Forest & Wood Products Australia

Carbon Primer and Glossary

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Document Approval and Revision

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Preamble

The emission of greenhouse gases (GHGs) such as carbon dioxide (CO_2) and methane (CH_4) are among the chief contributing factors to climate change and global warming. In 2022 the Australian Government legislated emissions reductions targets of 43% by 2030 (on 2005 levels) and net zero by 2050, meaning that every industry will need to play its part in reducing emissions.

Forests are a major component of the global carbon cycle. Through photosynthesis, forests sequester biogenic carbon dioxide, which is stored in timber and wood products, and emitted at end of life through decomposition or combustion (either in forest fires or in biofuels). Biogenic carbon can also be emitted when land is cleared for agricultural or industrial purposes.

The forestry and wood products sector also releases fossil-based GHGs such as carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) through forestry management activities, timber harvesting and processing, and the manufacture of wood products.

Overall, the forestry and wood products sector has a positive story to tell. Our forests sequestered, and wood products stored, approximately 22 million tonnes of carbon dioxide between 2011-2016, which offset around 3.5% of Australia's greenhouse gas emissions for this period (ABARES, 2018). We have a key role to play in helping our partners to meet their legislative and industry emissions reductions targets.

It is now broadly accepted that decarbonising the building sector will help to reduce the effects of climate change. Embodied carbon emissions in Australia's built environment were estimated to be 16% in 2019 (GBCA & thinkstep-anz, 2021) but are expected to climb to 85% by 2050 if nothing changes in manufacturing processes. Industry focus is rapidly shifting from reducing operational carbon to embodied carbon emissions, raising important issues for the forest and wood products industry to understand and respond to, such as:

- transitioning to a sustainable, whole of life 'net-zero' built environment;
- stimulating innovation and investment in low carbon, circular building solutions; and
- rewarding transparent, healthy, low-embodied carbon building products.

Timber and wood products can play a major role in reducing embodied carbon in Australia's buildings. Wood stores carbon and is a comparatively low carbon emitting material, with majority of sawn or engineered wood products consumed by the building sector. Innovation in the production and use of engineered wood is helping to shape the future of large-scale carbon-neutral buildings. In February 2022, on the back of Clean Energy Finance Corporation (CEFC) research showing that expanding timber use in construction will significantly cut carbon emissions, the Australian Government launched a $300 million program to encourage mass timber construction across the property sector.

In this rapidly developing space, Australian native forest managers, plantation growers, timber and wood processors and importers will benefit from:

- access to a shared interpretation of the carbon concepts widely adopted by the building sector,
- understanding and engaging in the frameworks and initiatives which offer opportunities for forestry and wood products in Australia,
- advocating to reinforce policy settings, influence industry specifications and explore financial incentives which will protect the industry and grow the market for timber.

This is the first of a series of three resources produced for FWPA and members, the others include:

- a WoodSolutions Carbon Guide - targeted at Building & Design Professionals, and
- Forests/Plantations/Timber and Carbon Balance Guide - targeted at Policy Makers.

Together these resources will educate, inform, and support timber industry stakeholders to participate confidently in the current carbon / sustainability dialogue and importantly, enable them to identify potential opportunities for future focus by FWPA and its members.

Contents

1 Context and use

A series of three documents have been developed as the building sector ramps up efforts to decarbonise, and emissions become a significant consideration in forestry and plantation management as well as building and construction materials selection.

These resources clarify terminology around carbon and net zero over the life cycle of wood products and buildings, and highlight opportunities for forestry and wood products in Australia.

Carbon Primer & Glossary (this document)

Target Audience: Forest and wood product sector company representatives

Aim: This primer and glossary clarifies a range of carbon and greenhouse gas concepts, terms, and definitions, and is intended to upskill the sector on frameworks shaping the market for forest and wood products, particularly those used in construction. This will assist in supporting timber industry stakeholder understanding and participation in the carbon / sustainability dialogue which is rapidly evolving.

Access: https://fwpa.com.au/wp-content/uploads/2023/06/Carbon-Primer-Glossary-06-2023-1.pdf

WoodSolutions Carbon and Wood Products Technical Guide

Target Audience: Wood product users, building and design professionals

Aim: This practical and informative guide explains and clarifies a range of carbon and GHG concepts and is intended to upskill users of wood products, particularly building and design professionals, on how wood products can be used and assessed within different carbon frameworks. With a particular focus on carbon reduction and embodied carbon, this guide will support increased specification of timber products.

Forests, Plantations, Wood Products and Australia's Carbon Balance

Target Audience: Policy makers

Aim: This credible and simple to understand resource clarifies and upskills policy makers on how native forestry, plantations, imported timber, timber and wood products can sustainably meet the modern needs of the economy, including circular economy and various carbon frameworks. This will support increased policies that favour forest and wood products.

2 Key terms

To assist with establishing a universal carbon language among FWPA members, this primer and glossary explains and clarifies a range of greenhouse gas (GHG) and carbon concepts, terms, definitions, and frameworks which shape the market for forest and wood products, particularly those used in construction.

Key carbon terms

Some key terms used in climate change and carbon policy dialogue are explained below to support timber industry stakeholders' understanding of this rapidly evolving area.

Climate change is used to describe changes in the Earth's climate which can be attributed to human activity (such as burning fossil fuels, clearing vegetation and changing land use) that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Carbon, in the context of climate change, is commonly understood as a short form of "carbon dioxide", the most important greenhouse gas released by humans. **Greenhouse Gases** (GHG) on the other hand, are emissions of any gas capable of absorbing and emitting radiation. Carbon dioxide and methane are the most important greenhouse gases created from human activities.

As there are multiple greenhouse gases, each with a different effect on global warming (or **global warming potential** (GWP)), a measure is used to compare the relative impacts of each greenhouse gas. This measure is called **Carbon Dioxide Equivalence** (abbreviated to CO_2-eq).

Whilst the term **Carbon Footprint** refers to carbon, it is an expression of the total amount of greenhouse gases released as the result of a given activity. Similarly, the term **Carbon Emissions** typically refers to all emissions of greenhouse gases, whether or not they actually contain carbon.

Carbon neutral / Net Zero means there is no net change in carbon dioxide emissions. Carbon neutrality can be achieved by changing an activity so it no longer emits GHGs or (more typically) by offsetting the GHGs produced.

Carbon Sequestration is a process of capturing and storing carbon dioxide from the atmosphere, for example in the form of trees.

Carbon Storage in timber and wood products occurs naturally, i.e., in products manufactured from harvested wood such as paper, timber, or panel products or wood in landfill.

Carbon capture and storage (CCS) is an emerging technology which captures carbon emissions from sources like coal-fired power plants and stores them in geological formations like coal seams, aquifers, and depleted oil and gas reservoirs.

Biogenic carbon refers to the carbon removals associated with carbon sequestration into biomass, including natural building materials (e.g., timber) as well as any emissions associated with this sequestered carbon.

Scope 1, 2 and 3 emissions

Terms used in relation to organisation-wide carbon emissions. Businesses use these to calculate and report their emissions.

Scope 1 – direct emissions

Scope 1 emissions are emissions released as a direct result of a process under your control. Forestry and wood processing examples include burning diesel in plant and mobile equipment releasing fossil CO_2, the release of small volumes of methane and N_2O from burning forest residues post-harvest, or from burning processing residues to kiln dry timber or generate steam.

Scope 2 – indirect emissions

Scope 2 emissions are emissions released from the consumption of energy. For forestry and wood processing this is predominantly electricity usage to operate fixed plant and equipment such as saws, kiln fans, compressors, and dust extraction.

Scope 3 – all other indirect emissions

Scope 3 emissions are all indirect emissions (not included in scope 2) that occur upstream or downstream in your supply chain but are not under your direct control. For wood processors this would be emissions from log harvest and haulage, downstream haulage, and the processing of sold products. Scope 3 emissions are not reportable under National Greenhouse and Energy Reporting (NGER) but may be reportable under voluntary organisation-wide greenhouse gas GHG reporting schemes.

Scope 1, 2 and 3 emissions

In the construction industry, carbon is often described as operational, embodied or beyond the lifecycle, as illustrated in Figure 1 and explained below.

Embodied Carbon refers to GHG emissions associated with materials and construction processes throughout the whole lifecycle of an asset (i.e. material extraction, transport, manufacture, construction, use (and replacement), demolition and end of life). Until recently these emissions have largely been overlooked but are thought to currently contribute around 11% of all global carbon emissions (World Green Building Council, 2019). The embodied carbon stages are represented by modules A1-A5, B1-B5, and C1-C4 in Figure 2.

Upfront Carbon refers to the GHG emissions released in the materials production and construction phases of an asset's lifecycle, before the asset begins to be used. These emissions have already been released into the atmosphere before an asset is occupied or commences operation. It is estimated that more than half of total carbon emissions from all global construction between 2020 and 2050 will be due to upfront emissions from new building construction and renovations (World Green Building Council, 2019).

Operational Carbon includes emissions associated with heating, cooling and energy use of the asset: see module B6 in Figure 2.

Whole of Life Carbon includes emissions from all lifecycle phases, encompassing both embodied and operational carbon together.

Life cycle stages

Investigation and comparisons of the environmental impacts of an individual product, or an assembly of products, such as a building, is generally undertaken using a life cycle assessment (LCA). While a full LCA includes the assessment of over a dozen environmental impact categories, the one of greatest industry focus is global warming potential (GWP).

EN 15798:2011 (Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method) is currently the most widely cited standard for building LCA. EN 15804:2012+A2:2019 (Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products) has been used to create thousands of Environmental Product Declarations (EPDs) for building products worldwide. The life cycle stages (A-D) used in building LCAs, and life cycle modules (A1-A5, B1-B6, C1-C4 and D) are illustrated in Figure 2.

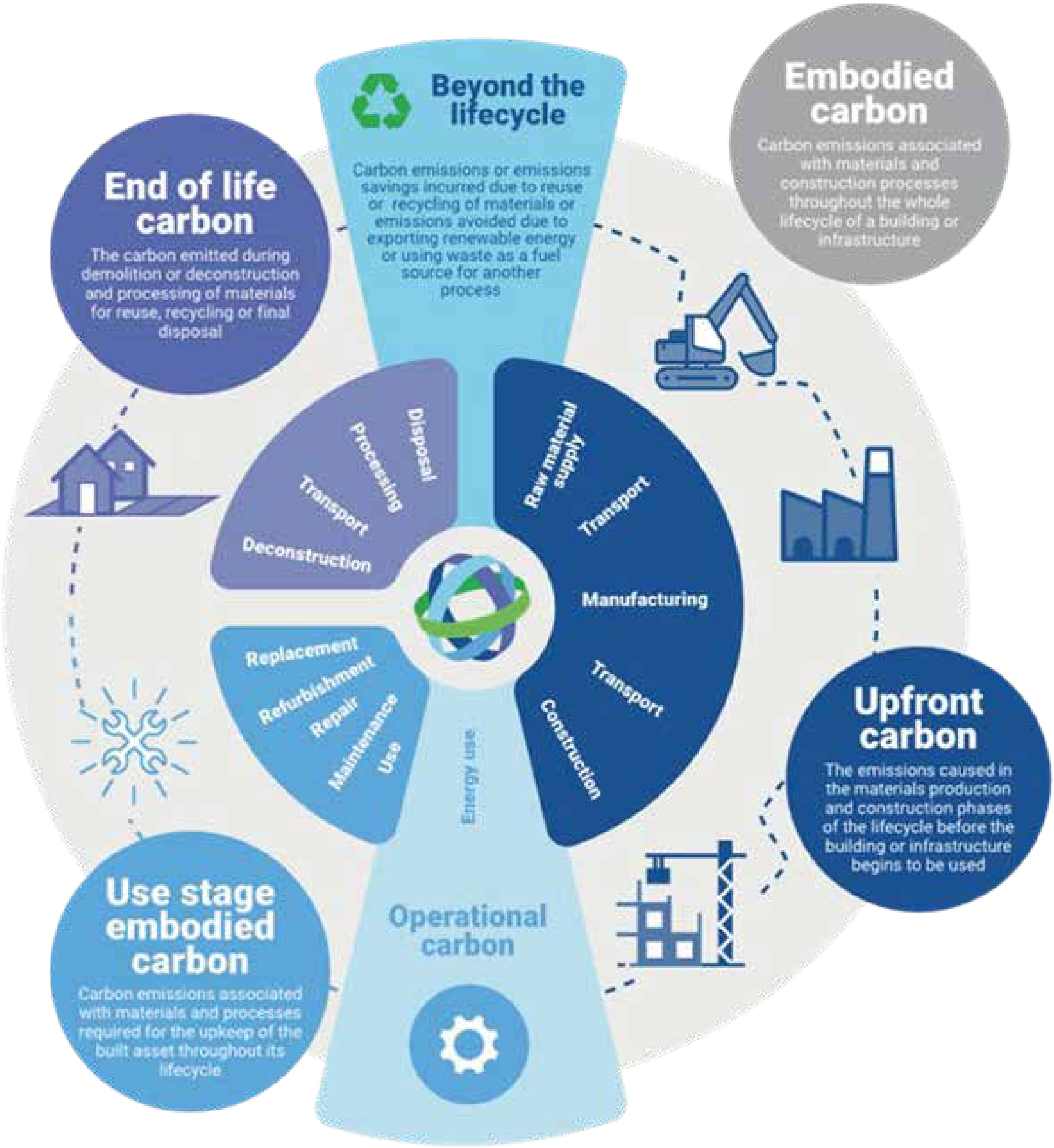

Figure 1: Scope of carbon emissions across different stages of the building life cycle[1]

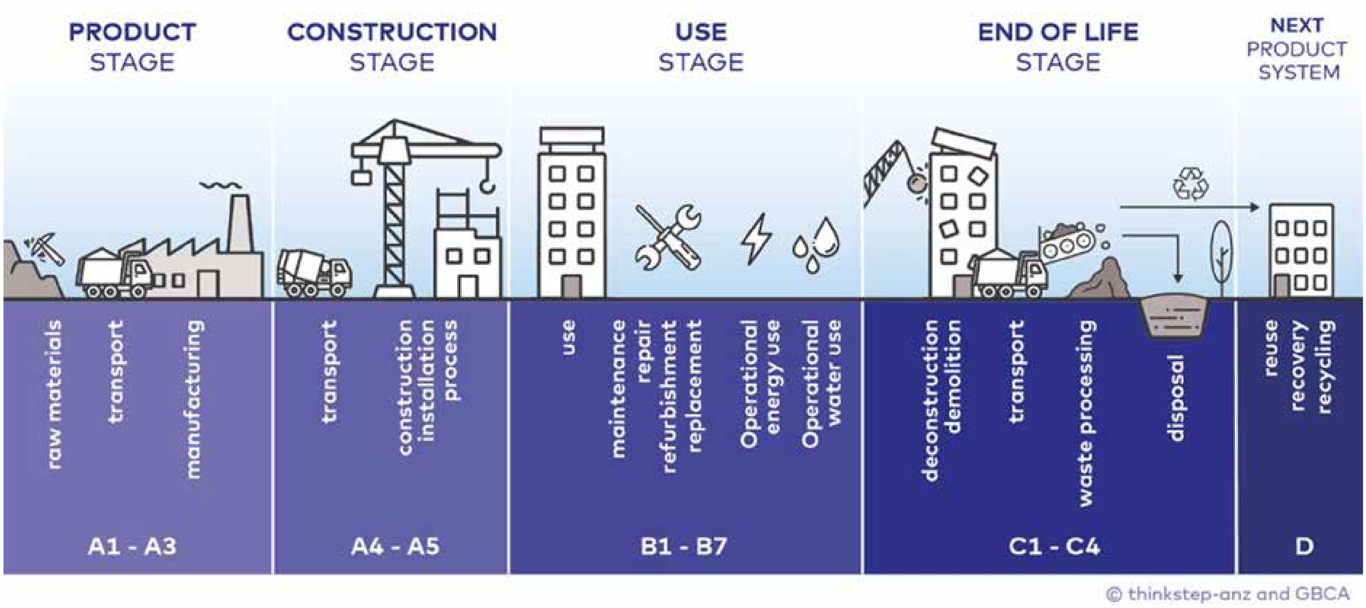

Figure 2 - Life cycle stages for forest and wood products according to ISO 21930, EN 15804 & EN 15978

3 Carbon cycle of forestry and wood products

The world's forests, forest soils and wood products are an integral part of the global carbon cycle. Simplified illustrations of the Australian softwood plantations and softwood wood products carbon cycle are provided in Figure 3 and of the native commercial forestry and hardwood products in Figure 4 .

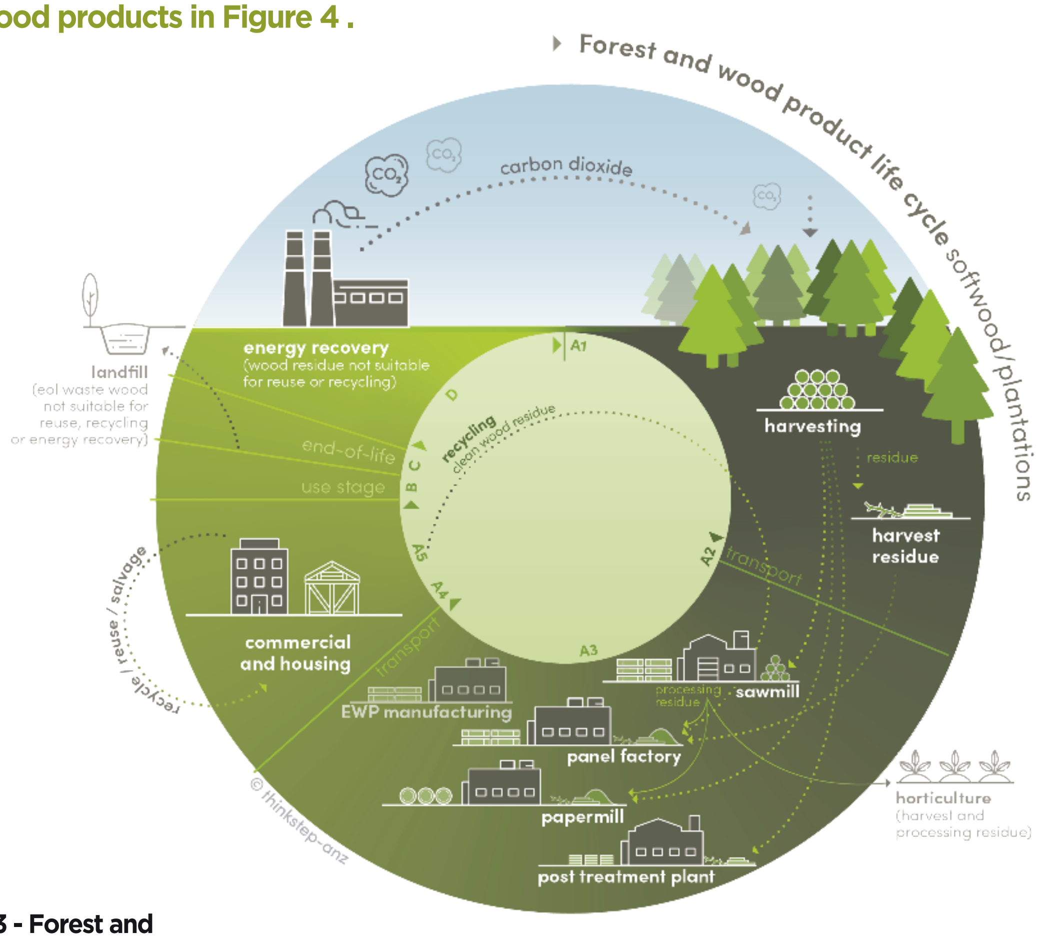

Figure 3 - Forest and wood products life cycle – softwood/plantations

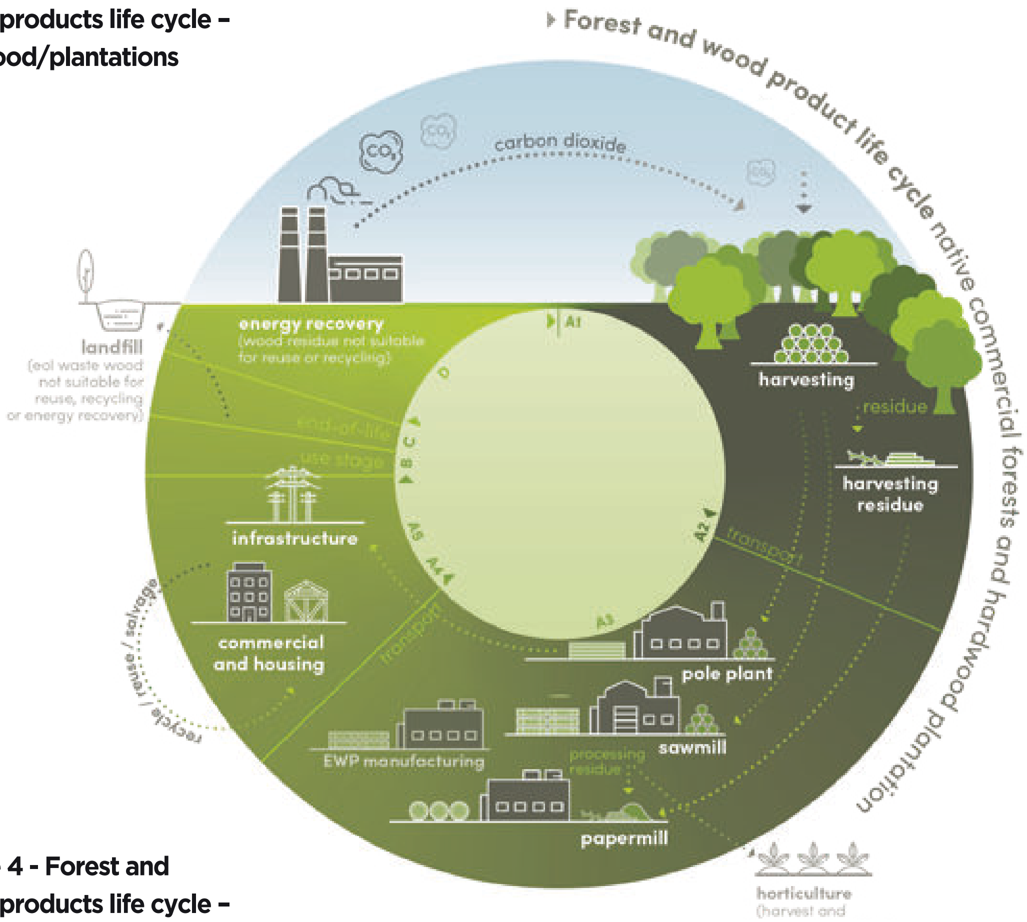

Figure 4 - Forest and wood products life cycle – hardwood/native commercial forestry

Typically about 50% of the dry weight of trees is made up of carbon[2]

3.1 Forests sequester carbon

Forests sequester carbon as individual growing trees absorb carbon dioxide from the atmosphere through photosynthesis, the process by which plants take in carbon dioxide (CO_2) and water (H_2O) from the air and soil. The water is oxidised, with the oxygen released back into the air, while the CO_2 is reduced. This process results in the carbon being stored in the tree biomass in the form of carbon compounds such as carbohydrates (including cellulose and hemicellulose) and lignin, and in soil, where it can remain locked away for tens to hundreds of years.

Much of the biomass in trees is in the woody fraction (stem and branches) and roots. Bark and leaves typically account for 10-15% of the above-ground biomass in trees. Though the carbon content of the biomass in trees can vary with plant part and wood type, typically about 50% of the dry weight of trees is made up of carbon[2].

The rate and extent to which trees sequester carbon is influenced by many factors including species, site-quality, climate and management. The rate of carbon sequestration in trees generally decreases with age. For example, in tall dense eucalypt forests the growth rates decrease progressively from around 6.4 tonnes carbon per hectare per year (for 1–10-year-old trees), to around 0.7 tonnes carbon per hectare per year for trees over 100 years old[3].

Carbon sequestered by trees may be released back into the atmosphere through bushfires or biological decay. In sustainably managed forest systems, any carbon that is emitted because of harvest activity is re-absorbed by growing trees. At a landscape level, productive forest systems contain forests at varying stages of growth, absorbing carbon at different rates. The cycles of harvest and regrowth over time lead to stable carbon levels across the forest estate.

For a commercially productive forest, the wood products generated through harvesting and processing add to the total carbon benefit from the forest over time, even though the forest itself is stable.

GHG emissions from the land use, land-use change, and forestry (LULUCF) sector is a balance of emissions from converting forests to other uses, converting other uses to forests, activities like harvesting and regeneration, and fire and other disturbances. Australia's net GHG emissions in the LULUCF sector in 2020 were negative, at around 26 million tonnes CO_2-eq[4] (i.e. a net carbon removal from the atmosphere), as sequestration in existing and newly planted forests exceeded losses through land clearing and other disturbances. Forestry is the only sector of the Australian economy that is a net carbon 'sink'.

3.1.1 Carbon stocks in forests

Carbon stocks in mature managed native forests, including those managed for production and conservation, typically range between 130 to 415 tonnes carbon per hectare (Ximenes, et al., 2018). Radiata pine plantations can provide between 14 and 17 tonnes CO_2-e of net abatement per hectare each year over a 25-year period, resulting in carbon stocks at year 25 ranging between 95-115 tonnes of carbon per hectare.

Native forests are the main source of hardwood saw logs. Hardwood plantations and native forests also provide pulp logs to produce wood-based panels, paper and paperboard. However, only a very small area of forest identified for production is harvested for timber products. The average annual area harvested on multiple-use public native forest in 2015-16 was 78,000 hectares over the period 2011-12 to 2015-16. This is 0.75% of the total area of multiple-use public forest (ABARES, 2018).

Forest management certification provides the best assurance to consumers, governments and enterprises that the forest and wood products they buy are legally harvested from sustainably managed forests. Chain-of-custody certification ensures that wood used in end products can be tracked back to a certified forest. Best practice standards for environmental product declarations regard biogenic carbon neutrality of wood valid for wood originating from forests which are operating under established certification schemes for sustainable forest management[5].

The 2018 Australia's State of the Forests Report recorded that of a total stock of 21,949 million tonnes of carbon was stored in Australia's forests at the end of June 2016:

- 85% was stored in non-production native forests
- 14% in production native forests; and
- 1.2% in plantations.

The important role that native forests can play in climate mitigation has been highlighted by several studies. For example, an analysis of the greenhouse gas implications of managing large areas of native forestry in southern and northern NSW (Ximenes, George, Cowie, Williams, & Kelly, 2012) concluded that native forests managed for production provide the greatest ongoing greenhouse gas benefits, with long-term carbon storage in products, and product substitution benefits critical to the outcome.

3.1.2 Carbon stocks in plantations versus environmental plantings

Commercial timber plantations also have significant carbon benefits. For example, a recent UK study comparing the relative climate change mitigation potential of commercial plantations to that of environmental plantings (Forster, Healey, Dymond, & Styles, 2021), concluded that the mitigation potential of commercial plantings far exceeded that of environmental plantings.

In a recent study conducted for FWPA (Perry, Pechey, & Binney, 2021), it was estimated that a 20% increase in the total commercial plantation area in Australia would offset the equivalent of 10% of the greenhouse gas emissions from the top 50 ASX companies for the next 25 years.

3.1.3 Climate change mitigation potential of production forests

The climate change mitigation potential of production forests can be further enhanced by the optimal use of sustainably derived harvest and processing residues and end of life timber in the production of bio-products. There are large volumes of this resource currently under-utilised in Australia; in NSW alone the figure is conservatively estimated at 2 million tonnes of forestry residues[6]. Using this resource to generate bio-products can result in substantial emission reductions by displacing fossil-fuel based products. The UN Food and Agriculture Organization recognised that increasing the sustainable use of bio-based products to replace fossil-fuel based products will be essential if the world is to meet many of the sustainable development goals (Verkerk, et al., 2021). Demand for wood is expected to grow as the circular bioeconomy expands and new products are developed. Commercial forests could supply a large share of these future demands whilst delivering comparable or more long-term GHG mitigation compared with conservation forests.

When trees are processed into timber and wood products, the carbon stored in the wood remains with the solid pieces of wood.

3.2 Wood products store carbon

When trees are processed into timber and wood products, the carbon stored in the wood remains with the solid pieces of wood. For each cubic metre of kiln-dried sawn softwood, kiln-dried sawn hardwood and dressed white cypress pine a total of 900, 1220 and 1223 kg CO_2-eq respectively is stored in the product at least for the duration of its service life (see Table 1).

Table 1 - Amount of carbon stored in Australian sawn wood products (weighted average)

AU Wood Product Group	AU Selected Product	Stored carbon in final product kg CO_2/m^3
Sawn Softwood	Kiln-dried dressed softwood	-900
Sawn Hardwood	Kiln-dried dressed hardwood	-1220
Dressed White Cypress	Dressed white cypress	-1223

The medium service life for timber framing and hardwood sleepers is around 50 years, around 20 years for particleboard and MDF kitchen cabinets, around 6 years in hardwood pallets and palings and around 2 years in paper (Australian Government Department of Industry, Science, Energy and Resources, 2021).

Carbon in final wood products, such as sawn timber, engineered wood products, and particleboard, remains stored during its service life (for example when used in structural applications such as a frame and truss, mass timber construction, or in fit-out applications such as flooring, panels, cabinetry, stairs, mouldings, furniture and so on) if it is well protected from the weather, insect attack and fire.

At the end of their service life, wood products may be salvaged and reused (more common for hardwoods and plywood than softwoods, MDF and particleboard), recycled into new products such as particleboard or landscaping mulch, used to provide renewable energy, or landfilled. The carbon that is stored in wood products remains in the wood for as long as it remains a solid product. This is the case for salvage and reuse, recycling into new particleboard or landfilling.

Throughout the last 50 years, the service life of wood products has reflected consumer preferences and rapid urban development rather than a gauge of material performance. This is likely to change with growing emphasis on circularity and recycling. The last decade has seen a dramatic uptake in the use of mass wood products such as cross-laminated timber (CLT), glue-laminated timber (GLT) and laminated veneer lumber (LVL) which are expected to retain their structural integrity and be of high reuse value.

Because engineered timber is a relatively new building material, real life reference examples of the full range of end-of-life options are not yet available. Historically, high value timber, particularly hardwoods in Australia, is reused with established practices already in place. However, current standards for LCA and EPDs require that until data for end-of-life scenarios are available for large-dimensioned engineered timber used in in modular construction, a 'landfill (typical)' scenario should be used for 100 percent of the end-of-life product where no other reliable data is available.

Wood products in use in Australia contain 97 million tonnes of carbon (Australian Government Department of Industry, Science, Energy and Resources, 2021). There has been considerable research in Australia based on both excavations of old landfills and experimental bioreactor work[7]. This research has conclusively demonstrated that carbon loss from wood and wood products in Australian landfills is insignificant - a maximum of 1.4% of the carbon may be lost.

The concepts of sequestering and storing carbon are very relevant to the forestry and wood products industry as they support a positive environmental narrative such as in the "*Wood Stores Carbon*" campaign. Calculations are often utilised to demonstrate the beneficial and unique environmental attributes of forest growth and wood products.

3.3 Processing residues have a small carbon footprint

Approximately 35% of hardwood and 45% of softwood logs are converted to timber products, with processing residues typically burnt consumed to make particle-based panel boards, paper and cardboard, used in horticultural or animal bedding products, or burnt at the processing facility to kiln dry timber or produce energy.

Burnt processing residues release carbon dioxide and small amounts of other greenhouse gases into the atmosphere. If the wood is harvested sustainably the carbon dioxide released can be regarded as carbon neutral, as the carbon was sequestered when the tree grew. However, other greenhouse gases (such as methane and nitrous oxides) are also released and do have a small carbon footprint.

Carbon stored in processing residues sent to landfill or sold is not included in the total carbon stored in a timber product. Life Cycle Assessment standards and methods require that the carbon storage claim can only apply to the carbon stored directly within the product.

3.4 Bushfires

Major bushfires can have a significant impact on emissions for a given year. It is estimated for example, that in the 2019/20 bushfires 7.4 million hectares of forests were burnt, with 830 million tonnes CO_2-eq emitted (Department of Industry Science Energy & Resources, 2020). By way of comparison, the most recent total figure (2019) for total annual greenhouse gas emissions in Australia was 519 million tonnes CO_2-eq (Australian Government Department of Industry, Science, Energy and Resources, 2021).

However, bushfires mainly affect debris and grasses or understorey vegetation, and sometimes forest canopy (leaves, twigs), which all rapidly build up carbon again following fire – within 10-15 years (Australian Government Department of Industry, 2021).

3.5 Imported timber

Most of the sawn timber imported into Australia is also sourced from well managed forests, often certified. The carbon footprint of the imported timber is therefore similar to that of Australian wood products although there will be some additional carbon footprint for transport, generally by sea, which is comparatively low compared to air or truck transport). EPDs are available for timber sourced from North America and Europe.

3.6 Timber from deforestation and forest degradation

Some sources of wood, mostly related to hardwood timber imported from developing countries, are from land clearing for agriculture and other land development processes. This change in land use can release large quantities of greenhouse gases into the atmosphere (in the case of clearing Indonesian peat lands for example). It also reduces the cleared land's ability to absorb and store carbon (where land is not allowed to regenerate, or harvested trees are not replaced).

While forestry practices in many parts of the world from where we import timber are generally of a high standard, this calls into question the validity of including the stored carbon in the carbon footprint of some imported timber and local timber from land clearing operations.

Responsible sourcing of timber, which avoids these impacts, can be relied upon where the timber purchase is associated with a chain of custody certification. Wood certification schemes such as the Forest Stewardship Council (FSC), Responsible Wood (endorsed by PEFC for Australia and New Zealand) and the Programme for the Endorsement of Forest Certification (PEFC) are third-party audited certification systems which ensure that end products can be tracked back to the certified forest where they were grown, and are kept separate from non-certified material along the supply chain.

4 Carbon footprint of forestry and wood products

The concept of carbon sequestration in forests is well understood. However, it is only part of the picture of the carbon footprint of forests and production of wood products. Whilst considering the carbon absorbed by forests, it is also necessary to consider the biogenic carbon emitted from sources such as forest fires, and fossil sources such as liquid and gaseous fuels, and electricity.

4.1 Fossil carbon emissions

Plantations and commercial native forests require energy to establish and maintain them for wood production as well as for the actual harvest process. The energy used is mostly in the form of fossil fuels such as diesel and petrol for establishment, fire protection, roading maintenance as well as for harvest and haulage of logs. Electricity, typically sourced from the grid, may also be used in plantation nurseries.

Primary wood product manufacturing requires energy for log break down, processing, sawing, kiln drying, dressing, and packaging. The production of panel products also requires energy to manufacture other inputs such as adhesives, coatings, preservatives, and packaging which themselves have a fossil carbon footprint. While a substantial proportion of energy needs of Australian primary wood product manufacturers are met by burning wood residues, significant quantities of diesel, natural gas and fossil fuel generated electricity are also used.

4.2 Biogenic carbon emissions

Prescriptive burns in commercial forests and plantations also generate greenhouse gases. These will be mostly biogenic carbon dioxide but also include small amounts of nitrous oxide (N_2O) and methane (CH_4).

In sawmills a large proportion of the energy used to convert logs into wood products may be from biogenic sources such as sawmill residues. For example, many kilns used to dry timber rely on wood biomass for energy – the release of the biomass carbon does not result in net GHG emissions if this wood is from sustainably managed forests. The small amounts of nitrous oxide and methane released from forests, product storage and produced during combustion of residues should be included in the carbon footprint calculations. Those emissions are accounted for as “biogenic GHG emissions other than CO_2”.

Because biogenic carbon does not contribute more carbon to the atmosphere than it sequesters, it has advantages over fossil-based carbon which can persist in the atmosphere for many thousands of years. However its benefits are dependent on the replenishment of the feedstocks in which they are stored. For example, deforestation and land-clearing efforts produce biogenic carbons, but because the trees, plants and grasses which stored the carbon will not be regrown, these biogenic emissions disrupt the natural biogenic carbon cycle and interfere with CO_2 concentrations in our atmosphere.

4.3 Why separate accounting?

The biogenic and fossil carbon footprints of products are separated to follow standards required for the life cycle assessment of building products (EN 15804). This standard requires these to be separated for several reasons:

- The fossil carbon footprint value can be hidden by the biogenic carbon value due to the stored biogenic carbon being notably higher.
- Calculation of the biogenic carbon footprint is likely to be less precise, due to known variations in the moisture content and density of products, even within the same species.
- What happens to the stored biogenic carbon also needs to be considered at the end of life of the product (modules C1-C4 in Figure 2). By considering only the production total carbon footprint (modules A1-A3 in Figure 2), carbon emissions released from the timber product after it has been used in a building (by decomposition, combustion products from being burnt, or returning a carbon 'credit' towards a future life cycle) is not included.

4.4 Total carbon emissions

4.4.1 Carbon emissions from Australian sawn softwood products

Detailed information on the emission footprint of the key types of wood products used in Australia is contained in ***Environmental Product Declarations*** (EPDs). For example (as illustrated in Figure 5) the production of 1m³ of kiln-dried dressed softwood results in 157kg CO_2-eq of fossil-fuel derived emissions and 25kg CO_2-eq of biogenic GHG emissions other than CO_2. The biogenic CO_2 emissions from production do not count towards the emission footprint of the product as the CO_2 is re-absorbed by the growing trees in sustainable forest systems. At the mill gate, this results in a net carbon footprint of -718 kg CO_2/m^3 of dry and dressed softwood. In other words, when both carbon stored in the timber and cradle to gate fossil GHG emission and biogenic GHG emissions other than CO_2 are accounted for, the net impact is the retention of 718 kg CO_2 in each cubic meter of timber produced.

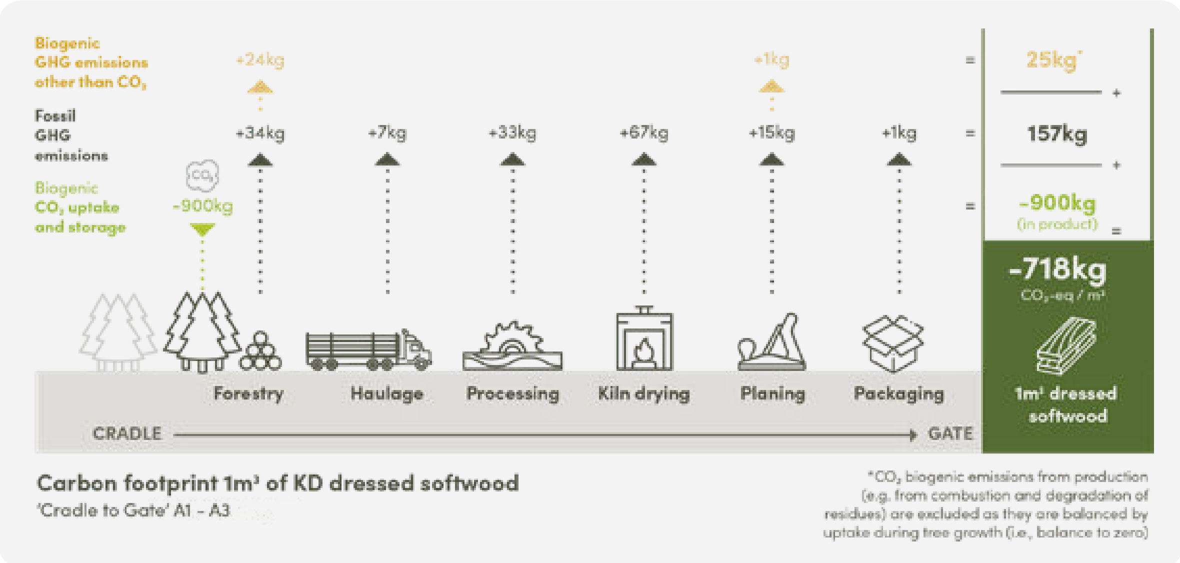

Figure 5 - Carbon footprint of 1m³ of kiln-dried dressed softwood (FWPA, Australian Sawn Softwood EPD S-P-00560 v2.0, 2022)

4.4.2 Carbon emissions from Australian sawn hardwood products

The production of 1m³ of kiln-dried dressed hardwood results in 327 kg CO_2-eq of fossil-fuel derived emissions and 162 kg CO_2-eq of biogenic GHG emissions; with a net carbon footprint of -731 kg CO_2/m³.

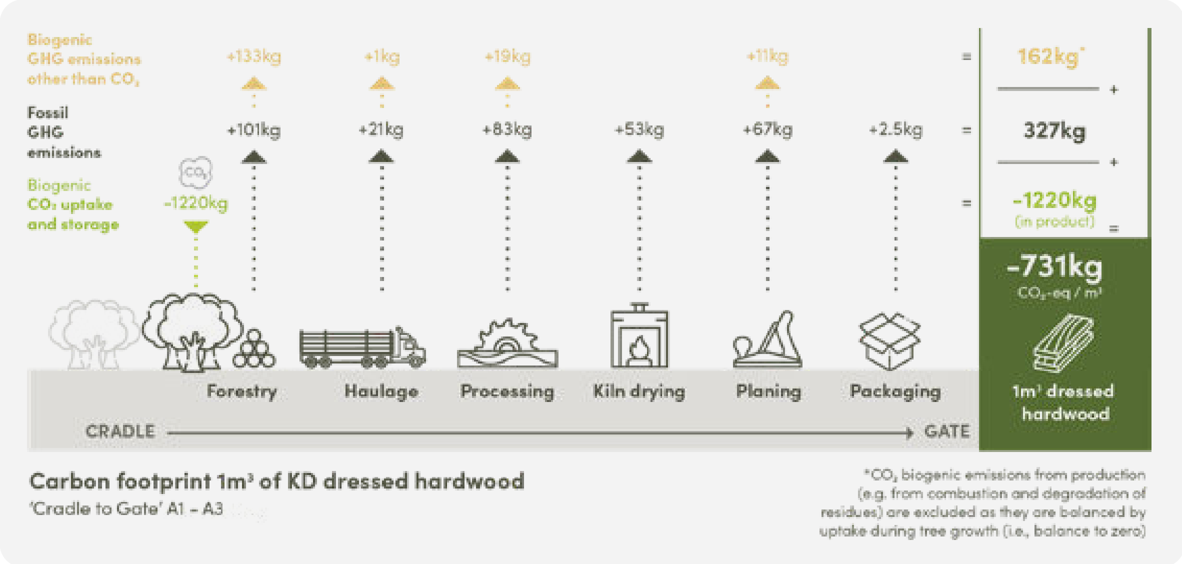

Figure 6 - Carbon footprint of 1m3 of kiln-dried dressed hardwood (FWPA, Australian Sawn Hardwood EPD S-P-00561, 2017)

4.4.3 Carbon emissions from Australian White Cypress

The production of 1m³ of dressed white cypress results in 188 kg CO_2-eq of fossil-fuel derived emissions and 26 kg CO_2-eq of biogenic GHG emissions, with a net carbon footprint of -1009 kg CO_2/m³.

Figure 7 - Carbon footprint of 1m3 of kiln-dried dressed white cypress (FWPA, Australian White Cypress Timber, 2022)

4.4.4 The need for action to reduce carbon emissions

To maximise the climate benefit of timber, industry needs a plan to reduce and eventually eliminate fossil fuel emissions and other biogenic emissions.

This reduction will be implemented over time through careful planning and renewal of industry infrastructure and processes. The steps involved in the transition are as listed below. Multiple steps may occur concurrently.

1. Increase efficiency of operations through minimising emissions-producing activities and substituting with less emissions-intensive alternatives.
2. Seek to use biofuels from renewable sources to replace fossil fuel use, e.g., renewable diesel.
3. Where electricity is used, convert to renewable electricity either through on-site or off-site solutions.
4. Electrify other energy uses that require fossil fuels (natural gas, diesel, etc) to operate.
5. During transition, seek carbon offsets for remaining fossil fuel and other biogenic (methane, nitrous oxide, etc.) emissions. Offsets must be 'additional', in that they must fund an initiative that would not have existed without that investment - an existing forest is not an offset.

4.5 Quantifying the upfront carbon footprint of wood products

Environmental performance information for construction products is in growing demand from architects, developers, legislators and increasingly consumers. The information required has also become more detailed and complex, with integrated environmental assessments of buildings required at tender stage, in architectural competitions and under sustainable building certification schemes such as the Green Star certification program operated by the Green Building Council of Australia (GBCA).

Evidence of a product's embodied carbon performance is included within independently verified Environmental Product Declarations (EPDs). EPDs contain third-party verified Life Cycle Assessment (LCA) results for a specified standard quantity of a product or assembly. Based on common rules known as Product Category Rules (PCR), EPDs report the results of an LCA for a particular material (industry average) or product (brand specific) in a common format.

There are EPDs published under FWPA's WoodSolutions brand for 7 Australian wood product groups[8]. EPDs are also available for sawn timber and other wood products produced overseas that are imported into Australia including New Zealand, Sweden, and North America. Australian wood products industry sector EPDs can be sourced from the ***WoodSolutions website***.

These and other Australian and New Zealand wood and wood product EPDs are registered and published with ***EPD Australasia*** – an ISO 14025 accredited EPD Programme Operator –and a regional partner of the International EPD System which has over 2,500 EPDs published.

4.6 EPDs quantify improvements

EPDs allow the industry to set a baseline for the carbon footprint of their products. When they are updated the reduction of the carbon footprint can be quantified. For example, the latest update of the Australian sawn softwood EPDs has documented a 12% reduction in the fossil carbon footprint manufactured between 2015/16 and 2019/20 financial years.

4.7 Other carbon footprinting quantification methods

EPDs are the most widely used form of documenting building product emissions and are recommended for calculating embodied carbon emissions of buildings as they provide data that are more transparent, precise, and representative.

Several LCA quantification methods do exist, and include;

- **Bottom-up, process-based LCA** (Process LCA) - the starting point for process LCA is the unit process: a single process (typically a manufacturing process) that transforms inputs into outputs. Process LCA is the aggregation of these different unit processes to create an often-complex production chain. An inventory is compiled by summing together the resource use, energy use, and emissions incurred through every step in a product's life cycle. This inventory is then multiplied by characterisation factors (emission factors) to calculate potential impacts on the environment, such as the product's contribution to climate change. Process LCA has the advantage of detail: it allows even small differences between products and processes to be investigated.
- **Top-down economy-wide input-output LCA** (IO-LCA) starts from the direct impacts of an entire economic sector and then adds indirect impacts through trade with other sectors (i.e., from purchased goods and services). Emission intensities (e.g., kg CO_2e per $) are calculated by dividing the direct and indirect emissions by the monetary value the sector contributes to the economy. It is useful for national, economy-wide scale analysis.
- **Hybrid LCA** is a combination of the above two methods but is not suitable for use at a product level or to make decisions about relative product impacts or substitution, as the economic data is too broad to be useful on a product-to-product level.

A form of this last method "Hybrid LCA" has been used by the authors of the EPiC database of embodied environmental flows of over 250 construction materials (Crawford, 2019). The authors of the EPiC database attempt to include the second-order effects of producing something, eg., the marketing and sales departments, in addition to process-based data.

Process LCA is the most widely adopted and preferred methodology for specific product data to support decision making:

- It is consistently used internationally for product EPDs.
- It is based on agreed international standards and product category rules.
- It is strongly supported by most or all of the Australasian building products sectors.
- It is the only recognised route to genuine comparability of products and brands through third-party verified, transparent data.
- It is useful to the manufacturer for hotspot identification and process improvement.

For the timber industry, it is particularly important that correct process-based LCAs are used to provide reliable, transparent data about wood products. Process LCAs offer the most appropriate methodology to quantify the true impacts, and advantages, of wood products.

5 Emissions footprints and substitution effects

The concept of carbon sequestration in forests is well understood. However, it is only part of the picture of the carbon footprint of forests and production of wood products. Whilst considering the carbon absorbed by forests, it is also necessary to consider the biogenic carbon emitted from sources such as forest fires, and fossil sources such as liquid and gaseous fuels, and electricity.

5.1 Emissions footprints and substitution effects

Wood products generally require comparatively lower fossil-fuel based energy in their manufacture compared to greenhouse gas-intensive materials such as bricks, aluminium, steel, and portland cement-based products such as concrete.

This means that it can be beneficial from a building carbon footprint perspective to substitute wood products for fossil-based products in buildings. This benefit can be quantified by calculating the difference in the carbon emissions associated with the production of the wood product and the alternative product. However, determining a conclusive substitution factor for a given scenario in the construction sector is complex.

The difference in using wood products may not always result in a climate benefit. For example, in the case of a wood product that displaces another wood product with a lower emission footprint, or if a large amount of a wood product is required to replace a comparatively smaller component. The comparison must always be done using equivalent functions of products being compared.

Substitution effects in Australia for mass timber products such as Glulam and CLT are not yet published, however a meta-analysis of 51 LCAs found that using wood and wood-based products is often associated with lower fossil and process-based emissions when compared to non-wood products[9]. A 2021 international study identified embodied carbon reductions of up to 50 percent when replacing concrete and steel with mass timber construction in functionally equivalent 8, 12 and 18 storey buildings in three US regions (Puettmann, et al., 2021).

5.2 Embodied carbon comparisons in structural materials

Several terms and concepts need to be understood so that comparisons between alternatives result in material improvements.

Declared units

The embodied carbon emissions (GWP) associated with the production of construction materials (A1-A3 or cradle to gate) in Australia are often provided in Environmental Product Declarations (EPDs) by declared unit of production, e.g., kg, tonne, m^3. Using declared units in EPDs for side-by-side comparisons to inform materials selection can be problematic. Materials comparisons using EPDs must consider equivalent functionality and contribution to overall building impacts for comparisons to be fair and meaningful.

Functional comparison – whole building

The most useful and objective comparisons are made between functionally equivalent whole building designs across the whole life cycle of the project. In practice, at the design stage many practitioners just compare the production stage impacts of materials (A1-A3). As this extends over time to cover the impacts of transport to site (A4), the construction process and site wastage (A5), more accurate comparisons can be made between Australian and international products.

Comparisons should account for the different requirements each design must satisfy – whether that be aesthetic value or function, such as beam spacing, total floor area, different loads the structure must resist, as well as fire, thermal and durability performance requirements.

A 2021 international study identified embodied carbon reductions of up to 50 percent when replacing concrete and steel with mass timber construction.

6 Carbon accounting in whole building assessments

The drive to build more sustainably commonly includes an imperative to measure the carbon footprint of proposed developments. This is driven by rating tools such as the new Green Star Buildings by the Green Building Council of Australia and the Infrastructure Sustainability Council's IS Rating Scheme. It is also increasingly pursued by builders and consultants seeking to understand the total carbon footprint of their projects and to drive it down in future builds.

Just as using standards for product carbon footprinting is important, there is also a common standard mandated for building footprints in Australia: European standard EN 15978:2011 - Sustainability of Construction Works. Assessment Of Environmental Performance of Buildings. Calculation Method (see Figure 2 and explanation in Section 1).

EN15978 requires the use of data from EN 15804 compliant EPDs and uses an identical modular structure for a building's life cycle (refer to Figure 2). Rating tools for buildings commonly call up compliance with EN15978 for the Life Cycle Assessment component of their certification.

6.1 Opportunities in timber for whole of building LCA

Measuring embodied carbon is key to evaluating the highest-impact and most cost-effective solutions to reducing embodied carbon on a building project. An LCA measures environmental impact across a range of issues such as impact on air quality, water usage and water quality, toxicity to human life and to ecosystem functioning, impact to climate or "global warming potential" (GWP), as well as resource use. Embodied carbon is the GWP result (excluding operational carbon) and is measured for each stage of the asset or product's life cycle, allowing comparisons across any combination of stages.

For the timber and wood products industry, the metric of greatest interest is the carbon footprint. Where a development is seeking to reduce embodied carbon, a lower carbon timber product could theoretically be favoured over a fossil-based alternative, where substitution is appropriate. This advantage may not always be realised in the context of a whole building assessment, if LCA practitioners are not using up-to-date or reliable input data.

At present, some rating tools do not allow carbon stored in wood to be offset against other elements used in the building. Instead, they generally allow timber to claim a zero-carbon footprint, which can offset the fossil and biogenic footprint from production of the timber building material but cannot offset the impacts of other materials. An example is the Green Building Council of Australia's (GBCA) Green Star Buildings rating tool - see Figure 8. The GBCA's Green Star Buildings Submission Guidelines refer to sequestered carbon rather than stored carbon.

Bio-based materials in 'Upfront Carbon Emissions'

For purposes of the reduction calculation in 'upfront carbon emissions', products that have a Global Warming Potential Total (GWPT) of less than zero must use a GWPT of zero.

In other words, should a product have a negative Global Warming Potential Biogenic (GWPB) that exceeds the Global Warming Potential Fossil (GWPF), that product can be assumed to have no carbon, but cannot be used to reduce the carbon for another product or other modules.

GWPB can only be taken into account when the calculation includes the end of life stage, and the timber has an FSC, Responsible Wood, or PEFC chain of custody.

Figure 8 – Treatment of sequestration in Green Star Buildings rev 1B (Green Building Council Australia, 2021)

6.2 Data sources to support building LCAs

Underpinning the credibility of whole building LCAs are standards to ensure reliable data is available and utilised for the materials used in the building.

EN15978 requires that building product data conforms with EN15804. This data is required to be published in Environmental Product Declarations (EPDs).

The most accurate data to support building LCAs is found in product and company specific EPDs, which include specific data for the products available from a particular company's manufacturing. This data can be used directly in whole building LCAs.

The next best option, and one that is available within the Australian wood products industry, is data from industry-sector EPDs. These contain averaged data collected from industry participants. Where this data is used, the following precautions apply:

- the data can only be used to represent products from companies that contributed to the EPD.
- the EPDs contain additional data on the variability (range) in results. Where the data is used in building LCAs, the upper end of the range should be used as a conservative estimate.

See Section 4.4 & 4.5 for details of Australian wood products EPDs.

7 References

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8 Glossary of carbon terms

Term	Definition
Absolute Zero Carbon	Achievement of zero carbon/GHG emissions, using a whole-of-life basis or other defined boundary, without any carbon offsets or other compensation mechanisms
Anthropogenic	Relating to or resulting from the influence of human beings on nature.
BECCS	Bioenergy Carbon Capture and Storage: CCS from burning biomass
Bioeconomy	Production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy.
Biogenic carbon	Carbon sequestration into biomass, including natural building materials (e.g., timber) as well as any emissions associated with this sequestered carbon.
Biomass	Material of biological origin excluding material embedded in geological and/or fossilized formations.
Bioenergy	Energy generated from biomass, such as electricity or heat.
Biofuel	An alternative fuel that is developed from biological, natural, and renewable sources. Biofuels are an attractive option due to their high energy density and convenient handling and storage properties. Biofuels can be used on their own (with some precautions or restrictions) or blended with petroleum fuels.
Carbon (C)	Carbon is by definition a non-metallic chemical element, with the symbol 'C' and the atomic number 6 that readily forms compounds with many other elements and is a constituent of organic compounds in all known living tissues (including wood).
Carbon Capture and Storage (CCS)	Capture and storage of carbon (greenhouse gas) emissions from industrial processes by injecting the captured greenhouse gases back into the ground for permanent storage.
Carbon dioxide (CO_2)	A naturally occurring gas, CO_2 is also a by-product of burning fossil fuels (such as oil, gas and coal), of burning biomass, of land-use changes (LUC) and of industrial processes. It is the principal human produced (anthropogenic) GHG that affects the Earth's radiative balance. It is the reference gas against which other GHGs are measured and therefore has a global warming potential (GWP) of 1.
Carbon dioxide equivalents (CO_2-eq)	A measure that quantifies the global warming effect of different greenhouse gases in terms of the amount of carbon dioxide (CO_2) that would deliver the same global warming effect.
Carbon emissions	An industry term that refers to greenhouse gas (GHG) emissions. Not all GHG emissions contain carbon.
Carbon footprint	The total carbon emissions caused by an organisation, event or product in a given time frame.
Carbon negative	See carbon positive
Carbon neutral	Balanced between emitting carbon and absorbing carbon from the atmosphere in carbon sinks.
Carbon offsets	An action intended to compensate for carbon emissions, meeting criteria as part of a commercial scheme
Carbon positive	A city, development, building, or product that goes beyond being Carbon Neutral to intentionally remove CO_2 from the atmosphere and turns it into useful forms

Glossary of carbon terms

Term	Definition
Carbon reduction plan or framework	A government or organisation's plan or framework for achieving the GHG Emissions reductions it has committed to including actions and milestones.
Carbon sequestration	The process of removal and storage of CO_2 from the atmosphere in carbon sinks (such as forests, woody plants, algae, kemp, mangroves or soils).
Carbon sink	Carbon sinks are forests and other ecosystems that absorb carbon, thereby removing it from the atmosphere and offsetting CO_2 emissions.
Carbon storage	Carbon sequestered from the atmosphere and stored in wood or other ecological or artificial sinks. Carbon stored in harvested wood products changes with time based on the product, age and decay rates.
Certified wood	Certified wood is one where the wood used has been verified as harvested in a sustainable way - including the impact of harvesting on the surrounding environment in terms of protecting the biodiversity of an area, erosion control and preserving water resources. The wood has been certified to a recognised forest certification scheme such as FSC®, PEFC or Responsible Wood.
Cradle to Gate	The scope of measurement of impacts in an LCA or Carbon Footprint from raw material acquisition to a finished product at the exit gate of the manufacturing facility
Cradle to Grave	The scope of measurement of impacts in an LCA or Carbon Footprint across the entire lifespan of the product, from raw material acquisition through to final disposal, reuse or recycling.
Embodied carbon	Carbon emissions associated with materials and construction processes throughout the whole lifecycle or a building or infrastructure, excluding operational energy.
Embodied energy	The total energy necessary for an entire product lifecycle, including both non-renewable and renewable energy.
Emission factors	Emission factors are used to convert a unit of activity into its emissions equivalent. (e.g., a factor that specifies the kilograms of CO_2-eq emissions per unit of activity).
End of Life carbon	The carbon emissions which occur after an asset's lifetime – whether associated with deconstruction/demolition, transport from the site, waste processing, or disposal
Environment Product Declaration (EPD)	An independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products and services in a credible way. An EPD is compliant with the standard ISO 14025 and is a Type III environmental declaration.
Forest carbon stock	Forest carbon stock is the amount of carbon that has been sequestered from the atmosphere and is now stored within the forest ecosystem, mainly within living biomass and soil, and to a lesser extent also in dead wood and litter.
Global Warming Potential (GWP)	The Global Warming Potential (GWP) of a greenhouse gas is its ability to trap extra heat in the atmosphere over time relative to carbon dioxide (CO_2).
Greenhouse gases (GHG)	Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, which cause the greenhouse effect, as detailed in the IPCC Glossary. Carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), ozone (O_3) and water vapour (H_2O), are the primary GHGs in the Earth's atmosphere. GHG emissions are often referred to as 'carbon emissions' in general usage.

Term	Definition
Life Cycle Assessment or Analysis (LCA)	An analysis of the environmental and/or social impacts of a product, process or a service for its entire life cycle. It looks at the raw material extraction, production, manufacture, distribution, use and disposal of a product.
Net Zero Carbon	A calculated result of zero carbon emissions, including netting of inward and outward flows of GHG, the use of carbon offsets or other compensation mechanisms.
Operational Carbon	GHG emissions arising from all energy consumed by an asset in-use, over its life cycle.
Scope 1, 2 & 3 emissions	A term used in relation to organisation-wide carbon emissions. ***Scope 1 emissions*** are direct emissions from owned or controlled sources. ***Scope 2 emissions*** are indirect emissions from the generation of purchased energy (electricity, heat, steam, heating, cooling sources) consumed by the reporting company. ***Scope 3 emissions*** are all indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions.
Upfront Carbon	The emissions caused in the materials production and construction phases (modules A1-A5) of the lifecycle before the building or infrastructure begins to be used.
Whole of Life Carbon	Whole Life Carbon' emissions are the sum total of all asset related GHG emissions and removals, both operational and embodied over the life cycle of an asset including its disposal.

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