Embodied carbon assessment using a dynamic climate model: Case-study comparison of a concrete, steel and timber building structure. *Structures*, Vol. 33, 2021.

   - ***Utilises dynamic climate models to assess embodied carbon, emphasizing timber's superiority.***
   - Case studies from the United Kingdom that compare the use of concrete, steel, and timber structures, and highlighting timber's emissions reduction benefits.
   - Highlights the long-term advantages of timber construction.
   - The study integrates dynamic climate models for accurate carbon assessments.

8. Jayalath et al. (2020) Life cycle performance of Cross Laminated Timber mid-rise residential buildings in Australia. *Energy and Buildings*, Vol. 223, 2020,110091.

   - The study evaluates the life cycle performance of CLT mid-rise buildings, compared to (conventional) reinforced concrete buildings, with case studies from across three Australian cities. ***The CLT building was found to have 30 % less Life Cycle GHG emissions (LCGHCE) compared with the reinforced concrete building over a life span of 50 years in Melbourne, and 34% and 29% reduction in LCGHCE in Sydney and Brisbane, respectively.***
   - ***The study demonstrates reductions in life cycle GHG emissions and costs, supporting CLT's superiority in both aspects, compared to non-timber alternatives.***

9. Kremer and Symmons (2015) Mass timber construction as an alternative to concrete and steel in the Australia building industry: a PESTEL evaluation of the potential. *International Wood Products Journal*, 2015, Vol. 6, No.3, 138-147.

- Evaluates the potential of mass timber, considering its environmental, social, and economic aspects.
- ***Highlights the need for sustainable construction material alternatives, supporting mass timber's potential.***
- Highlights the importance of a comprehensive evaluation using a PESTEL framework.
- Study also explores the broader implications of mass timber in the building industry.

10. Kuittinen et al. (2021) How can carbon be stored in the built environment? A review of potential options. *Architectural Science Review*, 2021.

- Reviews options for carbon storage in the built environment, emphasizing sustainable practices.
- ***Discusses potential carbon storage benefits in mass timber construction and provides insights into various options for carbon storage in construction.***
- Highlights the importance of sustainable alternatives in reducing carbon emissions.

11. Liu et al. (2016) Assessing cross laminated timber (CLT) as an alternative material for mid-rise residential buildings in cold regions in China - A life-cycle assessment approach. *Sustainability*, Vol. 8, 1047.

- The study conducts a life-cycle assessment of CLT in mid-rise residential buildings in cold regions in China.
- ***Demonstrates reductions in energy consumption and carbon emissions, supporting CLT's viability.***
- The study also highlights the importance of life-cycle assessments in evaluating timber alternatives.

12. Lukić et al. (2021) Embodied energy and GHG emissions of residential multi-storey timber buildings by height – A case with structural connectors and mechanical fasteners. *Energy and Buildings*, Vol. 252, 2021.

- The study analyses embodied energy and GHG emissions in multi-storey timber buildings, considering different heights and connectors.
- Discusses the environmental impact of structural connectors and mechanical fasteners.
- Highlights the need for a detailed analysis of embodied energy and emissions in timber construction.

13. Perry et al. (2021) *Estimating the benefits of an emissions reduction fund method for the use of timber products in buildings*. Report prepared for Forest and Wood Products Australia (FWPA), Australia, PRA541-2021.

- The study explores the potential for policy-driven emission reduction through timber use, and estimates benefits of an Emissions Reduction Fund (ERF) method for timber products in buildings.
- ***The report stresses the positive impact of using timber in reducing emissions in construction and highlights the importance of considering innovative methods to promote timber use***.

14. Skullestad et al. (2016) High-rise Timber Buildings as a Climate Change Mitigation Measure – A Comparative LCA of Structural System Alternatives. *Energy Procedia*, Vol. 96, 2016.

- Conducts a comparative LCA of structural system alternatives in high-rise timber buildings and provides insights into the role of timber in climate change mitigation.
- Highlights the importance of LCAs in understanding the environmental benefits of timber and utilises *SimaPro v7* as software tool for the LCA.
- Demonstrates the potential of timber structures in mitigating climate change. ***Irrespective of the assumptions made, the timber structures cause lower climate change impacts (i.e. emissions) than the reinforced concrete structures.*** By applying attributional LCA, the timber structures were found to cause a climate change impact that was 34-84 % lower than the RC structures.

15. World Business Council for Sustainable Development (2021) *Net-zero buildings – Where do we stand?* Report prepared by ARUP for the WBCSD

- Provides insights into the progress and challenges of achieving net-zero buildings, emphasizing sustainability in the construction sector.
- ***Emphasizes the crucial role of sustainable construction materials in achieving net-zero building targets and highlights the environmental benefits of using materials with lower carbon footprints, specifically acknowledging the potential of mass timber in reducing embodied carbon.***
- Recognises the need for rigorous life cycle assessments (LCAs) to accurately evaluate the environmental impact of construction materials, supporting the adoption of whole life cycle analysis methodologies.
- ***Stresses the importance of considering the entire life cycle of building materials, including production, construction, use, and end-of-life phases***.

16. World Green Building Council (2019) *Bringing embodied carbon upfront - coordinated action for the building and construction sector to tackle embodied carbon*. Report by the World Green Building Council (WGBC) and Ramboll.

- ***Highlights the need for upfront consideration of embodied carbon, including in material choices like timber.***
- Supports the adoption of coordinated industry efforts and strategies for reducing embodied carbon in construction.

17. Ximenes and Thinkstep-ANZ (2023) *Forests, plantations, wood products & Australia's carbon balance*. Report prepared for Forest & Wood Products Australia (FWPA), Australia:

- Presents a report on the management of forests, plantations and wood products in Australia, and their impact on the national carbon balance.
- ***Emphasizes the important role of timber in contributing to carbon balance and sustainable practices and supports the need for understanding the broader environmental impact of forestry and timber use***.
- ***There is significant potential to use more wood products in building applications.*** This can increase carbon in the national wood products pool and displace emissions associated with more energy-intensive building products such as steel and concrete. This benefit has been quantified in Life Cycle Assessment (LCA) studies.

- In LCAs the environmental impacts of a product or production system are quantified in all relevant stages of the product life cycle, from production to disposal. For example, an LCA study has demonstrated that maximising the use of wood products in typical single-storey and double-storey houses in Sydney could result in a net saving of around 30 t CO_2-e per house (refer to the reference below).

18. Ximenes and Grant (2013) Quantifying the greenhouse benefits of the use of wood products in two popular house designs in Sydney, Australia. *International Journal of Life Cycle Assessment,* Vol. 18, No. 4, 891-908.

- Incorporates a life cycle assessment (LCA) comparison of two popular house designs in Sydney, incorporating a reference case ('house as designed') and the proposed case ('timber maximised') for both designs.
- The LCA was undertaken using the *SimaPro 7.1* model, with the functional unit being the supply of base building elements for domestic houses in Sydney and its subsequent use over a 50-year period.
- ***Showed that significant GHG emission savings were achieved by optimising the use of wood products for two common house designs***. The timber maximised design resulted in approximately half the GHG emissions associated with the base designs. The sub-floor had the largest greenhouse impact due to the concrete components, followed by the walls due to the usage of bricks.
- The study provides specific metrics for understanding the greenhouse gas benefits of timber and highlights the need to quantify and communicate the environmental benefits of timber use.

19. Yu et al. (2017) The carbon footprint of Australia's construction sector. *Procedia Engineering*, Vol. 180, 211 – 220.

- Investigates the carbon footprint of Australia's construction sector.
- Recommends focusing on renewable energy and ***material substitution, highlighting timber as a low-carbon alternative***.
- Stresses the importance of reducing, reusing, and recycling construction materials, while emphasizing the role of timber products.
- The study suggests strategies for reducing the carbon footprint in the construction sector, with an emphasis on timber's contribution.

Summary data

Published papers	Country	Project type	Product groups	Lifecycle assessment	Carbon benefits from use of wood products
Abed, J. et al. (2022) *A Review of the Performance and Benefits of Mass Timber as an Alternative to Concrete and Steel for Improving the Sustainability of Structures.*	Australian study (RMIT); international literature review	Construction sector	Mass timber products; Mass timber construction; primarily laminated timber products	Literature review across a broad range of studies	Mass timber is superior to concrete and steel when taking into consideration all key performance factors, including reduced carbon emissions.
ARUP (2019) *Rethinking Timber Buildings - Seven perspectives on the use of timber in building design and construction.*	UK-based study; international literature review	Multi-storey timber buildings	Mass timber (encompassing massive timber, heavy timber, solid timber, or engineered timber, and *massivholz* (German)).	Literature review across a broad range of studies	Whether optimal end-of-life scenarios are employed or not, timber still claims a smaller carbon footprint than other major construction materials, as well as being sustainable and reusable. And if techniques such as anaerobic burial can be harnessed, timber could help to actively reduce the environmental impact of construction.
Crawford, R.H. & Cadorel, X. (2017) *A framework for assessing the environmental benefits of mass timber construction.*	Australian study (University of Melbourne), with international review of LCAs	Mass timber construction (all levels)	Mass timber construction (MTC)	Drew on previous LCAs (spanning A1 - C4 stages) to identify factors affecting the environmental performance and or benefits of MTC.	Recognises there is a common belief that MTC will provide environmental benefits compared to non-timber products, and proposes a life cycle-based assessment framework, guided by the European Standard EN 15978, separating the building life cycle into four phases: product, construction process, use and end-of-life, to assess environmental performance of MTC.
Duan, Z. et al. (2022) *Comparative life cycle assessment of a reinforced concrete residential building with equivalent cross laminated timber alternatives in China.*	China (Tianjin)	High-rise residential buildings	Assessment of three building types: reinforced concrete, CLT and hybrid CLT	Full LCA, incorporating end-of-life stage, and carbon storage as well as substitution benefits	The CLT and hybrid CLT buildings produced 15% and 11% lower GHG emissions, respectively, over the modelled 50-year life cycle compared to the RC building. The embodied GHG emissions of CLT and hybrid CLT buildings were reduced by 47% and 37%, respectively, in the product and construction stage compared to the RC building.

Published papers	**Country**	**Project type**	**Product groups**	**Lifecycle assessment**	**Carbon benefits from use of wood products**
GBCA and Thinkstep-ANZ (2021) *Embodied Carbon and Embodied Energy in Australia's Buildings.*	Australia	Commercial and residential buildings	All construction products	A complex analysis assessing embodied carbon and embodied energy at the national level, through use and comparison of a Process LCA, Hybrid LCA, and Input-Output LCA	Current embodied emissions from Australia's residential buildings are lower than international averages today. Among other factors, this is likely due to the use of timber framing and the high proportion of single-story dwellings with simpler foundations. However, embodied carbon will become an increasingly large portion of Australia's total emissions as other parts of the economy decarbonise.
Hart, J. et al. (2021) *Whole-life embodied carbon in multi-story buildings - Steel, concrete and timber structures.*	United Kingdom	Building superstructures for multi-storey buildings (2-19 stories)	Assessment of three structural systems: reinforced concrete, steel, and engineered timber.	Full LCA, '*cradle to grave*', with Monte Carlo analysis to provide sets of embodied carbon coefficients to support the comparison of whole life embodied carbon (WLEC).	In terms of WLEC, on average the timber frame system is substantially better than the other two options, although there is some overlap in the results distribution. Timber frames also had, by a wide margin, the lowest mass, and this can also lead to lower mass and WLEC of foundations. Whilst cradle-to-gate emissions are the largest overall, failure to include stages up to and including construction would result in a significant understatement of the true impacts for all systems, and it is also particularly important to consider the end-of-life stages for timber.
Hawkins, W. et al. (2021) *Embodied carbon assessment using a dynamic climate model: Case-study comparison of a concrete, steel and timber building structure.*	United Kingdom study	Typical mid-rise building structure in the UK	Comparing concrete, steel, and timber options	Dynamic LCA model, encompassing end-of-life processes ('*cradle to grave*'); while highlighting the importance of the initial emissions from material production & construction, which can cause high rates of short-term temperature	Concrete was found to have a higher climate impact (GHG emissions) than steel, with the climate response of both options dominated by the large initial emissions of material production and construction. Timber had the smallest impact, under a typical scenario with sustainable forest management and re-emission of sequestered carbon at end-of-life. An optimistic timber scenario, whereby future carbon-capture technology avoids most end-of-life emissions,

Published papers	Country	Project type	Product groups	Lifecycle assessment	Carbon benefits from use of wood products
				increase and accumulated radiative heat for all buildings.	demonstrates the possibility of structures with small long-term climate cooling effects.
World Business Council for Sustainable Development (2021) *Net-zero buildings – Where do we stand?*	Europe – noting a particularly relevant case study in the Netherlands	Office buildings including all-electric office building, mixed-use building, and residential towers.	Comparing the use of steel, concrete, timber, aluminium, reinforcement steel, and glass.	Drew on six case studies using whole life carbon assessments (WLCA), across A - D stages.	The residential timber tower case example in the Netherlands "is a successful example of how using timber as primary structural material can reduce the embodied carbon impact. Although a significant amount of concrete and steel were required to achieve the desired geometry and deal with the ground conditions, the total embodied carbon at practical completion is 418 $kgCO_{2e}/m^2$; this represents a 58% saving in comparison with the business-as-usual benchmark for an office building (~1,000 $kgCO_{2e}/m^2$). The benchmark for a middle/high rise would be higher than that".
Jayalath, A. et al. (2020) *Life cycle performance of Cross Laminated Timber mid-rise residential buildings in Australia*	Australia	Mid-rise residential buildings in the three most populated cities in Australia (Sydney, Melbourne, Brisbane)	LCA comparison of CLT and traditional reinforced concrete (RC) residential buildings	LCA conducted within the boundaries of the product and construction, operational and maintenance (operational emissions), and end-of-life phases.	The CLT building was found to have 30 % less life cycle GHG emissions (LCGHCE) compared with the RC building over a life span of 50 years in Melbourne, and 34% and 29% reduction in LCGHCE in Sydney and Brisbane, respectively. The cost analysis results showed that costs for CLT building is 1.3% lower than conventional RC in Melbourne, and0.9% lower in Sydney and Brisbane. The initial and end of life phases reflected reductions in LCGHGE and LCC for the CLT building whilst the operation phase incurred higher values. The extended service life of buildings has a major impact on the operational phase while changes in the discount rate have strong effects on the lifecycle operational and maintenance costs. Overall, the CLT building outperformed the RC building in terms of LCGHGE and LCC across three cities.

Published papers	Country	Project type	Product groups	Lifecycle assessment	Carbon benefits from use of wood products
Kremer, P. D. & Symmons, M.A. (2015) *Mass timber construction as an alternative to concrete and steel in the Australia building industry: a PESTEL evaluation of potential*.	Australia	MTC is ideally suited to low- to medium-rise structures, and has been used internationally to great effect in public occupancy buildings and detached and multi-residential housing	Mass timber construction as an alternative to concrete and steel	Principally a PESTEL analysis (Political, Economic, Social, Technological, Environmental & Legal considerations), with reference to LCAs in literature review.	MTC construction is an attractive alternative and potentially viable alternative or mainstream construction method in Australia. Potential advantages are outlined including, construction and labour cost savings, improvements to building energy efficiency and advantages related to the lived environment of timber buildings. "*These factors might open the door to government assistance to establish a local industry if doing so aids the nation's commitments to reduce overall carbon footprints through sequestration and a reduced reliance on more energy-intensive processes involved in the production of steel and concrete*".
Kuittinen, M. et al. (2021) *How can carbon be stored in the built environment? A review of potential options.*	German study; international literature review	Built environment, defined broadly	Literature review encompassing all construction products, including 'bio-based materials', notably wood	Assessment of options based on literature review.	Use of 'organic construction materials', particularly timber and bamboo, are identified as the approach that is the most mature and have sufficient impacts on climate mitigation. However, it is of the utmost importance that the service life of bio-based products is extended beyond the time required for their source environment to restore their natural carbon equilibrium.
Liu, Y. et al. (2016) *Assessing cross laminated timber as an alternative material for mid-rise residential buildings in cold regions in China - A life-cycle assessment approach*	China	Assessment based on 7-storey buildings	Comparison of concrete buildings (reference buildings) with equivalent design using CLT (locally sourced larch)	LCA incorporating consideration of material choices, operational emissions, and end-of-life outcomes over 50 years period.	In the Xi'an region, CLT construction was found reduce energy consumption by 36.4% and reduce carbon emissions by 42.9%, assuming 55% of the CLT was recycled at the end of the project. In the colder Harbin region, CLT construction was found to reduce energy consumption by 32.3% and reduce carbon emissions by 45%. The study also concludes that carbon emissions would be further reduced under a scenario where 90% of the CLT was recycled at the end of the project.

Published papers	Country	Project type	Product groups	Lifecycle assessment	Carbon benefits from use of wood products
Perry, M. et al. (2021) Estimating the benefits of an Emissions Reduction Fund (ERF) method for the use of timber products in buildings	Australia	Use of structural timber in class 1 (standalone single houses, terrace houses, or townhouses), class 2 (apartment buildings below 9 storeys) and non-residential buildings	All wood products (Softwood, Hardwood, CLT, LVL, glulam, plywood, particleboard), compared with concrete and steel products	Economic modelling; not an LCA.	The study found a 1% upward shift in the market share of structural timber in place of steel and concrete, in class 1, class 2 (below 9 storey) and non-residential buildings over the period of 2021 to 2050 would reduce emissions by 1.3 Mt CO_2-e in total and 1.0 Mt CO_2-e domestically. The study also found the domestic emissions reduction from a 1% upward shift is equivalent to 0.03 Mt CO_2-e annually over the assessment period. A 10% and 20% increase in market share over this timeframe is estimated to have a ten and twentyfold effect on the level of emissions reductions.
Skullestad, J L. et al. (2016) *High-rise Timber Buildings as a Climate Change Mitigation Measure – A Comparative LCA of Structural System Alternatives.*	Norway	Assessment based on four buildings ranging from 3 - 21 storeys	Assessment based on substituting multi-storey steel and reinforced concrete (RC) building structures with timber structures	*Use of SimaPro v7 as software tool for LCA.* The functional unit was defined to be a building structural system including foundations with a certain load bearing capacity and a given number of storeys, with a 60-year lifetime. Since only the building structures are assessed, and the goal is to compare two material choices, the system boundaries were set to *cradle-to-gate*. This corresponds to A1-A3 (per	Irrespective of the assumptions made, the timber structures cause lower climate change (CC) impact than the structures. By applying attributional LCA, the timber structures were found to cause a CC impact that is 34-84 % lower than the RC structures. The large span is due to different building heights and methodological assumptions. The CC saving per square metre of floor area obtained by substituting a RC structure with a timber structure decreased slightly with building height up to 12 storeys but increased from 12 to 21 storeys. From a consequential LCA perspective, constructing timber structures can result in avoided GHG emissions, indicated by a negative CC impact, with savings > 100%. Despite the methodological differences, the timber structures cause lower CC impacts than

Published papers	Country	Project type	Product groups	Lifecycle assessment	Carbon benefits from use of wood products
				standard NS-EN 15643-2). In a consequential approach, the avoided impacts due to recycling or reuse of materials after end-of-life are also accounted for (stage D).	the benchmark structures for all structures, in all approaches and scenarios.
WGBC (2019) *Bringing embodied carbon upfront - coordinated action for the building and construction sector to tackle embodied carbon.*	Global study	Construction sector	Consideration of all product types	Presents a vision setting out high-level pathways to achieve decarbonisation of the global building construction sector.	Managed harvesting of mature timber for use in construction, making space for new growth, has the potential to make a significant contribution to decarbonisation efforts.
Ximenes, F. & Grant, T. (2013) *Quantifying the greenhouse benefits of the use of wood products in two popular house designs in Sydney, Australia.*	Australia	Residential dwellings: (i) single storey house and (ii) double-storey house, in Sydney	Consideration of all product types. Two construction variations were assessed: the original intended construction, and a “timber-maximised” alternative.	*Use of SimaPro v7.1 as software tool for LCA.* The functional unit was defined as the supply of base building elements for domestic houses in Sydney and subsequent use over a 50-year period. The system boundaries reflect *cradle-to-grave*.	The study showed that significant GHG emission savings were achieved by optimising the use of wood products for two common house designs in Sydney. The switch of the sub-floor and floor covering components to a “wood” option accounted for most of the GHG savings. Inclusion of end-of-life parameters significantly impacted on the outcomes of the study.
Yu, M., Widmann, T., Crawford, R., Tait, C. (2017) *The carbon footprint of Australia’s construction sector.*	Australia	Residential buildings, non-residential buildings, road & bridge	Consideration of timber, iron, cement, brick, plaster, ceramic, textiles, steel,	National assessment based on Input-Output analysis using GHG emissions data for	The results show the carbon footprint of the Australian construction sector in 2013 comprised 18.1% of Australia’s total carbon footprint. It recommended focusing mitigation efforts on renewable energy sources in the

Published papers	Country	Project type	Product groups	Lifecycle assessment	Carbon benefits from use of wood products
		construction, other heavy & civil engineering construction.	plastics, polymers, rubber and limestone products	products, supply chains and services.	supply chain and focusing on material substitution; specifically, replacing steel and concrete products with engineered wood products and low carbon geopolymer concrete, as well as reducing, reusing and recycling construction materials/
