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Environmental Product Declaration
Softwood Timber

Environmental Product Declaration (EPD)
in accordance with ISO 14025 and EN 15804

EPD Registration No. S-P-00560 | Version 2.0
Issued 23 June 2015 | Revised 14 Feb 2022 | Valid until 14 Feb 2027

Geographical Scope: Australia

Environmental Product Declarations

WoodSolutions has developed a suite of EPDs for industry-average, Australian-produced timber products.

These EPDs help to showcase the environmental credentials of Australian wood products. They also provide life cycle data for calculating the impacts of wood products at a building level.

EPDs include:

#01 Softwood Timber

#02 Hardwood Timber

#03 Particleboard

#04 Medium Density Fibreboard (MDF)

#05 Plywood

#06 Glued Laminated Timber (Glulam)

#07 White Cypress Timber

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WoodSolutions is resourced by Forest and Wood Products Australia (FWPA). It is a collaborative effort between FWPA members and levy payers, supported by industry peak bodies and technical associations.

This work is supported by funding provided to FWPA by the Commonwealth Government.

978-1-925213-19-5

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Version history

V1.0 Initial version based on 2005/06 data from CSIRO and produced by thinkstep Pty Ltd and the Timber Development Association (NSW) Ltd.

V1.1 Minor corrections to text and images in V1.0.

V1.2 Revised version incorporating 2015/16 data from a new industry survey, as well as updates to Global Warming Potential (GWP) and fresh water indicators.

V1.3 - Revised version for correction of the validity period, documentation of the forestry carbon modelling assumptions and correction of minor typographical errors.

V2.0 - New version incorporating data for 2019-20 production year from a new industry survey, updated methane recovery from landfill, updated text, and references.

Produced: February 2022

EPD Details

An Environmental Product Declaration, or EPD, is a standardised and verified way of quantifying the environmental impacts of a product that is based on a consistent set of rules known as a PCR (Product Category Rules).

EPDs within the same product category from different programs may not be comparable. EPDs of construction products may not be comparable if they do not comply with EN 15804.

Forest & Wood Products Australia has sole ownership, responsibility, and liability for this EPD.

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CEN standard EN15804+A1 served as the core PCR

PCR:
PCR 2012:01 Construction products and Construction services, Version 2.33, 2020-09-18

PCR review was conducted by:
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Independent verification of the declaration and data, according to ISO 14025:
☐ EPD process certification (Internal)
☑ EPD verification (External)

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Verifier approved by: EPD Australasia Ltd

Procedure for follow-up of data during EPD validity involves third-party verifier:
☐ Yes
☑ No

Introduction

This Environmental Product Declaration presents the average performance of sawn timber from Australian grown softwood processed in Australia by members of Forest and Wood Products Australia (FWPA). It recognises the importance of transparency by providing information on the raw materials, production and environmental impacts of Australian softwood.

This EPD has been prepared in accordance with ISO 14025:2006, EN 15804:+A1 and PCR 2012:01 (IEPDS 2020). It covers Australian seasoned softwood products produced in accordance with the following standards:

- AS/NZS 1748 Timber – Mechanically stress-graded for structural purposes
- AS 2858 Timber – Softwood – Visually stress-graded for structural purposes
- AS 4785 Timber – Softwood – Sawn and milled products.

The environmental data presented in this document are primarily derived from a survey of industry members covering production in the 2019-20 financial year conducted by thinkstep-anz on behalf of FWPA. This is an update of an earlier survey conducted by thinkstep-anz based on production in the 2015-16 financial year, which was used in the previous version of this EPD. The current survey covers over 40% of total sawn softwood production in Australia.

Production of this EPD has been facilitated by FWPA and Australian Forest Products Association (AFPA) with participation of current sawn softwood timber producer members of FWPA listed in Table 1. All FWPA members have contributed financially through levies paid to FWPA and some have also contributed data (as shown in Table 1).

Table 1: FWPA members contributing to this EPD.

Sawn softwood producer company name	Financial contributor	No. of sawmills contributing data 2020
Allied Timber Products Pty Ltd	X	
Associated Kiln Driers Pty Ltd trading as A.K.D. Softwoods	X	2
Australian United Timbers Pty Ltd	X	
Auswest Timbers Pty Ltd	X	
Pentarch Forestry	X	
Carter Holt Harvey Woodproducts Australia[1]	X	
D&R Henderson Pty Ltd	X	
Highland Pine Products Pty Ltd[2]	X	
Hyne Timber	X	1
KSI Sawmills Pty Ltd	X	
LM Hayter & Sons Pty Ltd	X	
Lorimer Timber Pty Ltd trading as Davids Timber	X	
McDonnell Industries Pty Ltd trading as NF McDonnell & Sons	X	
OneFortyOne Plantations Pty Ltd	X	1
Penrose Pine Products Pty Ltd	X	
Rodpak Pty Ltd	X	
SA Sawmilling Pty Ltd	X	
Tarmac Sawmilling Pty Ltd	X	
TASCO trading as Dongwha Timbers Pty Ltd	X	
Timberlink Australia	X	2
Wespine Industries Pty Ltd	X	1
Whiteheads Timber Sales Pty Ltd	X	

[1] Not a softwood manufacturer in 2020 [2] Joint venture of AKD Softwoods and Pentarch Forestry

Description of the Australian Sawn Softwood Industry

The Australian softwood manufacturing industry is an important contributor to the Australian economy – particularly to the regional economies where many producers are based. In 2017-18 it is estimated that 76,200 people were employed in all forestry, logging, and wood manufacturing categories, with forestry and forest product manufacturing contributing 0.5% of Australia's GDP (ABARES 2019).

In 2018-19, the industry produced 3.3 million cubic metres of sawn softwood timber products (excluding cypress pine) (based on the 2018-19 total from Gavran 2020 as adjusted to saleable volume following Houghton 2015). There are 58 softwood sawmills manufacturing sawn softwood across Australia - see Table 2. Production is dominated by large sawmills, 20 of which have a log input capacity greater than 100,000 m^3 per year (Downham et. al. 2019).

Table 2: Softwood sawmills by Australian state

NSW[a]	Vic.	QLD	SA	WA & Tas[b]	Aust.
14	9	17	13	5	58

a Includes ACT
b includes Northern Territory.
Source: ABARES 2019

Description of Sawn Softwood Products

Seasoned sawn softwood is widely used in residential and multi-residential frame construction (wall frames: studs, plates, headers; floor and roof truss components) and other internal fit-out elements (see Table 3).

Structural grade seasoned softwood is usually sold with a dressed surface finish (planer gauged). It may also be rougher headed, which is a reeded finish. Structural softwood is also available preservative treated (see Other Environmental Information section) for a variety of internal (termite protected) and external (termite and decay protected) applications. Factory manufactured finger-jointed and metal plate connector joined products are also available.

Appearance grade seasoned softwood is usually sold for internal fit-out elements such as mouldings, wall and ceiling linings, furniture, cladding and flooring.

Table 3: Proportion of Australian softwood by product group (2019-20).
Source: FWPA Softwood Timber Survey 2021

Softwood product	% of total
Outdoor Domestic	8.9%
Appearance	0.5%
Outdoor Other	9.2%
Structural Untreated	26.1%
Structural H2 and H2F	22.6%
Packaging	19.9%
Ungraded	9.0%
Export	3.7%
Total	**100%**

Image courtesy of Hyne Timber

Image courtesy of FWPA

Image courtesy of Timberlink Australia

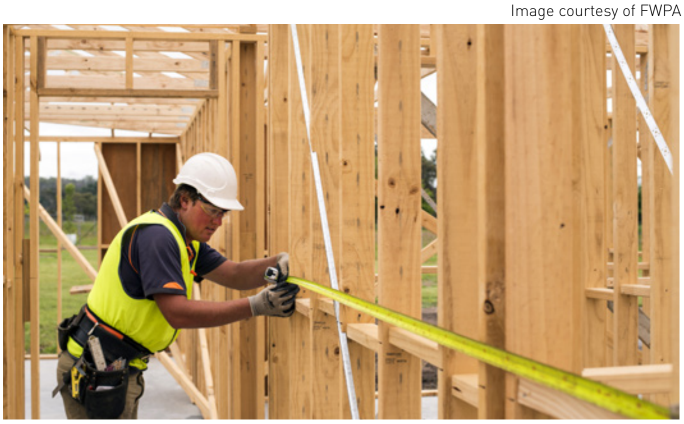


Image courtesy of Timberlink Australia

Seasoned sawn softwood timber is sold by grades for strength or appearance and the quantity specified by cross section and lineal metres. Although it is possible to cut timber to a large range of cross sections, there are a number of common dimensions for the dominant building products such as timber studs for floor, wall and roof framing (see Table 4 and Table 5).

Table 4: Structural grades of seasoned sawn softwood and availability. Source: WPV 2009

Typical species	Stress grade	Supply
Radiata Pine, Hoop Pine, Slash Pine, Maritime Pine, Caribbean Pine	F5	Readily available
	F7	Available from selected suppliers
	MGP10	Readily available
	MGP12	Available from selected suppliers
	MGP15	Available from selected suppliers

Table 5: Structural seasoned softwood - available sizes. Source: WPV 2009.

Breadth (mm)	Depth (mm)							
	42	70	90	120	140	190	240	290
35	X	Y	Y	Y	Y	Y	X	X
45		Y	Y	Y	Y	Y	Y	Y
90			X					

Key: X = Available from selected suppliers; Y = Readily available

Use of EPDs in Green Star and Sustainable Infrastructure Rating Systems

Green Star

This document complies with the requirements for an industry or sector wide EPD under the Green Building Council of Australia's Green Star rating system given that:

- It conforms with ISO 14025 and EN 15804.
- It has been verified by an independent third party.
- It has at least a cradle-to-gate scope.
- The participants in the EPD are listed (see Table 1).

Additional points may be applicable under the Responsible Products Framework currently under development.

IS® Rating

This EPD complies with requirements under the Infrastructure Sustainability Council's IS® rating scheme given that it is:

- Compliant with ISO 14025 and EN15804
- Verified by a third party.

Scope

Products

This Sector EPD describes the following average products (declared units) manufactured in Australia by the FWPA members listed in Table 1:

- *1 m^3 of sawn kiln-dried softwood*
  12% moisture content (dry basis), density of 551 kg/m^3
- *1 m^3 of dressed kiln-dried softwood*
  12% moisture content (dry basis), density of 551 kg/m^3

The declared units above represent an entire product category rather than a specific product from a specific manufacturer. The values represent a production volume weighted average. As such, a specific product purchased on the market may have a lesser or greater environmental impact than the average presented in this EPD. Some products may also undergo further processing (e.g. fabrication into frames and trusses) before being used in a building.

All wood used in these products is from Australian native and exotic (non-native) softwood species grown in plantations. The dominant softwood species used to produce sawn timber in Australia is *Pinus radiata* (radiata pine). Other softwood species used are *Araucaria cunninghami* (hoop pine), *Pinus pinaster* (maritime pine) and the Southern Pines: *Pinus elliottii* (slash pine), *Pinus caribaea* (Caribbean pine) and hybrids thereof.

The results in the main body of this EPD are for untreated timber. Information on treatment can be found in the Additional Environmental Information section. The results for the specific treatment type used can be added to the results for untreated timber to calculate the environment profile for treated timber.

Table 6 indicates the availability of softwood by hazard class (a bold **X** indicates a common product).

Table 6: Availability of softwood by hazard class

Products	Untreated	H1	H2/H2F	H3	H4	H5	H6
Softwood, rough sawn, kiln-dried	**X**			**X**	**X**	X	
Softwood, dressed, kiln-dried	**X**		**X**	X	X		

End Uses

Sawn kiln-dried softwood	Packaging, outdoor domestic and fencing (after appropriate treatment)
Dressed sawn kiln-dried softwood	Structural framing, utility, H2F structural framing, mouldings, architraves, joinery, furniture, flooring grades

Representativeness

Market coverage: The data in this EPD are from detailed surveys of 7of the 29 softwood mills in Australia which are operated by FWPA members. These 7 mills collectively processed 3,963,271 m^3 softwood saw logs in 2019/20, equating to 41.1% of total harvest of approximately 9,651,000 m^3 of saw logs (based on the 2019/20 total from Gavran 2020 for softwood logs, excluding cypress, veneer, pulp and other logs) and approximately 45.6% of total softwood saw log inputs by FWPA sawn softwood producer members (assuming FWPA members account for 90% of Australian production).

Temporal representativeness: Primary data were collected from participating sites for the 2019/20 Australian financial year (1st July 2019 to 30th June 2020). Following EN 15804, site-specific data are valid for 5 years (to 30th June 2025), meaning that these datasets are valid until the end of this EPD's validity period.

Geographical and technological representativeness: The data are representative of the 7 sites surveyed, which collectively produce over 40% of all Australian-produced sawn softwood. More detailed information can be found in the Variation in Results section later in this EPD.

Industry Classifications

Product	Classification	Code	Category
All	UN CPC Ver.2.1	31101	Wood, sawn or chipped lengthwise, sliced or peeled, of a thickness exceeding 6 mm, of coniferous wood
All	ANZSIC 2006	1413	Timber resawing and dressing

LCA Calculation Rules

System Boundary

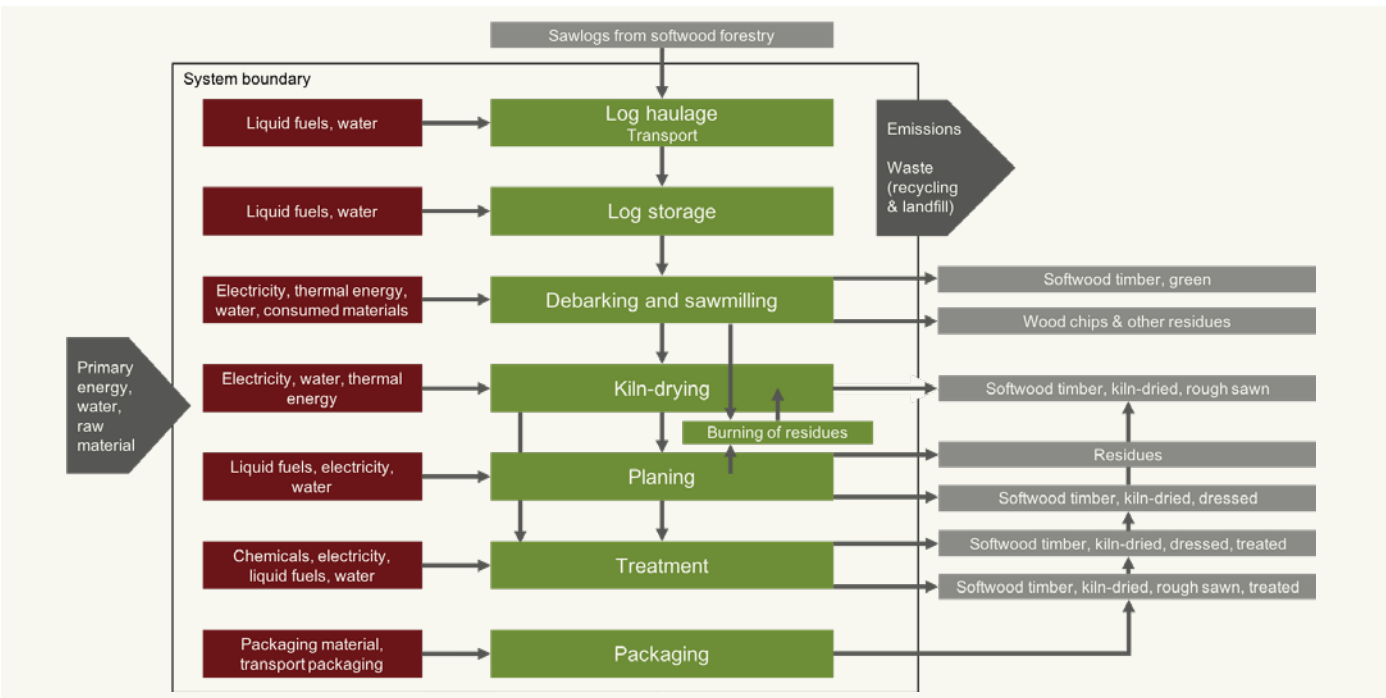
This EPD is of the 'cradle-to-gate' type with options. The options include the end-of-life stage, which is modelled through the use of scenarios.

Product stage			Con-struction process stage		Use stage							End-of-life stage				Benefits and loads beyond the system boundary
Raw material supply	Transport of raw materials	Manufacturing	Transport to customer	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport to waste processing	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	X	X	X

Key: X = included in the EPD
MND = module not declared (such a declaration shall not be regarded as an indicator result of zero)

Production

The production stage includes the forestry, sawmilling and kiln drying stages for all products and planing for dressed timber. Preservative treatment has been included separately to timber production within this EPD. Environmental profiles for a range of common treatment options are included in the Durability and Preservative Treatment section within this EPD.



End-of-Life

When a wood product reaches the end of its useful life, it may either be reused, recycled, landfilled or combusted to produce energy. Landfill is currently the most common end-of-life route for wood products in Australia. With the exception of reuse, which is not common for softwood, all other scenarios are in use in certain regions (Forsythe Consultants 2007; National Timber Product Stewardship Group) and have been included within this EPD.

Each scenario assumes that 100% of the wood is sent to that scenario. To create an end-of-life mix for a given region or end use, the reader should take a weighted sum of these scenarios. Where no data are available, the 'landfill (typical)' scenario should be used for 100% of the waste.

Landfill

This EPD includes two scenarios for landfill, each with a different value for the degradable organic carbon fraction (DOCf) of wood. The two values are based on bioreactor laboratory research. This experimental work involves the testing of a range of waste types in reactors operated to obtain maximum methane yields. As the laboratory work optimises the conditions for anaerobic decay, the results can be considered as estimates of the DOCf value that would apply over very long time horizons (Australian Government 2014a, p.17).

- **Landfill (typical):** DOC_f = 0.1%. This is based on bioreactor laboratory research by Wang *et al.* (2011) on radiata pine timber, the dominant softwood species in Australia.
- **Landfill (NGA)**: DOC_f = 10%. This is the value chosen for Australia's National Greenhouse Accounts (NGA) (Australian Government 2020). This is a reduction from the previous value of 23% (Australian Government 2014b) that was derived from early bioreactor laboratory research from the 1990s (e.g. Barlaz 1998) that investigated the degradability of wood tree branches ground to a fine powder under anaerobic conditions (Australian Government 2014a, p.17). This DOCf value can be considered extremely conservative when compared to values from later research (as used in the typical scenario above) and effectively assumes that at least part of the wood waste is ground into a powder to accelerate degradation.

The impacts associated with the landfill are declared in module C4. All landfill gas that is combusted for energy recovery (module C4) is assumed to occur in a power plant with an electrical conversion efficiency of 36% (Australian Government 2014b, p.189) and the resulting electricity receives a credit for offsetting average electricity from the Australian grid (module D) in line with EN 16485:2014 (Section 6.3.4.5).

Both landfill scenarios assume the following for carbon emissions:

- Of the gases formed from any degradation of wood in landfill, 50% is methane and 50% is carbon dioxide (Australian Government 2020, Table 46).
- All carbon dioxide is released directly to the atmosphere.
- 43% of the methane is captured, based on weighted average methane captured in Australian landfills (Australian Government 2021).
- Of this 43% captured, one-quarter (10.8% of the total) is flared and three-quarters (32.3% of the total) are used for energy recovery (Carre 2011).
- Of the 57% of methane that is not captured, 10% (5.7% of the total) is oxidised (Australian Government 2016, Table 43) and 90% (51.3%) is released to the atmosphere.
- In summary, for every kilogram of carbon converted to landfill gas, 74.4% is released as carbon dioxide and 25.7% is released as methane.

Energy recovery
This scenario includes shredding (module C3) and combustion with recovered energy offset against average thermal energy from natural gas (module D) in line with EN 16485:2014 (Section 6.3.4.5). Note that other options are also in use within Australia, including replacement of coal, replacement of electricity, and replacement of both electricity and thermal energy (via co-generation). The modelling assumes that the product waste has value after it has been sorted.

Recycling
Softwood may be recycled in many different ways. This scenario considers shredding and effectively downcycling into wood chips. Wood waste is chipped (module C3) and assigned credits relative to the avoided production of woodchips from virgin softwood (module D). The CO_2 sequestered and the energy content of the wood are assumed to leave the system boundary at C3 so that future product systems can also claim these without double-counting (EN 16485:2014, Section 6.3.4.2).

Key Assumptions

Energy: Thermal energy and transport fuels have been modelled as the Australian average (see Sphera 2020 for documentation). Electricity for production (modules A1-A3) has been modelled as a state-specific split based upon the volume of production in each state for the 2018-19 financial year (the most recent year split by state in Gavran, 2020): 30% NSW, 23% VIC, 18% SA, 15% QLD, 8% TAS, 6% WA. Electricity at end-of-life (module C) has been modelled using an average Australian electricity mix as the location where the product reaches end-of-life is unknown.

Forestry: All breakdown of forest matter after harvest is modelled as aerobic and therefore carbon neutral as carbon sequestered is released as carbon dioxide. Any burning of forestry material left behind after logging is modelled as being carbon neutral, aside from the trace emissions of various organic gases (Commonwealth of Australia, 2016). All forestry is assumed to be sustainably managed and as such there are no carbon emissions associated with land use change. Loss of carbon from the soil is assumed to be zero (i.e. no significant erosion). Wildfires are relatively rare in softwood plantations, but can be locally significant over short time periods. Carbon losses (and emissions) from fire are balanced by carbon gains (and sequestration) from regrowth. It is therefore better to review data over a longer-term horizon of several years.

Table 5.3 of Australia's State of the Forest Report 2018 (SOFR) (ABARES, 2018) reports net carbon losses/gains in softwood plantations from fire and regrowth from fire as 0.0 Mt over 2011-16 and -0.1Mt (so a release of 0.1 Mt of carbon) over the period 2001-16. CO_2 emissions from the 2001-16 period have been incorporated into this study. This report does not include calculations of other greenhouse gases emitted during forest fires as there is insufficient data however these are minor compared to CO_2 emissions.

Cut-off Criteria

Environmental impacts relating to personnel, infrastructure, and production equipment not directly consumed in the process are excluded from the system boundary as per the PCR (IEPDS 2020, Section 7.5.4). All other reported data were incorporated and modelled using the best available life cycle inventory data.

Allocation

Upstream data: For refinery products, allocation is done by mass and net calorific value. Inventories for electricity and thermal energy generation include allocation by economic value for some by-products (e.g. gypsum, boiler ash and fly ash). Allocation by energy is applied for co-generation of heat and power. For materials and chemicals, the allocation rule most suitable for the product is applied (see Sphera 2020).

Co-products (e.g. sawn wood and sawdust from milling): As the difference in economic value of the co-products is high (>25% as per EN 15804, Section 6.4.3.2), allocation has been done by economic value.

Background Data

Data for all energy inputs, transport processes and raw materials are from GaBi Databases 2020 (Sphera 2020). Most datasets have a reference year between 2016-2019 and all fall within the 10-year limit allowable for generic data under EN 15804 (Section 6.3.7).

EPD Results

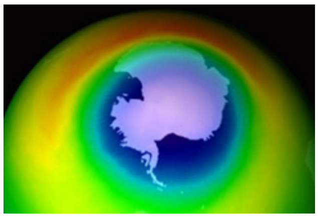
Note: these tables show the impacts associated with production and end-of-life. Any potential credits to future products from recycling or energy recovery are presented in the Other Environmental Information section.

Environmental Impact Indicators

An introduction to each environmental impact indicator is provided below. The best-known effect of each indicator is listed to the right of its name.

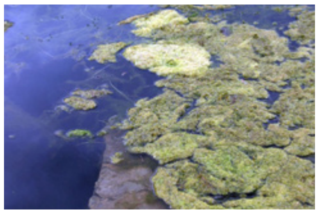
Global Warming Potential (GWP) → Climate Change
A measure of greenhouse gas emissions, such as carbon dioxide and methane. These emissions increase absorption of radiation emitted by the earth, intensifying the natural greenhouse effect. Contributions to GWP can come from either fossil or biogenic sources, e.g. burning fossil fuels or burning wood. GWP is reported as a total as well as being separated into biogenic carbon (GWPB) and fossil carbon (GWPF).

Ozone Depletion Potential (ODP) → Ozone Hole
A measure of air emissions that contribute to the depletion of the stratospheric ozone layer, causing higher levels of ultraviolet B (UVB) to reach the earth's surface with detrimental effects on humans, animals and plants.



Acidification Potential (AP) → Acid Rain
A measure of emissions that cause acidifying effects to the environment. Acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline and the deterioration of building materials.

Eutrophication Potential (EP) → Algal Blooms
A measure of nutrient enrichment that may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. It includes potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P).



Photochemical Ozone Creation Potential (POCP) → Smog
A measure of emissions of precursors that contribute to ground level smog formation (mainly ozone O3), produced by the reaction of VOCs and carbon monoxide in the presence of nitrogen oxides under the influence of UV light. Ground level ozone may be harmful to human and ecosystem health and may also damage crops.

Abiotic Depletion Potential (ADP)→ Resource Consumption
The consumption of non-renewable resources leads to a decrease in the future availability of the functions supplied by these resources. Depletion of mineral resource elements (ADPE) and non-renewable fossil energy resources (ADPF) are reported separately.

Table 7: Environmental impacts, 1 m³ of sawn, kiln-dried softwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-764	57.9	364	906	906
GWPF [kg CO_2-eq.]	117	56.6	56.8	5.58	5.58
GWPB [kg CO_2-eq.]	-881	1.28	307	900	900
ODP [kg CFC11-eq.]	1.80E-13	1.99E-13	1.99E-13	9.87E-16	9.87E-16
AP [kg SO_2-eq.]	0.740	0.170	0.196	0.0352	0.0352
EP [kg PO_4^{3}-eq.]	0.209	0.0203	0.0267	0.00818	0.00818
POCP [kg C_2H_4-eq.]	0.594	0.0106	0.0684	0.00306	0.00306
ADPE [kg Sb-eq.]	7.17E-05	4.70E-06	4.70E-06	6.86E-08	6.86E-08
ADPF [MJ]	1,430	814	814	73.8	73.8

Table 8: Environmental impacts, 1 m³ of dressed, kiln-dried softwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-718	57.9	364	906	906
GWPF [kg CO_2-eq.]	157	56.6	56.8	5.58	5.58
GWPB [kg CO_2-eq.]	-875	1.28	307	900	900
ODP [kg CFC11-eq.]	2.24E-13	1.99E-13	1.99E-13	9.87E-16	9.87E-16
AP [kg SO_2-eq.]	0.963	0.170	0.196	0.0352	0.0352
EP [kg PO_4^{3-}-eq.]	0.263	0.0203	0.0267	0.00818	0.00818
POCP [kg C_2H_4-eq.]	0.730	0.0106	0.0684	0.00306	0.00306
ADPE [kg Sb-eq.]	8.78E-05	4.70E-06	4.70E-06	6.86E-08	6.86E-08
ADPF [MJ]	1,900	814	814	73.8	73.8

Resource Use

Table 9: Resource use, 1 m³ of sawn, kiln-dried softwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	1,910	57.2	57.2	0.488	0.488
PERM [MJ]	9,290	0	0	-9,290	-9,290
PERT [MJ]	11,200	57.2	57.2	-9,290	-9,290
PENRE [MJ]	1,440	826	826	73.9	73.9
PENRM [MJ]	0	0	0	0	0
PENRT [MJ]	1,440	826	826	73.9	73.9
SM [kg]	0.00208	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	1.01	0.0124	0.0564	6.97E-04	6.97E-04

__PERE__ = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; __PERM__ = Use of renewable primary energy resources used as raw materials; __PERT__ = Total use of renewable primary energy resources; __PENRE__ = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; __PENRM__ = Use of non-renewable primary energy resources used as raw materials; __PENRT__ = Total use of non-renewable primary energy resources; __SM__ = Use of secondary material; __RSF__ = Use of renewable secondary fuels; __NRSF__ = Use of non-renewable secondary fuels; __FW__ = Net use of fresh water

Table 10: Resource use, 1 m³ of dressed, kiln-dried softwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	2,340	57.2	57.2	0.488	0.488
PERM [MJ]	9,290	0	0	-9,290	-9,290
PERT [MJ]	11,600	57.2	57.2	-9,290	-9,290
PENRE [MJ]	1,910	826	826	73.9	73.9
PENRM [MJ]	0	0	0	0	0
PENRT [MJ]	1,910	826	826	73.9	73.9
SM [kg]	0.00235	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	1.33	0.0124	0.0564	6.97E-04	6.97E-04

Waste and Output Flows

Table 11: Waste categories, 1 m³ of sawn, kiln-dried softwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	0.0103	2.34E-06	2.34E-06	1.07E-07	1.07E-07
NHWD [kg]	23.2	552	455	0.00172	0.00172
RWD [kg]	0.00232	0.00458	0.00458	7.87E-06	7.87E-06
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	551
MER [kg]	0	0	0	551	0
EEE [MJ]	0	1.07	107	0	0
EET [MJ]	0	0	0	0	0

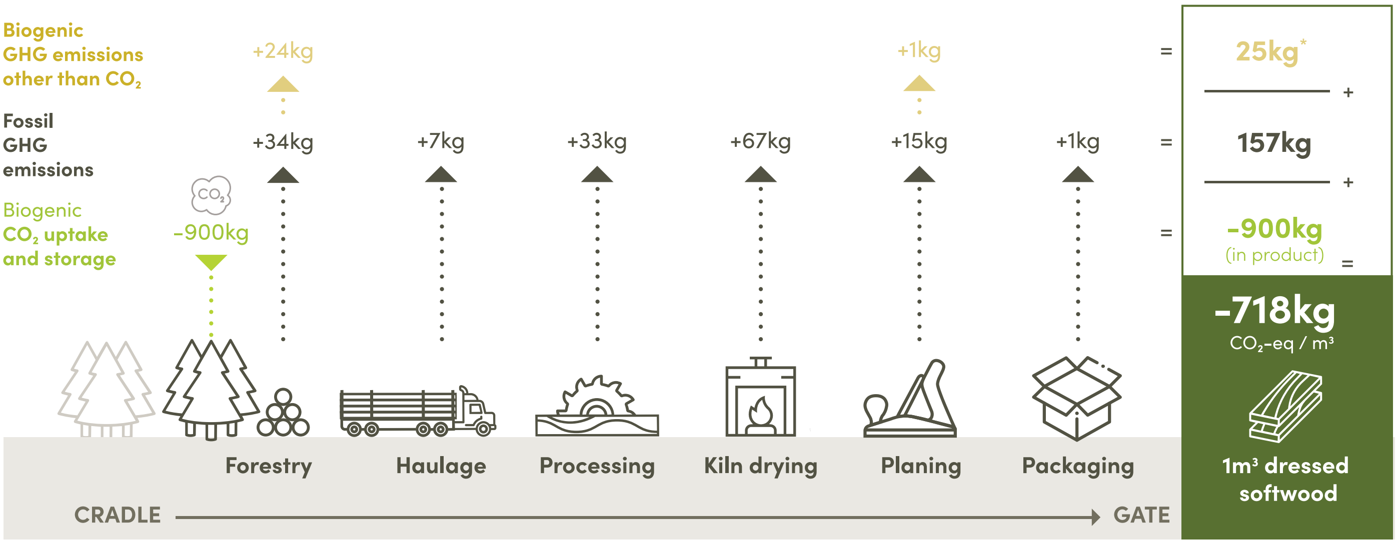
HWD *= Hazardous waste disposed;* ***NHWD*** *= Non-hazardous waste disposed;* ***RWD*** *= Radioactive waste disposed;*
CRU *= Components for reuse;* ***MFR*** *= Materials for recycling;* ***MER*** *= Materials for energy recovery;*
EEE *= Exported electrical energy;* ***EET*** *= Exported thermal energy*

Table 12: Waste categories, 1 m³ of dressed, kiln-dried softwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	0.0117	2.34E-06	2.34E-06	1.07E-07	1.07E-07
NHWD [kg]	29.8	552	455	0.00172	0.00172
RWD [kg]	0.00273	0.00458	0.00458	7.87E-06	7.87E-06
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	551
MER [kg]	0	0	0	551	0
EEE [MJ]	0	1.07	107	0	0
EET [MJ]	0	0	0	0	0

Interpretation

Understanding the Life Cycle of Softwood Timber



Carbon footprint 1m³ of KD dressed softwood
'Cradle to Gate' A1 – A3

*CO_2 biogenic emissions from production (e.g. from combustion and degradation of residues) are excluded as they are balanced by uptake during tree growth (i.e., balance to zero)

Variation in Results

The variation between sites used to create the average shown in this EPD are given in Table 13 for the environmental impact indicators in modules A1-A3.

Table 13: Inter-site variability for softwood (modules A1-A3).

	Sawn, kiln-dried softwood			Dressed, kiln-dried softwood		
Parameter [Unit]	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**
GWP [kg CO_2-eq.]	-7.7%	+7.0%	±5.5%	-11.8%	+10.1%	±7.9%
GWPF [kg CO_2-eq.]	-51.5%	+47.2%	±36.9%	-54.6%	+47.0%	±36.6%
GWPB [kg CO_2-eq.]	-0.1%	+0.1%	±0.1%	-0.2%	+0.1%	±0.1%
ODP [kg CFC11-eq.]	-28.0%	+46.9%	±27.2%	-33.8%	+59.4%	±33.1%
AP [kg SO_2-eq.]	-33.3%	+14.0%	±15.6%	-34.6%	+14.0%	±16.6%
EP [kg PO_4^{3}-eq.]	-13.2%	+6.3%	±6.5%	-13.8%	+6.2%	±6.8%
POCP [kg C_2H_4-eq.]	-7.2%	+4.5%	±4.2%	-7.4%	+4.5%	±4.1%
ADPE [kg Sb-eq.]	-1.1%	+6.6%	±2.9%	-1.0%	+6.4%	±2.6%
ADPF [MJ]	-51.2%	+59.3%	±44.9%	-54.0%	+53.4%	±43.5%

***Min** = (minimum - average) / average; **Max** = (maximum - average) / average;*
***CV** = coefficient of variation = standard deviation / average*

Carbon Dioxide Sequestration

All major Australian production forests and plantations are independently certified to one, or both, of the internationally recognised forest management certification systems: the Australian Standard® for Sustainable Forest Management (AS 4708) of Responsible Wood which is recognised under the Programme for the Endorsement of Forest Certification (PEFC), and/or the Forest Stewardship Council's (FSC®) Australian National Forest Stewardship Standard. It is therefore appropriate to include biogenic CO_2 sequestration in this EPD in line with EN 16485 (Section 6.3.4.2).

For more information on certification by forest owner or manager please see:

https://www.responsiblewood.org.au/search-database/ and

https://info.fsc.org/certificate.php

Other Environmental Information

Module D: Recycling, Reuse and Recovery Potentials

Table 14: Module D, 1 m³ of sawn, kiln-dried softwood.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.275	-27.5	-614	-68.1
GWPF [kg CO_2-eq.]	-0.275	-27.5	-615	-61.3
GWPB [kg CO_2-eq.]	-1.46E-04	-0.0146	1.29	-6.82
ODP [kg CFC11-eq.]	-1.70E-15	-1.70E-13	-1.28E-14	-1.70E-13
AP [kg SO_2-eq.]	-0.00110	-0.110	-0.0201	-0.418
EP [kg PO_4^{3-}-eq.]	-9.85E-05	-0.00985	-0.0424	-0.0976
POCP [kg C_2H_4-eq.]	-5.90E-05	-0.00590	0.0993	-0.317
ADPE [kg Sb-eq.]	-1.87E-08	-1.87E-06	-5.20E-05	-2.17E-05
ADPF [MJ]	-3.08	-308	-10,500	-782
Resource Use				
PERE [MJ]	-0.470	-47.0	-3.59	-1,890
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.470	-47.0	-3.59	-1,890
PENRE [MJ]	-3.09	-309	-10,500	-783
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-3.09	-309	-10,500	-783
SM [kg]	0	0	0	551
RSF [MJ]	0	0	9,290	0
NRSF [MJ]	0	0	0	0
FW [m^3]	-0.00148	-0.148	-0.00978	-0.454
Wastes and Outputs				
HWD [kg]	-5.00E-10	-5.00E-08	-2.42E-06	-3.95E-07
NHWD [kg]	-7.96E-04	-0.0796	25.9	-10.9
RWD [kg]	-5.28E-07	-5.28E-05	-7.17E-04	-5.39E-04
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 15: Module D, 1 m³ of dressed, kiln-dried softwood.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.275	-27.5	-614	-68.1
GWPF [kg CO_2-eq.]	-0.275	-27.5	-615	-61.3
GWPB [kg CO_2-eq.]	-1.46E-04	-0.0146	1.29	-6.82
ODP [kg CFC11-eq.]	-1.70E-15	-1.70E-13	-1.28E-14	-1.70E-13
AP [kg SO_2-eq.]	-0.00110	-0.110	-0.0201	-0.418
EP [kg PO_4^{3-}-eq.]	-9.85E-05	-0.00985	-0.0424	-0.0976
POCP [kg C_2H_4-eq.]	-5.90E-05	-0.00590	0.0993	-0.317
ADPE [kg Sb-eq.]	-1.87E-08	-1.87E-06	-5.20E-05	-2.17E-05
ADPF [MJ]	-3.08	-308	-10,500	-782
Resource Use				
PERE [MJ]	-0.470	-47.0	-3.59	-1,890
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.470	-47.0	-3.59	-1,890
PENRE [MJ]	-3.09	-309	-10,500	-783
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-3.09	-309	-10,500	-783
SM [kg]	0	0	0	551
RSF [MJ]	0	0	9,290	0
NRSF [MJ]	0	0	0	0
FW [m^3]	-0.00148	-0.148	-0.00978	-0.454
Wastes and Outputs				
HWD [kg]	-5.00E-10	-5.00E-08	-2.42E-06	-3.95E-07
NHWD [kg]	-7.96E-04	-0.0796	25.9	-10.9
RWD [kg]	-5.28E-07	-5.28E-05	-7.17E-04	-5.39E-04
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Durability and Preservative Treatment

As described in the Scope section, the body of the EPD covers untreated seasoned sawn softwood products. These products will deliver a long service life in most building, joinery and furniture applications when they are protected from termite attack and used inside a building envelope.

While the majority of seasoned sawn softwood produced in Australia for structural applications is untreated, a significant proportion is treated in the factory for termite and/or decay protection. Products to be used in outdoor applications such as decking, cladding, fencing and landscaping are usually treated to the appropriate hazard class. The following treatment types were used by the softwood producers participating in the survey and thus have been modelled:

Treatment	**Hazard class**
Bifenthrin	H2, H2F
Low organic solvent preservative (LOSP) (permethrin)	H2, H2F
Low organic solvent preservative (LOSP) (azole + permethrin)	H3
Copper chrome arsenic (CCA)	H3 & H4
Copper with didecyl dimethyl ammonium chloride or carbonate/bicarbonate (DDAX)	H3
Copper azole	H3 & H4

The values shown in Table 16 and Table 17 may be added to the A1-A3 values per m^3 of seasoned softwood given in Tables 7 to 12. This allows the associated A1-A3 impacts per m^3 of treated softwood to be calculated for each treatment type.

Table 16: Environmental data for preservative treatment of softwood (non-copper treatments), per m³ of treated wood

Parameter [Unit]	Bifenthrin [H2]	Bifenthrin [H2F]	LOSP (permethrin) [H2]	LOSP (permethrin) [H2F]	LOSP (azole + permethrin) [H3]
Environmental Impact					
GWP [kg CO_2-eq.]	10.8	10.5	11.8	11.0	58.6
GWPF [kg CO_2-eq.]	10.8	10.5	11.7	11.0	58.5
GWPB [kg CO_2-eq.]	0.0104	0.00820	0.0165	0.0119	0.0943
ODP [kg CFC11-eq.]	1.53E-12	8.99E-13	3.35E-12	2.00E-12	1.51E-10
AP [kg SO_2-eq.]	0.0417	0.0409	0.0443	0.0425	0.151
EP [kg PO_4^{3-}-eq.]	0.00379	0.00370	0.00408	0.00388	0.0140
POCP [kg C_2H_4-eq.]	0.0384	0.0228	0.0188	0.0120	6.74
ADPE [kg Sb-eq.]	2.67E-05	1.55E-05	8.73E-05	5.18E-05	1.75E-04
ADPF [MJ]	145	135	159	144	2,062
Resource Use					
PERE [MJ]	18.0	17.6	20.1	18.8	37.6
PERM [MJ]	0	0	0	0	0
PERT [MJ]	18.0	17.6	20.1	18.8	37.6
PENRE [MJ]	145	136	161	145	2,081
PENRM [MJ]	0	0	0	0	0
PENRT [MJ]	145	136	161	145	2,081
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	62.7	58.8	62.5	58.9	216
Wastes and Outputs					
HWD [kg]	3.12E-08	2.58E-08	5.48E-08	4.01E-08	3.50E-07
NHWD [kg]	0.0372	0.0336	0.0516	0.0423	0.312
RWD [kg]	2.67E-04	1.60E-04	7.20E-04	4.33E-04	0.00762
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	0
MER [kg]	0	0	0	0	0
EEE [MJ]	0	0	0	0	0
EET [MJ]	0	0	0	0	0

Table 17: Environmental data for preservative treatment of softwood (copper treatments), per m³ of treated wood.

Parameter [Unit]	Copper + DDAX [H3]	Copper azole [H3]	Copper azole [H4]	CCA [H3]	CCA [H4]
Environmental Impact					
GWP [kg CO_2-eq.]	17.4	14.9	18.8	32.2	24.7
GWPF [kg CO_2-eq.]	17.4	14.8	18.8	32.1	24.7
GWPB [kg CO_2-eq.]	0.0530	0.0365	0.0621	0.0832	0.0570
ODP [kg CFC11-eq.]	8.72E-11	5.72E-11	1.04E-10	8.19E-14	7.50E-14
AP [kg SO_2-eq.]	0.319	0.223	0.373	0.339	0.238
EP [kg PO_4^{3-}-eq.]	0.00613	0.00525	0.00662	0.0104	0.00811
POCP [kg C_2H_4-eq.]	0.0144	0.0102	0.0167	0.0162	0.0114
ADPE [kg Sb-eq.]	2.59E-04	1.70E-04	3.08E-04	0.00280	0.00186
ADPF [MJ]	274	222	304	386	297
Resource Use					
PERE [MJ]	23.6	21.3	24.9	26.4	23.3
PERM [MJ]	0	0	0	0	0
PERT [MJ]	23.6	21.3	24.9	26.4	23.3
PENRE [MJ]	280	226	310	394	303
PENRM [MJ]	0	0	0	0	0
PENRT [MJ]	280	226	310	394	303
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	98.2	82.8	107	105	87.7
Wastes and Outputs					
HWD [kg]	4.76E-04	3.12E-04	5.67E-04	2.00E-07	1.39E-07
NHWD [kg]	0.163	0.117	0.189	1.39	0.933
RWD [kg]	0.00214	0.00141	0.00255	0.00336	0.00223
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	0
MER [kg]	0	0	0	0	0
EEE [MJ]	0	0	0	0	0
EET [MJ]	0	0	0	0	0

Water Consumption

The "FW" indicator in the EPD results tables reports consumption (i.e. net use) of 'blue' water (which includes river water, lake water and ground water). This indicator deliberately excludes consumption of 'green' water (rain water).

PCR 2012:01 (Section 16.1) states that all water loss from a drainage basin is considered consumption, including any net loss of rain water. According to the PCR, net loss should be interpreted as any additional water loss beyond what would occur in the original, natural system. For plantation softwood forestry, the natural system might be a native forest or a grassland (Quinteiro et al. 2015).

The initial versions of this EPD (v1.0 and v1.1) included estimated losses of rain water in the main results tables, labelled as green water consumption. These values were based on calculated differences in water flow between plantation forests and a base case land use (pasture) from the original CSIRO LCI study (CSIRO 2009).

Table 18 reports green water consumption calculated by CSIRO using 2005-08 data. These values have not been updated and are now reported here rather than in the main results tables to reflect their uncertainty. At the time of writing, there is no internationally agreed method for calculating green water consumption due to evapotranspiration relative to a hypothetical natural state (Manzardo et al. 2016). As such, different calculation methods may yield significantly different results, introducing a high level of uncertainty.

The reader should also be aware that water consumption does not account for relative water stress in the catchment(s) where the forest is located, meaning that it provides no information about the potential impacts of any water consumption that does occur.

Table 18: Green water consumption estimates for modules A1-A3 from CSIRO (2009).

	Sawn, kiln-dried softwood	**Dressed, kiln-dried softwood**
Parameter [Unit]	A1-A3	A1-A3
Green water consumption in forest [m^3]	291	356

Timber & Forest Certification

Many Australian timber and reconstituted wood products are certified to a forest certification scheme. This certification is an independent auditing process which provides:

- Assurance that the timber is from well-managed forests certified to internationally and nationally accepted forest management standards
- Assurance that the timber is from legally harvested sources
- Chain of custody (CoC) certification extending from the forest to the end user, which is traceable throughout the supply chain.

Two schemes apply to Australian wood production forests. One is administered by Responsible Wood whose Australian Standard® for Sustainable Forest Management (AS 4708) is endorsed by the international Programme for Endorsement of Forest Certification (PEFC). The other scheme is administered by the Forest Stewardship Council (FSC®).

If a Green Star project elects to use the timber credit as part of their Green Star submission, the Green Building Council of Australia recognises PEFC-endorsed forest certification schemes (such as Responsible Wood) as well as FSC. Compliance with the chain of custody certification rules of either forest certification scheme for at least 95% by value of timber products used in the project will meet the requirements for credit (GBCA 2014).

There are 11.3 million hectares of native and plantation forests certified under Responsible Wood's sustainable forest management standard (PEFC 2020) and 1.2 million hectares certified under FSC's national Australian standard (FSC 2019). In addition, many Australian softwood manufacturers' premises listed in this EPD are chain of custody certified under one or both schemes so they can supply products with a valid certification claim.

Land Use and Biodiversity

Like other land uses, forestry operations for timber and wood production can have both positive and negative effects on biodiversity. However, as biodiversity varies considerably by region and as data are often limited, assessing potential biodiversity impacts within LCA is challenging.

An Australian study completed shortly before initial publication of this EPD (Turner et al. 2014) demonstrated a new method – BioImpact – to discern the biodiversity impacts of different land uses. A trial of this method was conducted using case studies in three different regions and four production systems in New South Wales: native hardwood forestry, plantation softwood forestry, mixed cropping and rangeland grazing. Managed forestry resulted in biodiversity impacts equivalent to or better than those of cropping/grazing systems.

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2

Environmental Product Declaration
Hardwood Timber

Environmental Product Declaration (EPD)
in accordance with ISO 14025 and EN 15804

EPD Registration No. S-P-00561 | Version 1.2
Issued 13 August 2015 | Revised 8 December 2017 | Valid until 8 December 2022

Geographical Scope: Australia

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Environmental Product Declarations

WoodSolutions has developed a suite of EPDs for industry-average, Australian-produced timber products.

These EPDs help to showcase the environmental credentials of Australian wood products. They also provide life cycle data for calculating the impacts of wood products at a building level.

EPDs include:

#01 Softwood Timber

#02 Hardwood Timber

#03 Particleboard

#04 Medium Density Fibreboard (MDF)

#05 Plywood

#06 Glued Laminated Timber (Glulam)

Jamberoo Farm House by Casey Brown Architecture

Photo credit: Patrick Bingham Hall / Pesaro Publishing

WoodSolutions is an industry initiative designed to provide independent, non-proprietary information about timber and wood products to professionals and companies involved in building design and construction.

WoodSolutions is resourced by Forest and Wood Products Australia (FWPA). It is a collaborative effort between FWPA members and levy payers, supported by industry peak bodies and technical associations.

This work is supported by funding provided to FWPA by the Commonwealth Government.

ISBN: 978-1-925213-15-7

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Version history

V1.0 Initial version based on 2005/06 data from CSIRO and produced by thinkstep Pty Ltd and the Timber Development Association (NSW) Ltd.

V1.1 Revised version incorporating 2015/16 data from a new industry survey, as well as updates to Global Warming Potential (GWP) and fresh water indicators.

V1.2 - Revised version for correction of the validity period, documentation of the forestry carbon modelling assumptions, correction of minor typographical errors. Fixed the double counting of the artificial release of biogenic carbon that occurred in Module C and D of the Reuse EOL scenario (now the release is only included in Module C).

Produced: December 2020

EPD Details

An Environmental Product Declaration, or EPD, is a standardised and verified way of quantifying the environmental impacts of a product that is based on a consistent set of rules known as a PCR (Product Category Rules).

EPDs within the same product category from different programs may not be comparable. EPDs of construction products may not be comparable if they do not comply with EN 15804.

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CEN standard EN 15804 served as the core PCR

PCR:
PCR 2012:01 Construction products and Construction services, Version 2.2, 2017-05-30

PCR review was conducted by:
The Technical Committee of the International EPD® System.
Chair: Massimo Marino. Contact via info@environdec.com.

Independent verification of the declaration and data, according to ISO 14025:
☐ EPD process certification (Internal)
☑ EPD verification (External)

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Introduction

This Environmental Product Declaration presents the average performance of sawn timber from Australian grown native hardwood processed in Australia by members of Forest and Wood Products Australia (FWPA). It recognises the importance of transparency by providing information on the raw materials, production and environmental impacts of Australian hardwood.

This EPD has been prepared in accordance with ISO 14025:2006, EN 15804:2013 and PCR 2012:01 (IEPDS 2017). It covers Australian hardwood products primarily produced in accordance with the following standards:

- AS 2082 Timber – Hardwood – Visually stress-graded for structural purposes
- AS 2796 Timber – Hardwood – Sawn and milled products.

The environmental data presented in this document were primarily derived from a survey of industry members covering the 2015/16 financial year conducted by thinkstep and Stephen Mitchell Associates on behalf of FWPA. This updates an earlier survey conducted by CSIRO (2009) based on the 2005/06 financial year, which was used in the first version of this EPD. The current survey covers approximately one quarter of total sawn hardwood production in Australia and half of all production by FWPA members.

Production of this EPD has been facilitated by FWPA with participation of its current sawn hardwood timber producer members listed in Table 1. All members have contributed financially through levies paid to FWPA and some have also contributed data (as shown in Table 1).

Table 1: FWPA members contributing to this EPD.

Company	Financial contributor	Data contributor
A E Girle and Sons	X	
A G Brown Pty Ltd	X	
Australian Solar Timbers	X	X
Australian Sustainable Hardwoods Pty Ltd	X	X
Auswest Timbers Pty Ltd	X	X
Blueleaf Corporation Pty Ltd trading as Whittakers Timber Products	X	
Boral Timber Division	X	X
Britton Bros Pty Ltd	X	X
Dale & Meyers Operations Pty Ltd trading as DTM Timber	X	
Endeavour Foundation trading as Nangarin Timbers	X	
Fenning Investments Pty Ltd trading as Fenning Bairnsdale	X	
Hallmark Oaks Pty Ltd	X	
Hexan Holdings Pty Ltd trading as Whiteland Milling	X	
Hurford Sawmilling Pty Ltd	X	X
Intech Operations Pty Ltd trading as Muckerts Sawmill	X	
Ironwood Taree Pty Ltd	X	
J Notaras & Sons Pty Ltd	X	
Jarrahwood Australia Pty Ltd	X	
Machin's Sawmill Pty Ltd	X	
McCormack Demby Timbers Pty Ltd	X	
McKay Timber	X	

Table 1: FWPA members contributing to this EPD (continued).

Company	Financial contributor	Data contributor
Millmerran Timbers Pty Ltd	X	
Nannup Timber Processing (NTP)	X	X
Neville Smith Forest Products	X	X
Parkside Building Supplies Pty Ltd	X	X
Porta Mouldings Pty Ltd	X	
Radial Timber Australia	X	
Ravenshoe Timbers Pty Ltd	X	
Ryan & McNulty Pty Ltd	X	
Saunders Sawmill	X	
Schiffke Sawmill Pty Ltd	X	
Urgenty Pty Ltd trading as Mary Valley Timbers	X	
Wade Sawmill	X	

Description of the Australian Sawn Hardwood Industry

The Australian timber and wood products industry is an important contributor to the Australian economy – particularly to the regional economies where many producers are based. In 2015-16 it is estimated that 64,300 people were employed in forestry, logging and wood manufacturing and forestry and forest product manufacturing industries contributed 0.5% of Australia's GDP.

In 2015-16 the industry produced an estimated 590,000 cubic metres of sawn timber products across 186 different sawmills. The distribution of hardwood sawmills by state is included in Table 2. 96% of hardwood sawmills had a log input capacity less than 45,000 m^3 per year. (ABARES 2017b).

Table 2: Hardwood sawmills by Australian state.

NSW[a]	Vic.	Qld	SA	WA[b]	Tas.	Aust.
63	30	46	0	16	27	182

a Includes ACT
b includes Northern Territory.

Use of EPDs in Sustainable Building and Infrastructure Rating Systems

This document complies with the requirements for an industry-wide EPD under the Green Building Council of Australia's Green Star rating system given that:

1. It conforms with ISO 14025 and EN 15804.
2. It has been verified by an independent third party.
3. It has at least a cradle-to-gate scope.
4. The participants in the EPD are listed (see Table 1).

It may be used by project teams using the *Design & As Built* and *Interiors* rating tools to obtain Green Star points under the following credits:

- Materials > Product Transparency and Sustainability.
- Materials > Life Cycle Assessment: By providing data for an EN 15978 compliant whole-of-building whole-of-life assessment.
- Innovation Challenge > Responsible Carbon Impact: By providing embodied carbon impacts (i.e. data on Global Warming Potential) which can be used in the calculation and reduction of the total embodied carbon impacts of a project.

This EPD is also recognised for credits in the Infrastructure Sustainability (IS) rating scheme of the Infrastructure Sustainability Council of Australia (ISCA).

Shearer's Quarters by John Wardle Architects, image by Trevor Mein

Bentleigh Secondary College Meditation and Indigenous Culture Centre by dwp suters, image by Emma Cross

House in the Woods by Wilson Architecture Pty Ltd and image by Aaron Pocock Architectural Photography

Scope

Products

This Sector EPD describes the following average products (declared units) manufactured in Australia by the FWPA members listed in Table 1:

- *1 m^3 of rough-sawn, kiln-dried hardwood*
  10% moisture content (dry basis), density of 735 kg/m^3
- *1 m^3 of dressed, kiln-dried hardwood*
  10% moisture content (dry basis), density of 735 kg/m^3
- *1 m^3 of rough-sawn, green hardwood*
  26% moisture content (dry basis), density of 768 kg/m^3

The declared units above represent an entire product category rather than a specific product from a specific manufacturer. The values represent a production volume weighted average. As such, a specific product purchased on the market may have a lesser or greater environmental impact than the average presented in this EPD. Some products may also undergo further processing (e.g. sawing) before being used in a building.

All products consist of 100% Australian native hardwood species grown in native forests.

The results in the main body of this EPD are for untreated timber. Information on treatment can be found in the Additional Environmental Information section. The results for the specific treatment type used can be added to the results for untreated timber to calculate the environment profile for treated timber.

The following table indicates the availability of softwood by hazard class (a bold **X** indicates a common product)

Table 3: Availability of sawn hardwood by hazard class.

Products	Untreated	H1	H2	H3	H4	H5	H6
Hardwood, rough-sawn, kiln-dried	**X**	**X**[1]		**X**[2]	X[2]	X[2]	
Hardwood, dressed, kiln-dried	**X**	**X**[1]		**X**[2]	X[2]	X[2]	
Hardwood, rough-sawn, green	**X**						

[1] Only available for hardwoods with lyctus susceptible sapwood present
[2] H3 treated Victorian Ash is also available

End Uses

Rough-sawn, kiln-dried hardwood
Hardwood for remanufacturers and 'rough look' kiln-dried structural hardwood.

Dressed, kiln-dried hardwood
Hardwood flooring, decking, cladding, stair treads, kiln-dried structural timber and commercial decking.

Rough-sawn, green hardwood
Green (unseasoned) structural hardwood, fencing, pallet-grade hardwood and landscape timbers.

Representativeness

Market coverage: The data in this EPD are from detailed surveys of 11 of the 43 hardwood mills in Australia who are FWPA members. (Mills that are not FWPA members were excluded from the scope of the study.) These mills collectively produced 145,151 m^3 of sawn hardwood in 2015/16, equating to 27% of total Australian production of approximately 587,071 m^3 (based on the 2015/16 total from ABARES 2017a, as adjusted to saleable volume following Houghton 2015) and approximately 54% of total production by FWPA members (assuming FWPA members account for 50% of Australian production).

Temporal representativeness: Primary data were collected from participating sites for the 2015/16 Australian financial year (1st July 2015 to 30th June 2016). Following EN 15804, site-specific data are valid for 5 years (to 30th June 2021), meaning that these datasets are valid until the end of this EPD's validity period.

Geographical and technological representativeness: The data are representative of the 11 sites surveyed, which collectively produce more than a quarter of all Australian-produced sawn hardwood. More detailed information can be found in the Variation in Results section later in this EPD.

Industry Classifications

Product	Classification	Code	Category
All	UN CPC Ver.2	31100	Wood, sawn or chipped lengthwise, sliced or peeled, of a thickness exceeding 6 mm
Some rough-sawn, green hardwood	UN CPC Ver.2	31330	Other wood in the rough (including split poles and pickets)
Rough-sawn green, hardwood	ANZSIC 2006	1411	Log sawmilling
Kiln-dried timber	ANZSIC 2006	1413	Timber resawing and dressing

LCA Calculation Rules

System Boundary

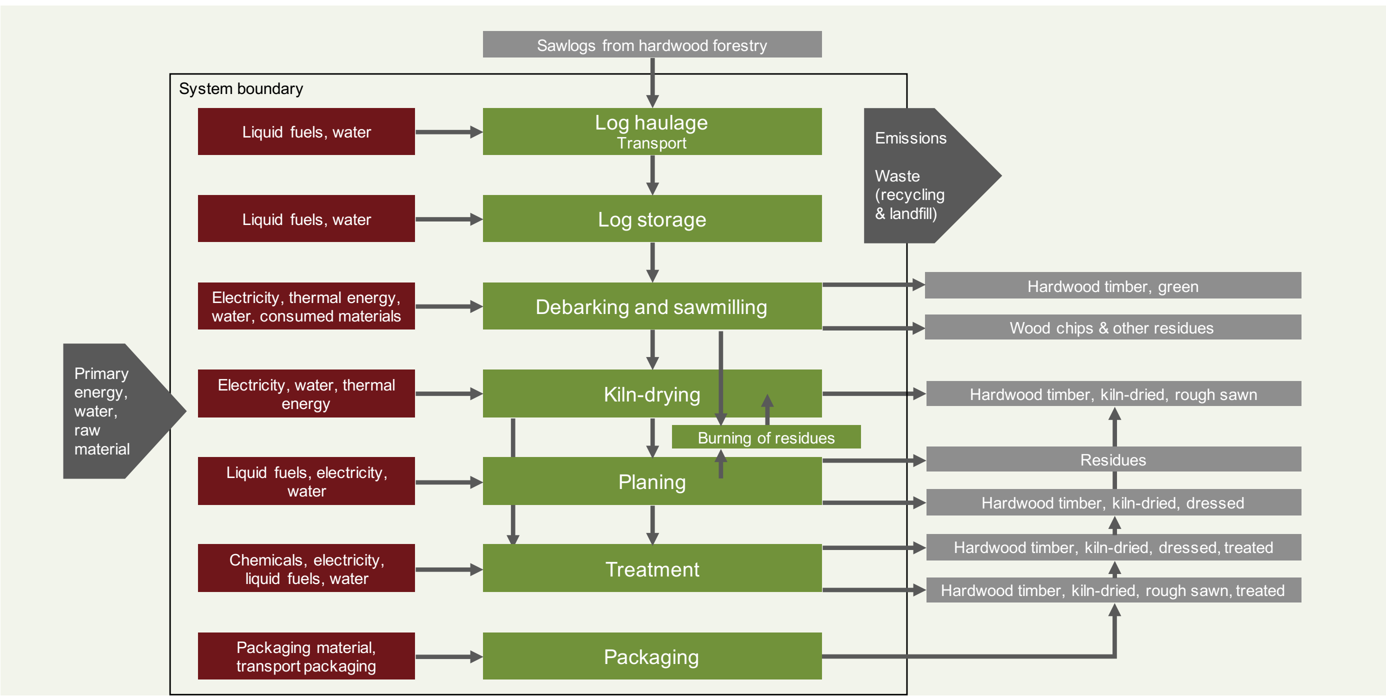
This EPD is of the 'cradle-to-gate' type with options. The options include the end-of-life stage, which is modelled through the use of scenarios.

Product stage			Con-struction process stage		Use stage							End-of-life stage				Benefits and loads beyond the system boundary
Raw material supply	Transport of raw materials	Manufacturing	Transport to customer	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport to waste processing	Waste processing	Disposal	Reuse- Recovery- Recycling- potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	X	X	X

Key: X = included in the EPD
MND = module not declared (such a declaration shall not be regarded as an indicator result of zero)

Production

The production stage includes the forestry and sawmilling processes for green sawn timber, kiln drying for kiln-dried timber and planing for dressed timber (green and kiln-dried). Preservative treatment has been included separately to timber production within this EPD. Environmental profiles for a range of common treatment options are included in the Durability and Preservative Treatment section later in this EPD.



End-of-Life

When a wood product reaches the end of its useful life, it may either be reused, recycled, landfilled or combusted to produce energy. Landfill is currently the most common end-of-life route for wood products in Australia. Reuse is also common for large dimension hardwoods. All other scenarios are in use in certain regions (Forsythe Consultants 2007; National Timber Product Stewardship Group) and have been included within this EPD.

Each scenario assumes that 100% of the wood is sent to that scenario. To create an end-of-life mix for a given region or end use, the reader should take a weighted sum of these scenarios. Where no data are available, the 'landfill (typical)' scenario should be used for 100% of the waste.

Landfill

This EPD includes two scenarios for landfill, each with a different value for the degradable organic carbon fraction (DOCf) of wood. The two values are based on bioreactor laboratory research. This experimental work involves the testing of a range of waste types in reactors operated to obtain maximum methane yields. As the laboratory work optimises the conditions for anaerobic decay, the results can be considered as estimates of the DOCf value that would apply over very long time horizons (Australian Government 2014a, p. 17).

- **Landfill (typical):** DOCf = 0%. This is based on bioreactor laboratory research by Wang *et al.* (2011) on blackbutt timber, one of the dominant hardwood species in Australia.
- **Landfill (NGA)**: DOCf = 10%. This is the value chosen for Australia's National Greenhouse Accounts (NGA) (Australian Government 2017). This is a reduction from the previous value of 23% (Australian Government 2014b) that was derived from early bioreactor laboratory research from the 1990s (e.g. Barlaz 1998) that investigated the degradability of wood tree branches ground to a fine powder under anaerobic conditions (Australian Government 2014a, p. 17). This DOCf value can be considered extremely conservative when compared to values from later research (as used in the typical scenario above) and effectively assumes that at least part of the wood waste is ground into a powder to accelerate degradation.

The impacts associated with the landfill are declared in module C4. All landfill gas that is combusted for energy recovery (module C4) is assumed to occur in a power plant with an electrical conversion efficiency of 36% (Australian Government 2014c, p. 189) and the resulting electricity receives a credit for offsetting average electricity from the Australian grid (module D) in line with EN 16485:2014 (Section 6.3.4.5).

Both landfill scenarios assume the following for carbon emissions:

- Of the gases formed from any degradation of wood in landfill, 50% is methane and 50% is carbon dioxide (Australian Government 2016, Table 43).
- All carbon dioxide is released directly to the atmosphere.
- 36% of the methane is captured, based on forecasted average methane capture in Australian landfills by 2020 (Hyder Consulting 2007). The year 2020 was chosen as landfill will take place in the future and this was the last year for which forecasts were available.
- Of this 36% captured, one-quarter (9% of the total) is flared and three-quarters (27% of the total) are used for energy recovery (Carre 2011).
- Of the 64% of methane that is not captured, 10% (6.4% of the total) is oxidised (Australian Government 2016, Table 43) and 90% (57.6%) is released to the atmosphere.
- In summary, for every kilogram of carbon converted to landfill gas, 71.2% is released as carbon dioxide and 28.8% is released as methane.

Energy recovery

This scenario includes shredding and combustion (module C3) with recovered energy offset against average electricity from the Australian grid and thermal energy from natural gas (module D) in line with EN 16485:2014 (Section 6.3.4.5).

Note that other options are also in use within Australia, including replacement of coal, replacement of electricity, and replacement of both electricity and thermal energy (via co-generation).

Recycling

Hardwood may be recycled in many different ways. This scenario considers recycling of smaller dimension hardwood that is shredded and effectively downcycled into wood chips. Wood waste is chipped (module C3) and assigned credits relative to the avoided production of woodchips from virgin hardwood (module D). The sequestered CO_2 and the energy content of the wood are assumed to leave the system boundary at C3 so that future product systems can also claim these without double-counting (EN 16485:2014 Section 6.3.4.2).

Reuse

The product is assumed to be removed from a building manually and reused with no further processing (i.e. direct reuse). Transport and wastage are excluded and only one reuse cycle is considered. The second life is assumed to be the same (or very similar) to the first, meaning that a credit is given for production of 1 m^3 of primary sawn hardwood in module D. The sequestered CO_2 and the energy content of the wood are assumed to leave the system boundary at C3 so that future product systems can also claim these without double-counting (EN 16485:2014 Section 6.3.4.2). Any further processing, waste or transport would need to be modelled and included separately, e.g. transporting old, large dimension hardwood beams offsite for sawing to make furniture.

Key Assumptions

Energy: Thermal energy and transport fuels have been modelled as the Australian average (see thinkstep 2017 for documentation). Electricity for production (modules A1-A3) has been modelled as a state-specific split based upon the volume of production in each state for the 2012-13 financial year (the most recent year split by state in ABARES, 2017a): 37% NSW, 33% Vic, 12% Qld, 10% Tas and 8% WA. Electricity at end-of-life (module C) has been modelled using an average Australian electricity mix as the location where the product reaches end-of-life is unknown.

Forestry: All breakdown of forest matter after harvest is modelled as aerobic and therefore carbon neutral as carbon sequestered is released as carbon dioxide. Any burning of forestry material left behind after logging is modelled as being carbon neutral, aside from the trace emissions of various organic gases (Commonwealth of Australia, 2016). All forestry is assumed to be sustainably managed and as such there are no carbon emissions associated with land use change. Loss of carbon from the soil is assumed to be zero (i.e. no significant erosion). It is assumed that all timber will be replanted (plantation forest) or will regrow (native forest) after bushfires.

Cut-off Criteria

Environmental impacts relating to personnel, infrastructure, and production equipment not directly consumed in the process are excluded from the system boundary as per the PCR (IEPDS 2017, Section 7.5.4). All other reported data were incorporated and modelled using the best available life cycle inventory data.

Allocation

Upstream data: For refinery products, allocation is done by mass and net calorific value. Inventories for electricity and thermal energy generation include allocation by economic value for some by-products (e.g. gypsum, boiler ash and fly ash). Allocation by energy is applied for co-generation of heat and power. For materials and chemicals, the allocation rule most suitable for the product is applied (see thinkstep 2017).

Co-products (e.g. sawn wood and sawdust from milling): As the difference in economic value of the co-products is high (>25% as per EN 15804, Section 6.4.3.2), allocation has been done by economic value.

Background Data

Data for all energy inputs, transport processes and raw materials are from GaBi Databases 2017 (thinkstep 2017). Most datasets have a reference year between 2013 and 2015 and all fall within the 10-year limit allowable for generic data under EN 15804 (Section 6.3.7).

EPD Results

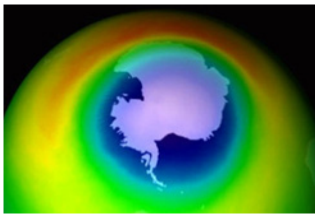
Note: these tables show the impacts associated with production and end-of-life. Any potential credits to future products from recycling or energy recovery are presented in the Other Environmental Information section.

Environmental Impact Indicators

An introduction to each environmental impact indicator is provided below. The best-known effect of each indicator is listed to the right of its name.

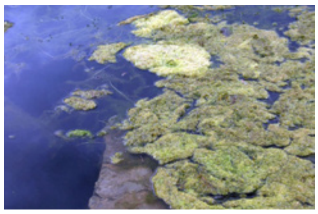
Global Warming Potential (GWP) → Climate Change
A measure of greenhouse gas emissions, such as carbon dioxide and methane. These emissions increase absorption of radiation emitted by the earth, intensifying the natural greenhouse effect. Contributions to GWP can come from either fossil or biogenic sources, e.g. burning fossil fuels or burning wood. GWP is reported as a total as well as being separated into biogenic carbon (GWPB) and fossil carbon (GWPF).

Ozone Depletion Potential (ODP) → Ozone Hole
A measure of air emissions that contribute to the depletion of the stratospheric ozone layer, causing higher levels of ultraviolet B (UVB) to reach the earth's surface with detrimental effects on humans, animals and plants.



Acidification Potential (AP) → Acid Rain
A measure of emissions that cause acidifying effects to the environment. Acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline and the deterioration of building materials.

Eutrophication Potential (EP) → Algal Blooms
A measure of nutrient enrichment that may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. It includes potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P).



Photochemical Ozone Creation Potential (POCP) → Smog
A measure of emissions of precursors that contribute to ground level smog formation (mainly ozone O3), produced by the reaction of VOCs and carbon monoxide in the presence of nitrogen oxides under the influence of UV light. Ground level ozone may be harmful to human and ecosystem health and may also damage crops.

Abiotic Depletion Potential → Resource Consumption
The consumption of non-renewable resources leads to a decrease in the future availability of the functions supplied by these resources. Depletion of mineral resource elements (ADPE) and non-renewable fossil energy resources (ADPF) are reported separately

Table 4: Environmental impacts, 1 m³ of rough-sawn, kiln-dried hardwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
GWP [kg CO_2-eq.]	-888	58.4	460	1,230	1,230	1,220
GWPF [kg CO_2-eq.]	209	58.4	58.6	7.46	7.46	0
GWPB [kg CO_2-eq.]	-1,100	-0.00716	401	1,220	1,220	1,220
ODP [kg CFC11-eq.]	7.42E-11	2.81E-11	2.81E-11	3.21E-13	3.21E-13	0
AP [kg SO_2-eq.]	1.79	0.186	0.212	0.0469	0.0469	0
EP [kg PO_4^{3}-eq.]	0.419	0.0244	0.0310	0.0110	0.0110	0
POCP [kg C_2H_4-eq.]	3.10	0.0114	0.0896	0.00407	0.00407	0
ADPE [kg Sb-eq.]	7.84E-06	1.16E-05	1.16E-05	9.30E-08	9.30E-08	0
ADPF [MJ]	2,500	846	846	97.2	97.2	0

Table 5: Environmental impacts, 1 m³ of dressed, kiln-dried hardwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
GWP [kg CO_2-eq.]	-731	58.4	460	1,230	1,230	1,220
GWPF [kg CO_2-eq.]	327	58.4	58.6	7.46	7.46	0
GWPB [kg CO_2-eq.]	-1,060	-0.00716	401	1,220	1,220	1,220
ODP [kg CFC11-eq.]	8.92E-11	2.81E-11	2.81E-11	3.21E-13	3.21E-13	0
AP [kg SO_2-eq.]	2.54	0.186	0.212	0.0469	0.0469	0
EP [kg PO_4^{3}-eq.]	0.565	0.0244	0.0310	0.0110	0.0110	0
POCP [kg C_2H_4-eq.]	3.88	0.0114	0.0896	0.00407	0.00407	0
ADPE [kg Sb-eq.]	1.14E-05	1.16E-05	1.16E-05	9.30E-08	9.30E-08	0
ADPF [MJ]	3,830	846	846	97.2	97.2	0

Table 6: Environmental impacts, 1 m³ of rough-sawn, green hardwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
GWP [kg CO_2-eq.]	-851	58.5	413	1,120	1,120	1,110
GWPF [kg CO_2-eq.]	151	58.5	58.7	7.79	7.79	0
GWPB [kg CO_2-eq.]	-1,000	-0.00771	354	1,110	1,110	1,110
ODP [kg CFC11-eq.]	6.50E-11	2.81E-11	2.81E-11	3.36E-13	3.36E-13	0
AP [kg SO_2-eq.]	1.45	0.187	0.210	0.0491	0.0491	0
EP [kg PO_4^{3}-eq.]	0.352	0.0246	0.0304	0.0115	0.0115	0
POCP [kg C_2H_4-eq.]	2.68	0.0115	0.0805	0.00426	0.00426	0
ADPE [kg Sb-eq.]	5.99E-06	1.16E-05	1.16E-05	9.71E-08	9.71E-08	0
ADPF [MJ]	1,800	847	847	102	102	0

Resource Use

Table 7: Resource use, 1 m³ of rough-sawn, kiln-dried hardwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
PERE [MJ]	879	53.3	53.3	1.76	1.76	0
PERM [MJ]	12,600	0	0	-12,600	-12,600	-12,600
PERT [MJ]	13,500	53.3	53.3	-12,600	-12,600	-12,600
PENRE [MJ]	2,510	862	862	97.2	97.2	0
PENRM [MJ]	0	0	0	0	0	0
PENRT [MJ]	2,510	862	862	97.2	97.2	0
SM [kg]	0	0	0	0	0	0
RSF [MJ]	0	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0	0
FW [m³]	1.17	0.00587	0.0506	0.00107	0.00107	0

***PERE** = Use of renewable primary energy excluding renewable primary energy resources used as raw materials;*
***PERM** = Use of renewable primary energy resources used as raw materials; **PERT** = Total use of renewable primary energy resources;*
***PENRE** = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials;*
***PENRM** = Use of non-renewable primary energy resources used as raw materials; **PENRT** = Total use of non-renewable primary energy resources; **SM** = Use of secondary material; **RSF** = Use of renewable secondary fuels; **NRSF** = Use of non-renewable secondary fuels;*
***FW** = Net use of fresh water*

Table 8: Resource use, 1 m³ of dressed, kiln-dried hardwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
PERE [MJ]	1,190	53.3	53.3	1.76	1.76	0
PERM [MJ]	12,600	0	0	-12,600	-12,600	-12,600
PERT [MJ]	13,800	53.3	53.3	-12,600	-12,600	-12,600
PENRE [MJ]	3,840	862	862	97.2	97.2	0
PENRM [MJ]	0	0	0	0	0	0
PENRT [MJ]	3,840	862	862	97.2	97.2	0
SM [kg]	0	0	0	0	0	0
RSF [MJ]	0	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0	0
FW [m³]	1.92	0.00587	0.0506	0.00107	0.00107	0

Table 9: Resource use, 1 m³ of rough-sawn, green hardwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
PERE [MJ]	111	53.3	53.3	1.84	1.84	0
PERM [MJ]	11,300	0	0	-11,300	-11,300	-11,300
PERT [MJ]	11,400	53.3	53.3	-11,300	-11,300	-11,300
PENRE [MJ]	1,810	863	863	102	102	0
PENRM [MJ]	0	0	0	0	0	0
PENRT [MJ]	1,810	863	863	102	102	0
SM [kg]	0	0	0	0	0	0
RSF [MJ]	0	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0	0
FW [m3]	0.616	0.00601	0.0454	0.00111	0.00111	0

Waste and Output Flows

Table 10: Waste categories, 1 m³ of rough-sawn, kiln-dried hardwood

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
HWD [kg]	1.02E-06	3.14E-06	3.14E-06	1.61E-07	1.61E-07	0
NHWD [kg]	26.7	738	620	6.70E-04	6.70E-04	0
RWD [kg]	0.00263	0.00609	0.00609	5.84E-06	5.84E-06	0
CRU [kg]	0	0	0	0	0	735
MFR [kg]	0	0	0	0	735	0
MER [kg]	0	0	0	735	0	0
EEE [MJ]	0	0	107	0	0	0
EET [MJ]	0	0	0	0	0	0

***HWD** = Hazardous waste disposed; **NHWD** = Non-hazardous waste disposed; **RWD** = Radioactive waste disposed;*
***CRU** = Components for reuse; **MFR** = Materials for recycling; **MER** = Materials for energy recovery;*
***EEE** = Exported electrical energy; **EET** = Exported thermal energy*

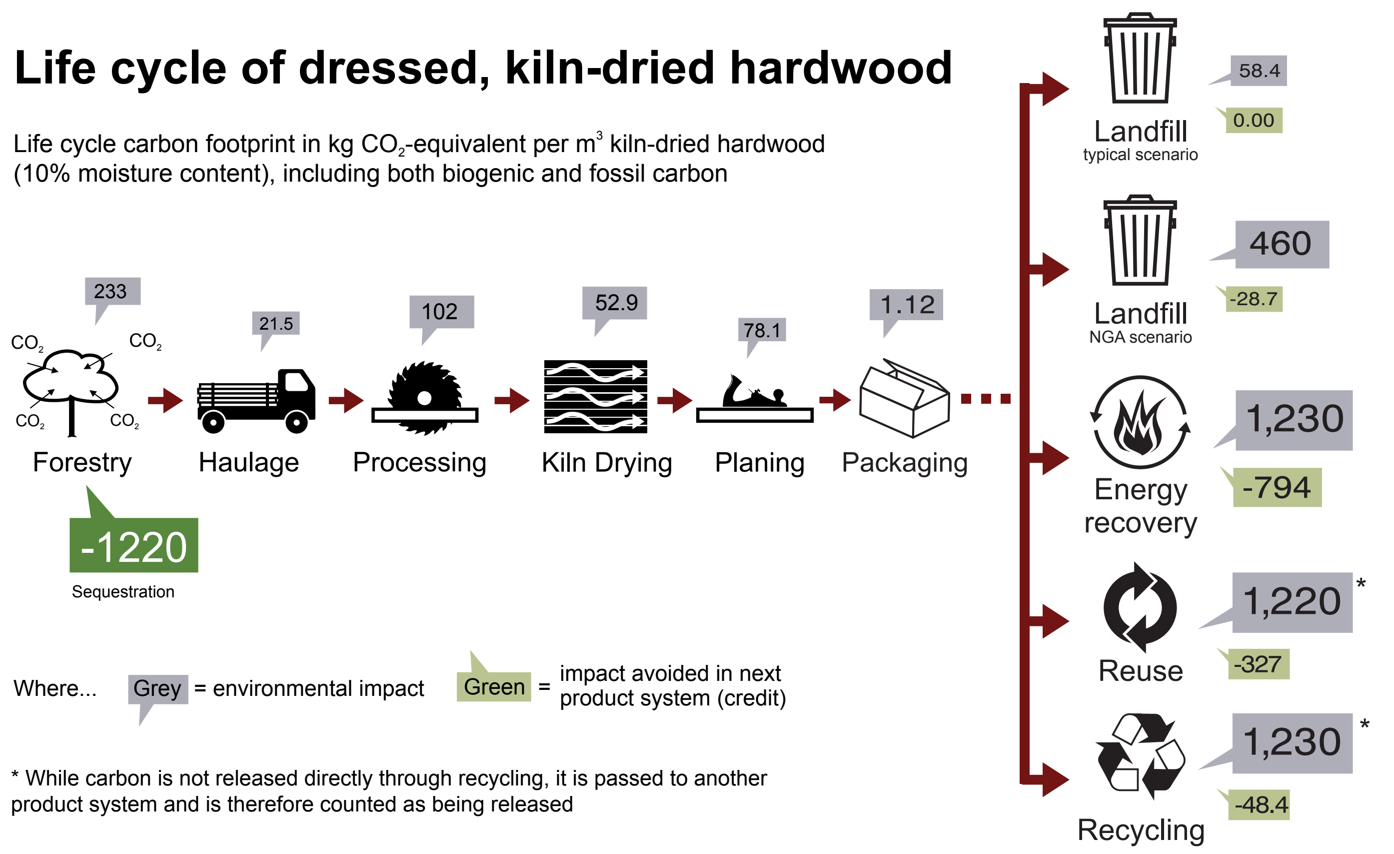
Table 11: Waste categories, 1 m³ of dressed, kiln-dried hardwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
HWD [kg]	1.29E-06	3.14E-06	3.14E-06	1.61E-07	1.61E-07	0
NHWD [kg]	46.4	738	620	6.70E-04	6.70E-04	0
RWD [kg]	0.00320	0.00609	0.00609	5.84E-06	5.84E-06	0
CRU [kg]	0	0	0	0	0	735
MFR [kg]	0	0	0	0	735	0
MER [kg]	0	0	0	735	0	0
EEE [MJ]	0	0	107	0	0	0
EET [MJ]	0	0	0	0	0	0

Table 12: Waste categories, 1 m^3 of rough-sawn, green hardwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
HWD [kg]	9.12E-07	3.21E-06	3.21E-06	1.68E-07	1.68E-07	0
NHWD [kg]	22.0	771	667	7.00E-04	7.00E-04	0
RWD [kg]	0.00222	0.00609	0.00609	6.10E-06	6.10E-06	0
CRU [kg]	0	0	0	0	0	768
MFR [kg]	0	0	0	0	768	0
MER [kg]	0	0	0	768	0	0
EEE [MJ]	0	0	94.7	0	0	0
EET [MJ]	0	0	0	0	0	0

Understanding the Life Cycle of Hardwood Timber



Variation in Results

The variation between sites used to create the average shown in this EPD are given in Table 13 below for the environmental impact indicators in modules A1-A3.

Table 24: Inter-site variability for softwood (modules A1-A3).

	Sawn, kiln-dried hardwood			Dressed, kiln-dried hardwood			Sawn, green hardwood		
Parameter [Unit]	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**
GWP [kg CO_2-eq.]	-32.0%	+33.2%	±18.3%	-32.2%	+42.8%	±23.3%	-33.4%	+17.0%	±17.3%
GWPF [kg CO_2-eq.]	-41.8%	+90.4%	±41.9%	-39.7%	+90.2%	±44.8%	-34.3%	+64.7%	±32.9%
GWPB [kg CO_2-eq.]	-31.2%	+14.5%	±14.8%	-30.9%	+13.1%	±14.7%	-33.8%	+15.6%	±16.0%
ODP [kg CFC11-eq.]	-50.8%	+178.3%	±73.1%	-42.6%	+155.5%	±61.9%	-64.0%	+190.1%	±81.8%
AP [kg SO_2-eq.]	-23.9%	+55.4%	±26.7%	-28.8%	+97.4%	±37.7%	-25.2%	+56.8%	±24.7%
EP [kg PO_4^{3}-eq.]	-24.7%	+54.9%	±26.4%	-28.5%	+79.5%	±29.8%	-26.7%	+48.6%	±25.1%
POCP [kg C_2H_4-eq.]	-18.9%	+49.5%	±19.9%	-19.3%	+79.4%	±28.4%	-20.4%	+49.1%	±19.8%
ADPE [kg Sb-eq.]	-47.0%	+241.9%	±84.1%	-42.9%	+278.2%	±106.3%	-41.8%	+185.6%	±74.4%
ADPF [MJ]	-39.4%	+97.0%	±42.9%	-37.0%	+103.3%	±47.6%	-32.0%	+74.0%	±33.2%

***Min** = (minimum - average) / average; **Max** = (maximum - average) / average;*

***CV** = coefficient of variation = standard deviation / average*

Carbon Dioxide Sequestration

During growth, trees absorb carbon dioxide (CO_2) from the atmosphere through the process of photosynthesis and convert this into carbon-based compounds that constitute various components of a tree, including wood. On average, half the dry weight of all wood is made up of the element carbon (Gifford 2000)

All major Australian production forests and plantations are independently certified to one or both of the internationally recognised forest management certification systems: the Australian Standard for Sustainable Forest Management (AS 4708), which is recognised under the Programme for the Endorsement of Forest Certification (PEFC), and/or one of the Forest Stewardship Council's (FSC®) interim forest management standards. It is therefore appropriate to include biogenic CO_2 sequestration in this EPD in line with EN 16485 (Section 6.3.4.2).

Module D: Recycling, Reuse and Recovery Potentials

Table 14: Module D, 1 m³ of rough-sawn, kiln-dried hardwood.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Environmental Impact					
GWP [kg CO_2-eq.]	0	-28.7	-795	-48.4	-209
GWPF [kg CO_2-eq.]	0	-28.7	-796	-39.9	-209
GWPB [kg CO_2-eq.]	0	-5.86E-04	1.91	-8.52	0
ODP [kg CFC11-eq.]	0	-8.19E-13	-8.04E-12	-3.75E-11	-7.42E-11
AP [kg SO_2-eq.]	0	-0.126	-0.0192	-0.754	-1.79
EP [kg PO_4^{3-}-eq.]	0	-0.0107	-0.0332	-0.148	-0.419
POCP [kg C_2H_4-eq.]	0	-0.00659	0.140	-0.296	-3.10
ADPE [kg Sb-eq.]	0	-2.13E-06	-4.83E-05	-2.02E-05	-7.84E-06
ADPF [MJ]	0	-327	-13,900	-458	-2,500
Resource Use					
PERE [MJ]	0	-36.7	-2.36	-2,630	-879
PERM [MJ]	0	0	0	0	0
PERT [MJ]	0	-36.7	-2.36	-2,630	-879
PENRE [MJ]	0	-327	-13,900	-464	-2,510
PENRM [MJ]	0	0	0	0	0
PENRT [MJ]	0	-327	-13,900	-464	-2,510
SM [kg]	0	0	0	735	735
RSF [MJ]	0	0	12,600	0	0
NRSF [MJ]	0	0	0	0	0
FW [m^3]	0	-0.170	-0.00885	-0.644	-1.17
Wastes and Outputs					
HWD [kg]	0	-4.32E-08	-1.06E-06	-7.88E-06	-1.02E-06
NHWD [kg]	0	-0.0835	35.8	-4.32	-26.7
RWD [kg]	0	-4.03E-05	-3.46E-04	-0.00239	-0.00263
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	0
MER [kg]	0	0	0	0	0
EEE [MJ]	0	0	0	0	0
EET [MJ]	0	0	0	0	0

Table 15: Module D, 1 m³ of dressed, kiln-dried hardwood.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Environmental Impact					
GWP [kg CO_2-eq.]	0	-28.7	-794	-48.4	-327
GWPF [kg CO_2-eq.]	0	-28.7	-796	-39.9	-327
GWPB [kg CO_2-eq.]	0	-5.86E-04	1.91	-8.52	0
ODP [kg CFC11-eq.]	0	-8.19E-13	-8.04E-12	-3.75E-11	-8.92E-11
AP [kg SO_2-eq.]	0	-0.126	-0.0195	-0.753	-2.54
EP [kg PO_4^{3-}-eq.]	0	-0.0107	-0.0332	-0.148	-0.565
POCP [kg C_2H_4-eq.]	0	-0.00659	0.140	-0.296	-3.88
ADPE [kg Sb-eq.]	0	-2.13E-06	-4.83E-05	-2.02E-05	-1.14E-05
ADPF [MJ]	0	-327	-13,900	-457	-3,830
Resource Use					
PERE [MJ]	0	-36.7	-2.36	-2,630	-1,190
PERM [MJ]	0	0	0	0	0
PERT [MJ]	0	-36.7	-2.36	-2,630	-1,190
PENRE [MJ]	0	-327	-13,900	-464	-3,840
PENRM [MJ]	0	0	0	0	0
PENRT [MJ]	0	-327	-13,900	-464	-3,840
SM [kg]	0	0	0	735	735
RSF [MJ]	0	0	12,600	0	0
NRSF [MJ]	0	0	0	0	0
FW [m^3]	0	-0.170	-0.00885	-0.643	-1.92
Wastes and Outputs					
HWD [kg]	0	-4.31E-08	-1.06E-06	-7.87E-06	-1.29E-06
NHWD [kg]	0	-0.0834	35.8	-4.32	-46.4
RWD [kg]	0	-4.03E-05	-3.46E-04	-0.00239	-0.00320
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	0
MER [kg]	0	0	0	0	0
EEE [MJ]	0	0	0	0	0
EET [MJ]	0	0	0	0	0

Table 16: Module D, 1 m³ of rough-sawn, green hardwood.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Environmental Impact					
GWP [kg CO_2-eq.]	0	-25.3	-710	-37.0	-151
GWPF [kg CO_2-eq.]	0	-25.3	-711	-29.0	-151
GWPB [kg CO_2-eq.]	0	-5.17E-04	1.75	-7.99	0
ODP [kg CFC11-eq.]	0	-7.23E-13	-7.18E-12	-2.51E-11	-6.50E-11
AP [kg SO_2-eq.]	0	-0.112	0.00536	-0.523	-1.45
EP [kg PO_4^{3-}-eq.]	0	-0.00942	-0.0247	-0.104	-0.352
POCP [kg C_2H_4-eq.]	0	-0.00582	0.130	-0.245	-2.68
ADPE [kg Sb-eq.]	0	-1.88E-06	-4.31E-05	-1.34E-05	-5.99E-06
ADPF [MJ]	0	-289	-12,500	-334	-1,800
Resource Use					
PERE [MJ]	0	-32.4	-2.09	-1,740	-111
PERM [MJ]	0	0	0	0	0
PERT [MJ]	0	-32.4	-2.09	-1,740	0
PENRE [MJ]	0	-289	-12,500	-339	-1,810
PENRM [MJ]	0	0	0	0	0
PENRT [MJ]	0	-289	-12,500	-339	-1,810
SM [kg]	0	0	0	768	768
RSF [MJ]	0	0	11,300	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0	-0.150	-0.00788	-0.428	-0.555
Wastes and Outputs					
HWD [kg]	0	-3.81E-08	-9.46E-07	-5.20E-06	-9.12E-07
NHWD [kg]	0	-0.0736	32.7	-3.26	-22.0
RWD [kg]	0	-3.56E-05	-3.07E-04	-0.00159	-0.00222
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	0
MER [kg]	0	0	0	0	0
EEE [MJ]	0	0	0	0	0
EET [MJ]	0	0	0	0	0

Durability and Preservative Treatment

As described in the Scope section, the body of the EPD covers untreated sawn hardwood products. These products will deliver a long service life in most building, joinery and furniture applications.

While most sawn hardwood produced in Australia is untreated, some is treated with wood preservative in the mill for protection of susceptible and non-durable sapwood from insect attack and/or fungal decay. Hardwoods with susceptible sapwood to be used in indoor applications such as flooring and joinery are commonly treated to Hazard Class H1. Hardwoods with non-durable sapwood to be used in outdoor applications such as decking, cladding, and landscaping are more commonly treated to Hazard Class H3 or above. The following treatment types were used by the hardwood producers participating in the survey and thus have been modelled:

Treatment	Hazard class
Boron	H1
Alkaline copper quaternary (ACQ)	H3
Copper azole	H3
Copper chrome arsenic (CCA)	H4, H5 & H6

The values shown in Table 17 may be added to the A1-A3 values per m3 of hardwood given in Tables 4 to 12. This allows the associated A1-A3 impacts per m^3 of treated hardwood to be calculated for each treatment type.

Table 17: Environmental data for preservative treatment of hardwood, per m^3 of treated wood.

Parameter [Unit]	Boron [H1]	ACQ [H3]	Copper azole [H3]	CCA [H4]	CCA [H5/H6]
Environmental Impact					
GWP [kg CO_2-eq.]	10.8	27.5	21.5	14.5	24.4
GWPF [kg CO_2-eq.]	10.8	27.4	21.5	14.4	24.0
GWPB [kg CO_2-eq.]	0.00243	0.121	0.0717	0.0973	0.333
ODP [kg CFC11-eq.]	7.11E-12	6.71E-10	1.31E-10	1.58E-10	5.41E-10
AP [kg SO_2-eq.]	0.0504	0.126	0.465	0.107	0.256
EP [kg PO_4^{3-}-eq.]	0.00442	0.0128	0.00824	0.00537	0.00899
POCP [kg C_2H_4-eq.]	0.00268	0.00849	0.0208	0.00528	0.0122
ADPE [kg Sb-eq.]	2.97E-04	0.0395	4.35E-04	6.65E-04	0.00228
ADPF [MJ]	135	357	357	178	297
Resource Use					
PERE [MJ]	13.3	49.3	23.2	32.4	46.1
PERM [MJ]	0	0	0	0	0
PERT [MJ]	13.3	49.3	23.2	32.4	46.1
PENRE [MJ]	135	381	365	648	1,020
PENRM [MJ]	0	0	0	0	0
PENRT [MJ]	135	381	365	648	1,020
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m^3]	0.0683	0.302	0.128	0.178	0.261
Wastes and Outputs					
HWD [kg]	2.28E-08	4.44E-07	7.14E-04	3.87E-07	6.51E-07
NHWD [kg]	0.0477	8.64	0.232	3.16	5.40
RWD [kg]	6.14E-05	0.00964	0.00320	0.00730	0.0125
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	0
MER [kg]	0	0	0	0	0
EEE [MJ]	0	0	0	0	0
EET [MJ]	0	0	0	0	0

Water Consumption

The "FW" indicator in the EPD results tables reports consumption (i.e. net use) of 'blue' water (which includes river water, lake water and ground water). This indicator deliberately excludes consumption of 'green' water (rain water).

PCR 2012:01 (Section 16.1) states that all water loss from a drainage basin is considered consumption, including any net loss of rain water. According to the PCR, net loss should be interpreted as any additional water loss beyond what would occur in the original, natural system. For plantation softwood forestry, the natural system might be a native forest or a grassland (Quinteiro et al. 2015).

The initial version of this EPD (v1.0) included estimated losses of rain water in the main results tables, labelled as green water consumption. These values were based on calculated differences in water flow between plantation forests and a base case land use (pasture) from the original CSIRO LCI study (CSIRO 2009).

Table 18 reports green water consumption calculated by CSIRO using 2005-08 data. These values have not been updated and are now reported here rather than in the main results tables to reflect their uncertainty. At the time of writing, there is no internationally agreed method for calculating green water consumption due to evapotranspiration relative to a hypothetical natural state (Manzardo et al. 2016). As such, different calculation methods may yield significantly different results, introducing a high level of uncertainty.

The reader should also be aware that water consumption does not account for relative water stress in the catchment(s) where the forest is located, meaning that it provides no information about the potential impacts of any water consumption that does occur.

Table 18: Green water consumption estimates for modules A1-A3 from CSIRO (2009).

	Rough-sawn, kiln-dried hardwood	**Dressed, kiln-dried hardwood**	**Rough-sawn, green hardwood**
Parameter [Unit]	A1-A3	A1-A3	A1-A3
Green water consumption in forest [m^3]	927	1,150	840

Timber & Forest Certification

Many Australian timber and reconstituted wood products are certified to a forest certification scheme. This certification is an independent auditing process that provides:

- Assurance that the timber is from well-managed forests certified to internationally and nationally accepted forest management standards
- Assurance that the timber is from legally harvested sources
- Chain of custody (CoC) certification extending from the forest to the end user, which is traceable throughout the supply chain.

Two schemes apply to Australian wood production forests. One is administered by the Australian Forestry Standard Ltd (AFS). The AFS scheme is also endorsed by the international Programme for Endorsement of Forest Certification (PEFC). The other scheme is administered by the Forest Stewardship Council (FSC®) Australia.

If a Green Star project elects to use the timber credit as part of their Green Star submission, the Green Building Council of Australia recognises PEFC-endorsed forest certification schemes (such as the Australian Forest Certification Scheme, AFCS) as well as FSC®. Compliance with the CoC certification rules of either forest certification scheme for at least 95% by value of timber products used in the project will meet the requirements for this credit point (GBCA 2014).

As of 2017, there are more than 26.7 million hectares of native and plantation forests certified under AFS (AFS 2017) and 1.2 million hectares certified under FSC® interim national standards (FSC 2017). In addition, many Australian hardwood manufacturers' premises listed in this EPD are CoC certified and can therefore supply certified products.

Land Use and Biodiversity

Like other land uses, forestry operations for timber and wood production can have both positive and negative effects on biodiversity. However, as biodiversity varies considerably by region and as data are often limited, assessing potential biodiversity impacts within LCA is challenging.

An Australian study completed shortly before initial publication of this EPD (Turner *et al.* 2014) demonstrated a new method – BioImpact – to discern the biodiversity impacts of different land uses. A trial of this method was conducted using case studies in three different regions and four production systems in New South Wales: native hardwood forestry, plantation softwood forestry, mixed cropping and rangeland grazing. Managed forestry resulted in biodiversity impacts equivalent to or better than those of cropping/grazing systems.

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3

Environmental Product Declaration
Particleboard

Environmental Product Declaration (EPD)
in accordance with ISO 14025 and EN 15804

EPD Registration No. S-P-00562 | Version 1.2
Issued 21 October 2015 | Revised 8 December 2017 | Valid until 8 December 2022

Geographical Scope: Australia

Environmental Product Declarations

WoodSolutions has developed a suite of EPDs for industry-average, Australian-produced timber products.

These EPDs help to showcase the environmental credentials of Australian wood products. They also provide life cycle data for calculating the impacts of wood products at a building level.

EPDs include:

#01 Softwood Timber

#02 Hardwood Timber

#03 Particleboard

#04 Medium Density Fibreboard (MDF)

#05 Plywood

#06 Glued Laminated Timber (Glulam)

WoodSolutions is an industry initiative designed to provide independent, non-proprietary information about timber and wood products to professionals and companies involved in building design and construction.

WoodSolutions is resourced by Forest and Wood Products Australia (FWPA). It is a collaborative effort between FWPA members and levy payers, supported by industry peak bodies and technical associations.

This work is supported by funding provided to FWPA by the Commonwealth Government.

978-1-925213-16-4

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Version history

V1.0 - Initial version based on 2005/06 data from CSIRO and produced by thinkstep Pty Ltd and the Timber Development Association (NSW) Ltd.

V1.1 - Revised version incorporating 2015/16 data from a new industry survey, as well as updates to Global Warming Potential (GWP) and fresh water indicators.

V1.2 - Revised version for correction of the validity period, documentation of the forestry carbon modelling assumptions and correction of minor typographical errors.

Produced: December 2020

EPD Details

An Environmental Product Declaration, or EPD, is a standardised and verified way of quantifying the environmental impacts of a product that is based on a consistent set of rules known as a PCR (Product Category Rules).

EPDs within the same product category from different programs may not be comparable. EPDs of construction products may not be comparable if they do not comply with EN 15804.

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CEN standard EN 15804 served as the core PCR

PCR:
PCR 2012:01 Construction products and Construction services, Version 2.2, 2017-05-30

PCR review was conducted by:
The Technical Committee of the International EPD® System.
Chair: Massimo Marino. Contact via info@environdec.com.

Independent verification of the declaration and data, according to ISO 14025:
☐ EPD process certification (Internal)
☑ EPD verification (External)

Third party verifier

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Introduction

This Environmental Product Declaration presents the average performance of particleboard manufactured in Australia from Australian grown wood residues by members of Forest and Wood Products Australia (FWPA). It recognises the importance of transparency by providing information on the raw materials, production and environmental impacts of Australian particleboard.

This EPD has been prepared in accordance with ISO 14025:2006, EN 15804:2013 and PCR 2012:01 (IEPDS 2017). It covers standard and moisture resistant particleboard panels that have a decorative overlay and flooring products produced in accordance with the following standards:

- AS/NZS 1859.1:2004 Reconstituted wood-based panels – Specifications – Particleboard
- AS/NZS 1859.3:2005 Reconstituted wood-based panels – Specifications – Decorative and overlaid wood panels
- AS/NZS 1860.1:2002 Particleboard flooring – Specifications.

The environmental data presented in this document are primarily derived from a survey of industry members covering the 2015/16 financial year conducted by thinkstep and Stephen Mitchell Associates on behalf of FWPA. This updates an earlier survey conducted by CSIRO (2009) based on the 2005/06 financial year, which was used in the first version of this EPD. The current survey covers 54% of total particleboard production in Australia.

Production of this EPD has been facilitated by FWPA with participation of its current particleboard producer members (listed below) and the Engineered Wood Products Association of Australasia (EWPAA):

- Carter Holt Harvey Woodproducts Australia
- D&R Hendersen Pty Ltd
- The Laminex Group

All companies above have contributed financially to this project through levies paid to FWPA. The companies that contributed data cannot be identified due to the small number of Australian producers, as it would then be possible to back-calculate the data of individual FWPA members.

Description of the Australian Particleboard Industry

The Australian particleboard industry is an important contributor to the Australian economy – particularly to the regional economies where mills are based. The overall contribution of the wood products industries to the Australian GDP in 2015-16 was 0.5% [ABARES 2017b]. In 2015-16, Australian particleboard manufacturers produced 955,000 cubic metres of particleboard products (ABARES 2017b) in seven different facilities.

Description of Particleboard Products

Particleboard production uses wood residues as its main input. These include pulp logs, forest thinnings, log harvesting residues, co-products of sawmilling and post-consumer wood.

Particleboard is a composite panel that can be engineered for specific applications. It is widely used to manufacture kitchens, wardrobes, laundries, furniture, wall panels, architectural joinery and flooring in retail fit outs, multi-residential buildings, hotels and housing projects.

Use of EPDs in Sustainable Building and Infrastructure Rating Systems

This document complies with the requirements for an industry-wide EPD under the Green Building Council of Australia's Green Star rating system given that:

1. It conforms with ISO 14025 and EN 15804.
2. It has been verified by an independent third party.
3. It has at least a cradle-to-gate scope.
4. The participants in the EPD are listed (see Table 1).

It may be used by project teams using the *Design & As Built* and *Interiors* rating tools to obtain Green Star points under the following credits:

- Materials > Product Transparency and Sustainability.
- Materials > Life Cycle Assessment: By providing data for an EN 15978 compliant whole-of-building whole-of-life assessment.
- Innovation Challenge > Responsible Carbon Impact: By providing embodied carbon impacts (i.e. data on Global Warming Potential) which can be used in the calculation and reduction of the total embodied carbon impacts of a project.

This EPD is also recognised for credits in the Infrastructure Sustainability (IS) rating scheme of the Infrastructure Sustainability Council of Australia (ISCA).

Scope

Products

This Sector EPD describes the following average products (declared units) manufactured in Australia by the FWPA members listed in the Introduction:

- 1m^2 of particleboard, 16 mm E0 & E1 standard melamine coated
- 1m^2 of particleboard, 18 mm E0 & E1 standard melamine coated
- 1m^2 of particleboard, 16 mm E0 & E1 moisture resistant (MR) melamine coated
- 1m^2 of particleboard, 18 mm E0 & E1 moisture resistant (MR) melamine coated
- 1m^2 of particleboard, 19 mm flooring (tongue & groove)
- 1m^2 of particleboard, 22 mm flooring (tongue & groove)
- 1m^2 of particleboard, 25 mm flooring (tongue & groove)

All wood used in these products is from Australian native and exotic (non-native) softwood species grown in plantations. The dominant softwood species used to produce particleboard in Australia is *Pinus radiata* (radiata pine). Other softwood species used are *Araucaria cunninghami* (hoop pine), *Pinus pinaster* (maritime pine) and the Southern Pines: *Pinus elliottii* (slash pine), *Pinus caribaea* (Caribbean pine) and hybrids thereof.

The properties and material composition of these particleboard products are defined in Table 1 and Table 2 below.

Table 1: Properties of particleboard products included in this EPD.

Properties	Std 16 mm	Std 18 mm	MR 16 mm	MR 18 mm	Flooring 19 mm	Flooring 22 mm	Flooring 25 mm
Area density (kg per m^2)	10.6	11.8	10.6	11.8	13.6	15.9	18.3
Density (kg per m^3)	660	656	660	656	718	723	731
Moisture content (dry basis)	8%	7%	8%	7%	10%	9%	9%
Gross calorific value (MJ/kg)	20.5	20.5	20.7	20.6	20.6	20.7	20.7
Net calorific value (MJ/kg)	17.5	17.7	17.7	17.9	17.3	17.4	17.4
CO_2 sequestered (kg CO_2e)	16.5	18.4	16.4	18.3	19.6	23.1	26.5

Table 2: Composition of particleboard products included in this EPD.

Materials	Std 16 mm	Std 18 mm	MR 16 mm	MR 18 mm	Flooring 19 mm	Flooring 22 mm	Flooring 25 mm
Softwood (dry)	84.1%	84.2%	83.5%	83.4%	77.6%	78.6%	78.6%
Urea formaldehyde	5.9%	7.3%	0.4%	0.2%	0.0%	0.0%	0.0%
Melamine formaldehyde (lamination)	0.8%	0.6%	0.8%	0.6%	0.0%	0.0%	0.0%
Melamine urea formaldehyde	0.0%	0.0%	6.0%	7.6%	10.9%	10.6%	10.7%
Paraffin wax	0.5%	0.4%	0.7%	0.6%	0.8%	0.9%	0.9%
Lamination paper (dry)	1.3%	1.1%	1.3%	1.1%	0.0%	0.0%	0.0%
Tongue (polypropylene)	0.0%	0.0%	0.0%	0.0%	0.5%	0.5%	0.5%
Ammonium sulphate	0.1%	0.2%	0.2%	0.2%	0.3%	0.0%	0.3%
Tannin	0.0%	0.0%	0.0%	0.0%	0.9%	0.8%	0.7%
Preservative	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Dyes	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Water	7.3%	6.2%	7.2%	6.3%	8.9%	8.6%	8.4%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

The declared units above represent an entire product category rather than a specific product from a specific manufacturer. The values represent an average weighted by production volume. As such, a specific product purchased on the market may have a lesser or greater environmental impact than the average presented in this EPD. Some products may also undergo further processing (e.g. sawing) before being used in a building.

Representativeness

Market coverage: The data in this EPD are from detailed surveys of three of the seven particleboard plants in Australia. These three plants collectively produced 514,000 m3 of particleboard in 2015/16, equating to 54% of total Australian production of approximately 955,000 m3 (based on the 2015/16 total from ABARES 2017a). Coverage of total production by FWPA members is also 54% as all Australian particleboard producers are members.

Temporal representativeness: Primary data were collected from participating sites for the 2015/16 Australian financial year (1st July 2015 to 30th June 2016). Following EN 15804, site-specific data are valid for 5 years (to 30th June 2021), meaning that these datasets are valid until the end of this EPD's validity period.

Geographical and technological representativeness: The data are representative of particleboard produced in Australia as the sites surveyed collectively produce more than half of all Australian-produced particleboard. The averages presented in this EPD are weighted by production volumes. More detailed information can be found in the "Variation in Results" section later in this EPD.

Industry Classifications

Product	Classification	Code	Category
All	UN CPC Ver.2	31430	Particle board and similar board of wood or other ligneous materials
All	ANZSIC 2006	1494	Reconstituted Wood Product Manufacturing

LCA Calculation Rules

System Boundary

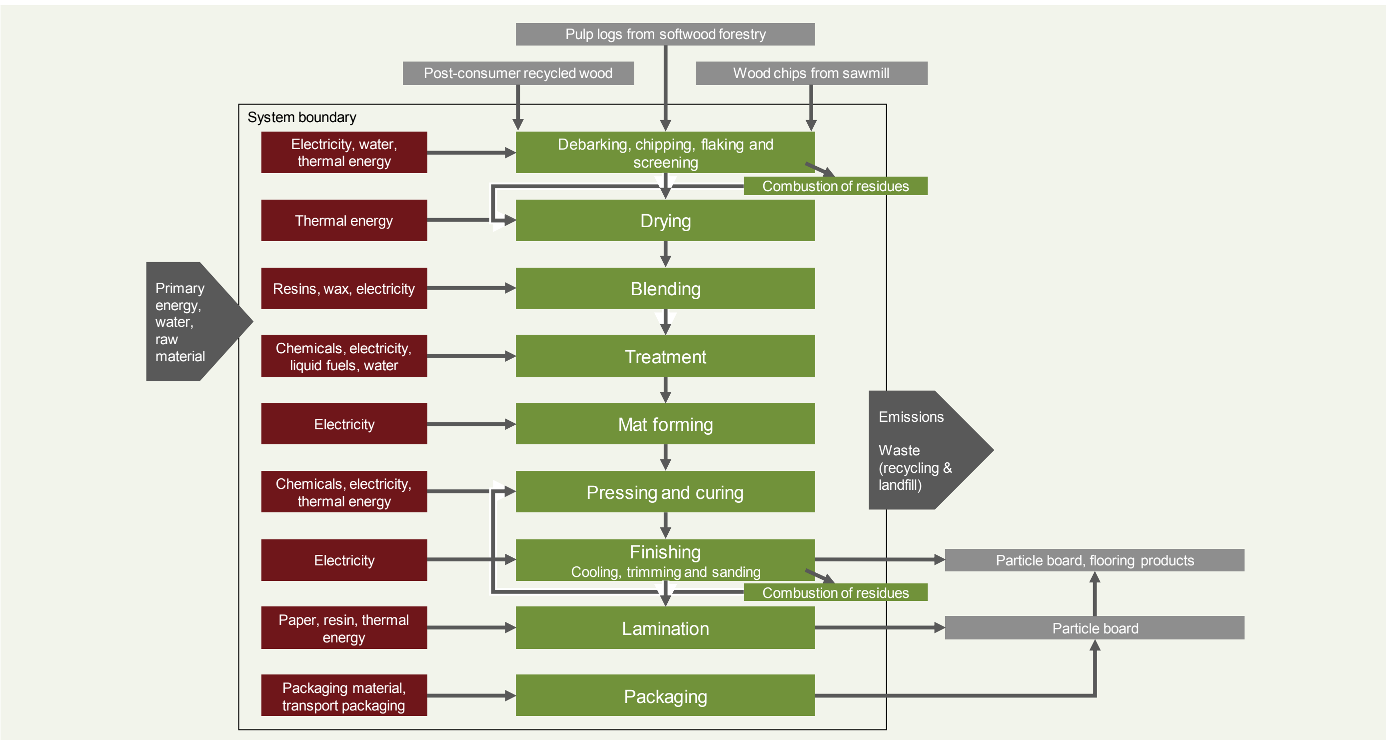
This EPD is of the 'cradle-to-gate' type with options. The options include the end-of-life stage, which is modelled through the use of scenarios.

Product stage			**Con-struction process stage**		**Use stage**							**End-of-life stage**				**Benefits and loads beyond the system boundary**
Raw material supply	Transport of raw materials	Manufacturing	Transport to customer	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport to waste processing	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	X	X	X

Key: X = included in the EPD
MND = module module not declared (such a declaration shall not be regarded as an indicator result of zero)

Production

The production stage includes growth and harvesting of wood inputs, production of resin and wax, blending of wood particles with resin and wax, pressing of the mixture to create the particleboard substrate, cutting, sanding and – if applied – adding a melamine-impregnated paper layer to the top and bottom surfaces.



End-of-Life

When a wood product reaches the end of its useful life, it may either be reused, recycled, landfilled or combusted to produce energy. Landfill is currently the most common end-of-life route for wood products in Australia. With the exception of reuse, which is not common for particleboard, all other scenarios are in use in certain regions (Forsythe Consultants 2007; National Timber Product Stewardship Group) and have been included within this EPD.

Each scenario assumes that 100% of the wood is sent to that scenario. To create an end-of-life mix for a given region or end use, the reader should take a weighted sum of these scenarios. Where no data are available, the 'landfill (typical)' scenario should be used for 100% of the waste.

Landfill

This EPD includes two scenarios for landfill, each with a different value for the degradable organic carbon fraction (DOCf) of wood. The two values are based on bioreactor laboratory research. This experimental work involves the testing of a range of waste types in reactors operated to obtain maximum methane yields. As the laboratory work optimises the conditions for anaerobic decay, the results can be considered as estimates of the DOCf value that would apply over very long time horizons (Australian Government 2014a, p.17).

- **Landfill (typical):** DOC_f = 1.6%. This is based on bioreactor laboratory research by Ximenes *et al*. (2013).
- **Landfill (NGA)**: DOC_f = 10%. This is the value chosen for Australia's National Greenhouse Accounts (NGA) (Australian Government 2017). This is a reduction from the previous value of 23% (Australian Government 2014b) that was derived from early bioreactor laboratory research from the 1990s (e.g. Barlaz 1998) that investigated the degradability of wood tree branches ground to a fine powder under anaerobic conditions (Australian Government 2014a, p.17). This DOCf value can be considered extremely conservative when compared to values from later research (as used in the typical scenario above) and effectively assumes that at least part of the wood waste is ground into a powder to accelerate degradation.

The impacts associated with the landfill are declared in module C4. All landfill gas that is combusted for energy recovery (module C4) is assumed to occur in a power plant with an electrical conversion efficiency of 36% (Australian Government 2014c, p.189) and the resulting electricity receives a credit for offsetting average electricity from the Australian grid (module D) in line with EN 16485:2014 (Section 6.3.4.5).

Both landfill scenarios assume the following for carbon emissions:

- Of the gases formed from any degradation of wood in landfill, 50% is methane and 50% is carbon dioxide (Australian Government 2016, Table 43).
- All carbon dioxide is released directly to the atmosphere.
- 36% of the methane is captured, based on forecasted average methane capture in Australian landfills by 2020 (Hyder Consulting 2007). The year 2020 was chosen as landfill will take place in the future and this was the last year for which forecasts were available.
- Of this 36% captured, one-quarter (9% of the total) is flared and three-quarters (27% of the total) are used for energy recovery (Carre 2011).
- Of the 64% of methane that is not captured, 10% (6.4% of the total) is oxidised (Australian Government 2016, Table 43) and 90% (57.6%) is released to the atmosphere.
- In summary, for every kilogram of carbon converted to landfill gas, 71.2% is released as carbon dioxide and 28.8% is released as methane.

Energy recovery

This scenario includes shredding (module C3) and combustion with recovered energy offset against average thermal energy from natural gas (module D) in line with EN 16485:2014 (Section 6.3.4.5). Note that other options are also in use within Australia, including replacement of coal, replacement of electricity, and replacement of both electricity and thermal energy (via co-generation). The modelling assumes that the product waste has value after it has been sorted.

Recycling

Particleboard may be recycled in many different ways – including into new particleboard. This scenario considers shredding into wood chips. Wood waste is chipped (module C3) and assigned credits relative to the avoided production of woodchips from virgin softwood (module D). The sequestered CO2 and the energy content of the wood are assumed to leave the system boundary at C3 so that future product systems can also claim these without double-counting (EN 16485: 2014, Section 6.3.4.2).

Key Assumptions

Energy: Thermal energy and transport fuels have been modelled as the Australian average (see thinkstep 2017 for documentation). Electricity for production (modules A1-A3) has been modelled as a state-specific split based upon the electricity consumption of the manufacturers who contributed data to this study. Electricity at end-of-life (module C) has been modelled using an average Australian electricity mix as the location where the product reaches end-of-life is unknown.

Forestry: All breakdown of forest matter after harvest is modelled as aerobic and therefore carbon neutral as carbon sequestered is released as carbon dioxide. Any burning of forestry material left behind after logging is modelled as being carbon neutral, aside from the trace emissions of various organic gases (Commonwealth of Australia, 2016). All forestry is assumed to be sustainably managed and as such there are no carbon emissions associated with land use change. Loss of carbon from the soil is assumed to be zero (i.e. no significant erosion). It is assumed that all timber will be replanted (plantation forest) or will regrow (native forest) after bushfires.

Cut-off Criteria

Environmental impacts relating to personnel, infrastructure, and production equipment not directly consumed in the process are excluded from the system boundary as per the PCR (IEPDS 2017, Section 7.5.4). All other reported data were incorporated and modelled using the best available life cycle inventory data.

Allocation

Upstream data: For refinery products, allocation is done by mass and net calorific value. Inventories for electricity and thermal energy generation include allocation by economic value for some by-products (e.g. gypsum, boiler ash and fly ash). Allocation by energy is applied for co-generation of heat and power. For materials and chemicals, the allocation rule most suitable for the product is applied (see thinkstep 2017).

Co-products (i.e. different particleboard products): Wood particles and energy are allocated per cubic metre of board produced. Decorative overlays are allocated by square metre applied. The polypropylene tongue in flooring is allocated based on square metres of board. Resins and waxes are allocated based on the dry mass required in average recipes supplied by manufacturers.

Post-consumer waste: Post-consumer particleboard waste is used by some sites to manufacture new particleboard. In these cases, the end of waste state is deemed to occur at deposit of this waste at a waste treatment facility, meaning that the incoming particleboard waste is considered burden-free. Only the impact of transport from the waste treatment facility to the production plant is included within module A1-A3.

Background Data

Data for primary wood inputs (pulplog and wood chips from sawmills) use the same forestry and sawmilling data as FWPA EPD #01 for Softwood Timber, but with different economic allocation factors.

Data for all energy inputs, transport processes and raw materials are from GaBi Databases 2017 (thinkstep 2017). Most datasets have a reference year between 2013 and 2015 and all fall within the 10-year limit allowable for generic data under EN 15804 (Section 6.3.7).

EPD Results

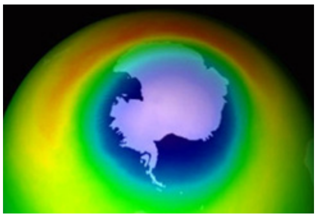
Note: these tables show the impacts associated with production and end-of-life. Any potential credits to future products from recycling or energy recovery are presented in the Other Environmental Information section.

Environmental Impact Indicators

An introduction to each environmental impact indicator is provided below.
The best-known effect of each indicator is listed to the right of its name.

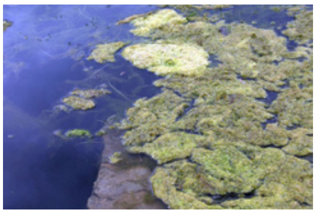
Global Warming Potential (GWP) → Climate Change
A measure of greenhouse gas emissions, such as carbon dioxide and methane. These emissions increase absorption of radiation emitted by the earth, intensifying the natural greenhouse effect. Contributions to GWP can come from either fossil or biogenic sources, e.g. burning fossil fuels or burning wood. GWP is reported as a total as well as being separated into biogenic carbon (GWPB) and fossil carbon (GWPF).

Ozone Depletion Potential (ODP) → Ozone Hole
A measure of air emissions that contribute to the depletion of the stratospheric ozone layer, causing higher levels of ultraviolet B (UVB) to reach the earth's surface with detrimental effects on humans, animals and plants.



Acidification Potential (AP) → Acid Rain
A measure of emissions that cause acidifying effects to the environment. Acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline and the deterioration of building materials.

Eutrophication Potential (EP) → Algal Blooms
A measure of nutrient enrichment that may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. It includes potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P).



Photochemical Ozone Creation Potential (POCP) → Smog
A measure of emissions of precursors that contribute to ground level smog formation (mainly ozone O3), produced by the reaction of VOCs and carbon monoxide in the presence of nitrogen oxides under the influence of UV light. Ground level ozone may be harmful to human and ecosystem health and may also damage crops.

Abiotic Depletion Potential (ADP) → Resource Consumption
The consumption of non-renewable resources leads to a decrease in the future availability of the functions supplied by these resources. Depletion of mineral resource elements (ADPE) and non-renewable fossil energy resources (ADPF) are reported separately.

Table 3: Environmental impacts, 1 m² of particleboard, 16 mm E0 & E1 standard melamine coated.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-10.2	1.86	6.74	17.7	17.7
GWPF [kg CO_2-eq.]	6.23	0.942	0.999	1.14	1.14
GWPB [kg CO_2-eq.]	-16.4	0.918	5.74	16.5	16.5
ODP [kg CFC11-eq.]	2.01E-11	4.48E-13	4.48E-13	4.62E-15	4.62E-15
AP [kg SO_2-eq.]	0.0262	0.00300	0.00332	6.74E-04	6.74E-04
EP [kg PO_4^{3}-eq.]	0.00502	0.00156	0.00772	1.58E-04	1.58E-04
POCP [kg C_2H_4-eq.]	0.00938	3.60E-04	0.00131	5.85E-05	5.85E-05
ADPE [kg Sb-eq.]	1.12E-06	1.86E-07	1.86E-07	1.34E-09	1.34E-09
ADPF [MJ]	87.8	13.5	13.5	1.40	1.40

Table 4: Environmental impacts, 1 m² of particleboard, 18 mm E0 & E1 standard melamine coated

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-11.1	2.09	7.58	19.9	19.9
GWPF [kg CO_2-eq.]	7.26	1.06	1.13	1.44	1.44
GWPB [kg CO_2-eq.]	-18.3	1.03	6.45	18.4	18.4
ODP [kg CFC11-eq.]	2.81E-11	5.04E-13	5.04E-13	5.16E-15	5.16E-15
AP [kg SO_2-eq.]	0.0299	0.00338	0.00374	7.53E-04	7.53E-04
EP [kg PO_4^{3}--eq.]	0.00643	0.00200	0.0102	1.76E-04	1.76E-04
POCP [kg C_2H_4-eq.]	0.0116	4.05E-04	0.00147	6.54E-05	6.54E-05
ADPE [kg Sb-eq.]	1.48E-06	2.09E-07	2.09E-07	1.49E-09	1.49E-09
ADPF [MJ]	106	15.2	15.2	1.56	1.56

Table 5: Environmental impacts, 1 m² of particleboard, 16 mm E0 & E1 moisture resistant (MR) melamine coated.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-8.53	1.86	6.77	17.7	17.7
GWPF [kg CO_2-eq.]	7.78	0.944	1.01	1.35	1.35
GWPB [kg CO_2-eq.]	-16.3	0.921	5.76	16.4	16.4
ODP [kg CFC11-eq.]	3.30E-11	4.48E-13	4.48E-13	4.62E-15	4.62E-15
AP [kg SO_2-eq.]	0.0268	0.00300	0.00332	6.74E-04	6.74E-04
EP [kg PO_4^{3}--eq.]	0.00610	0.00174	0.00890	1.58E-04	1.58E-04
POCP [kg C_2H_4-eq.]	0.00837	3.61E-04	0.00132	5.85E-05	5.85E-05
ADPE [kg Sb-eq.]	2.56E-06	1.86E-07	1.86E-07	1.34E-09	1.34E-09
ADPF [MJ]	111	13.5	13.5	1.40	1.40

Table 6: Environmental impacts, 1 m² of particleboard, 18 mm E0 & E1 moisture resistant (MR) melamine coated.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-8.76	2.10	7.61	19.9	19.9
GWPF [kg CO_2-eq.]	9.40	1.06	1.15	1.68	1.68
GWPB [kg CO_2-eq.]	-18.2	1.03	6.46	18.3	18.3
ODP [kg CFC11-eq.]	4.61E-11	5.04E-13	5.04E-13	5.16E-15	5.16E-15
AP [kg SO_2-eq.]	0.0302	0.00338	0.00374	7.54E-04	7.54E-04
EP [kg PO_4^{3-}-eq.]	0.00776	0.00224	0.0118	1.76E-04	1.76E-04
POCP [kg C_2H_4-eq.]	0.00976	4.05E-04	0.00148	6.54E-05	6.54E-05
ADPE [kg Sb-eq.]	3.55E-06	2.09E-07	2.09E-07	1.49E-09	1.49E-09
ADPF [MJ]	137	15.2	15.2	1.56	1.56

Table 7: Environmental impacts, 1 m² of particleboard, 19 mm flooring.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-7.23	2.28	8.46	22.3	22.3
GWPF [kg CO_2-eq.]	12.1	1.14	1.28	2.74	2.74
GWPB [kg CO_2-eq.]	-19.3	1.15	7.18	19.6	19.6
ODP [kg CFC11-eq.]	1.30E-10	5.33E-13	5.33E-13	5.97E-15	5.97E-15
AP [kg SO_2-eq.]	0.0377	0.00360	0.00400	8.71E-04	8.71E-04
EP [kg PO_4^{3-}-eq.]	0.0109	0.00315	0.0172	2.04E-04	2.04E-04
POCP [kg C_2H_4-eq.]	0.00980	4.44E-04	0.00165	7.56E-05	7.56E-05
ADPE [kg Sb-eq.]	9.99E-06	2.21E-07	2.21E-07	1.73E-09	1.73E-09
ADPF [MJ]	182	16.1	16.1	1.80	1.80

Table 8: Environmental impacts, 1 m² of particleboard, 22 mm flooring.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-9.18	2.67	9.92	26.3	26.3
GWPF [kg CO_2-eq.]	13.7	1.32	1.48	3.13	3.13
GWPB [kg CO_2-eq.]	-22.9	1.35	8.45	23.1	23.1
ODP [kg CFC11-eq.]	1.36E-10	6.18E-13	6.18E-13	6.96E-15	6.96E-15
AP [kg SO_2-eq.]	0.0428	0.00417	0.00465	0.00102	0.00102
EP [kg PO_4^{3-}-eq.]	0.0122	0.00352	0.0192	2.38E-04	2.38E-04
POCP [kg C_2H_4-eq.]	0.0115	5.19E-04	0.00193	8.82E-05	8.82E-05
ADPE [kg Sb-eq.]	1.12E-05	2.55E-07	2.55E-07	2.01E-09	2.01E-09
ADPF [MJ]	205	18.6	18.6	2.10	2.10

Table 9: Environmental impacts, 1 m² of particleboard, 25 mm flooring.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-10.5	3.05	11.4	30.1	30.1
GWPF [kg CO_2-eq.]	15.7	1.50	1.68	3.61	3.61
GWPB [kg CO_2-eq.]	-26.2	1.55	9.69	26.5	26.5
ODP [kg CFC11-eq.]	1.53E-10	7.02E-13	7.02E-13	7.99E-15	7.99E-15
AP [kg SO_2-eq.]	0.0488	0.00475	0.00529	0.00117	0.00117
EP [kg PO_4^{3-}-eq.]	0.0139	0.00411	0.0225	2.73E-04	2.73E-04
POCP [kg C_2H_4-eq.]	0.0131	5.93E-04	0.00221	1.01E-04	1.01E-04
ADPE [kg Sb-eq.]	1.27E-05	2.90E-07	2.90E-07	2.31E-09	2.31E-09
ADPF [MJ]	236	21.1	21.1	2.42	2.42

Resource Use

Table 10: Resource use, 1 m² of particleboard, 16 mm E0 & E1 standard melamine coated.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	53.6	0.850	0.850	0.0253	0.0253
PERM [MJ]	173	0	0	-173	-173
PERT [MJ]	227	0.850	0.850	-173	-173
PENRE [MJ]	88.9	13.7	13.7	1.40	1.40
PENRM [MJ]	14.2	0	0	-14.2	-14.2
PENRT [MJ]	103	13.7	13.7	-12.8	-12.8
SM [kg]	0.543	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.0371	1.92E-04	7.36E-04	1.53E-05	1.53E-05

***PERE** = Use of renewable primary energy excluding renewable primary energy resources used as raw materials;*
***PERM** = Use of renewable primary energy resources used as raw materials;*
***PERT** = Total use of renewable primary energy resources;*
***PENRE** = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials;*
***PENRM** = Use of non-renewable primary energy resources used as raw materials;*
***PENRT** = Total use of non-renewable primary energy resources;*
***SM** = Use of secondary material; **RSF** = Use of renewable secondary fuels;*
***NRSF** = Use of non-renewable secondary fuels;*
***FW** = Net use of fresh water*

Table 11: Resource use, 1 m² of particleboard, 18 mm E0 & E1 standard melamine coated.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	49.9	0.956	0.956	0.0283	0.0283
PERM [MJ]	193	0	0	-193	-193
PERT [MJ]	243	0.956	0.956	-193	-193
PENRE [MJ]	108	15.4	15.4	1.56	1.56
PENRM [MJ]	18.2	0	0	-18.2	-18.2
PENRT [MJ]	126	15.4	15.4	-16.6	-16.6
SM [kg]	0.104	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.0339	2.16E-04	8.27E-04	1.71E-05	1.71E-05

Table 12: Resource use, 1 m² of particleboard, 16 mm E0 & E1 moisture resistant (MR) melamine coated.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	54.0	0.850	0.850	0.0253	0.0253
PERM [MJ]	172	0	0	-172	-172
PERT [MJ]	226	0.850	0.850	-172	-172
PENRE [MJ]	113	13.7	13.7	1.40	1.40
PENRM [MJ]	17.0	0	0	-17.0	-17.0
PENRT [MJ]	130	13.7	13.7	-15.6	-15.6
SM [kg]	0.447	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.0502	1.93E-04	7.39E-04	1.53E-05	1.53E-05

Table 13: Resource use, 1 m² of particleboard, 18 mm E0 & E1 moisture resistant (MR) melamine coated.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	52.3	0.956	0.956	0.0283	0.0283
PERM [MJ]	191	0	0	-191	-191
PERT [MJ]	244	0.956	0.956	-191	-191
PENRE [MJ]	139	15.4	15.4	1.56	1.56
PENRM [MJ]	21.4	0	0	-21.4	-21.4
PENRT [MJ]	161	15.4	15.4	-19.9	-19.9
SM [kg]	0.131	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m^3]	0.0551	2.17E-04	8.30E-04	1.71E-05	1.71E-05

Table 14: Resource use, 1 m² of particleboard, 19 mm flooring.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	62.1	1.01	1.01	0.0327	0.0327
PERM [MJ]	203	0	0	-203	-203
PERT [MJ]	265	1.01	1.01	-203	-203
PENRE [MJ]	188	16.4	16.4	1.80	1.80
PENRM [MJ]	35.3	0	0	-35.3	-35.3
PENRT [MJ]	223	16.4	16.4	-33.5	-33.5
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m^3]	0.281	2.41E-04	9.28E-04	1.98E-05	1.98E-05

Table 15: Resource use, 1 m² of particleboard, 22 mm flooring.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	69.1	1.17	1.17	0.0382	0.0382
PERM [MJ]	240	0	0	-240	-240
PERT [MJ]	309	1.17	1.17	-240	-240
PENRE [MJ]	210	18.9	18.9	2.11	2.11
PENRM [MJ]	40.2	0	0	-40.2	-40.2
PENRT [MJ]	250	18.9	18.9	-38.1	-38.1
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.286	2.82E-04	0.00109	2.31E-05	2.31E-05

Table 16: Resource use, 1 m² of particleboard, 25 mm flooring.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	78.1	1.33	1.33	0.0438	0.0438
PERM [MJ]	276	0	0	-276	-276
PERT [MJ]	354	1.33	1.33	-276	-276
PENRE [MJ]	241	21.5	21.5	2.42	2.42
PENRM [MJ]	46.5	0	0	-46.5	-46.5
PENRT [MJ]	288	21.5	21.5	-44.0	-44.0
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.316	3.23E-04	0.00125	2.65E-05	2.65E-05

Waste and Output Flows

Table 17: Waste categories, 1 m² of particleboard, 16 mm E0 & E1 standard melamine coated.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	8.82E-08	4.74E-08	4.74E-08	2.32E-09	2.32E-09
NHWD [kg]	0.174	10.3	8.86	9.62E-06	9.62E-06
RWD [kg]	4.42E-04	9.73E-05	9.73E-05	8.39E-08	8.39E-08
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	10.6
MER [kg]	0	0	0	10.6	0
EEE [MJ]	0	0.248	1.55	0	0
EET [MJ]	0	0	0	0	0

***HWD** = Hazardous waste disposed; **NHWD** = Non-hazardous waste disposed; **RWD** = Radioactive waste disposed;*
***CRU** = Components for reuse; **MFR** = Materials for recycling; **MER** = Materials for energy recovery;*
***EEE** = Exported electrical energy; **EET** = Exported thermal energy*

Table 18: Waste categories, 1 m² of particleboard, 18 mm E0 & E1 standard melamine coated.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	9.45E-08	5.31E-08	5.31E-08	2.59E-09	2.59E-09
NHWD [kg]	0.224	11.5	9.89	1.08E-05	1.08E-05
RWD [kg]	5.96E-04	1.09E-04	1.09E-04	9.38E-08	9.38E-08
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	11.8
MER [kg]	0	0	0	11.8	0
EEE [MJ]	0	0.279	1.75	0	0
EET [MJ]	0	0	0	0	0

Table 19: Waste categories, 1 m² of particleboard, 16mm E0 & E1 moisture resistant (MR) melamine coated.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	8.88E-08	4.74E-08	4.74E-08	2.32E-09	2.32E-09
NHWD [kg]	0.224	10.3	8.85	9.62E-06	9.62E-06
RWD [kg]	7.04E-04	9.73E-05	9.73E-05	8.39E-08	8.39E-08
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	10.6
MER [kg]	0	0	0	10.6	0
EEE [MJ]	0	0.250	1.56	0	0
EET [MJ]	0	0	0	0	0

Table 20: Waste categories, 1 m² of particleboard, 18 mm E0 & E1 moisture resistant (MR) melamine coated.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	9.41E-08	5.32E-08	5.32E-08	2.59E-09	2.59E-09
NHWD [kg]	0.286	11.5	9.88	1.08E-05	1.08E-05
RWD [kg]	9.62E-04	1.09E-04	1.09E-04	9.38E-08	9.38E-08
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	11.8
MER [kg]	0	0	0	11.8	0
EEE [MJ]	0	0.280	1.75	0	0
EET [MJ]	0	0	0	0	0

Table 21: Waste categories, 1 m² of particleboard, 19 mm flooring.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	5.37E-08	5.88E-08	5.88E-08	2.99E-09	2.99E-09
NHWD [kg]	0.312	13.3	11.5	1.24E-05	1.24E-05
RWD [kg]	0.00167	1.16E-04	1.16E-04	1.08E-07	1.08E-07
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	13.6
MER [kg]	0	0	0	13.6	0
EEE [MJ]	0	0.314	1.96	0	0
EET [MJ]	0	0	0	0	0

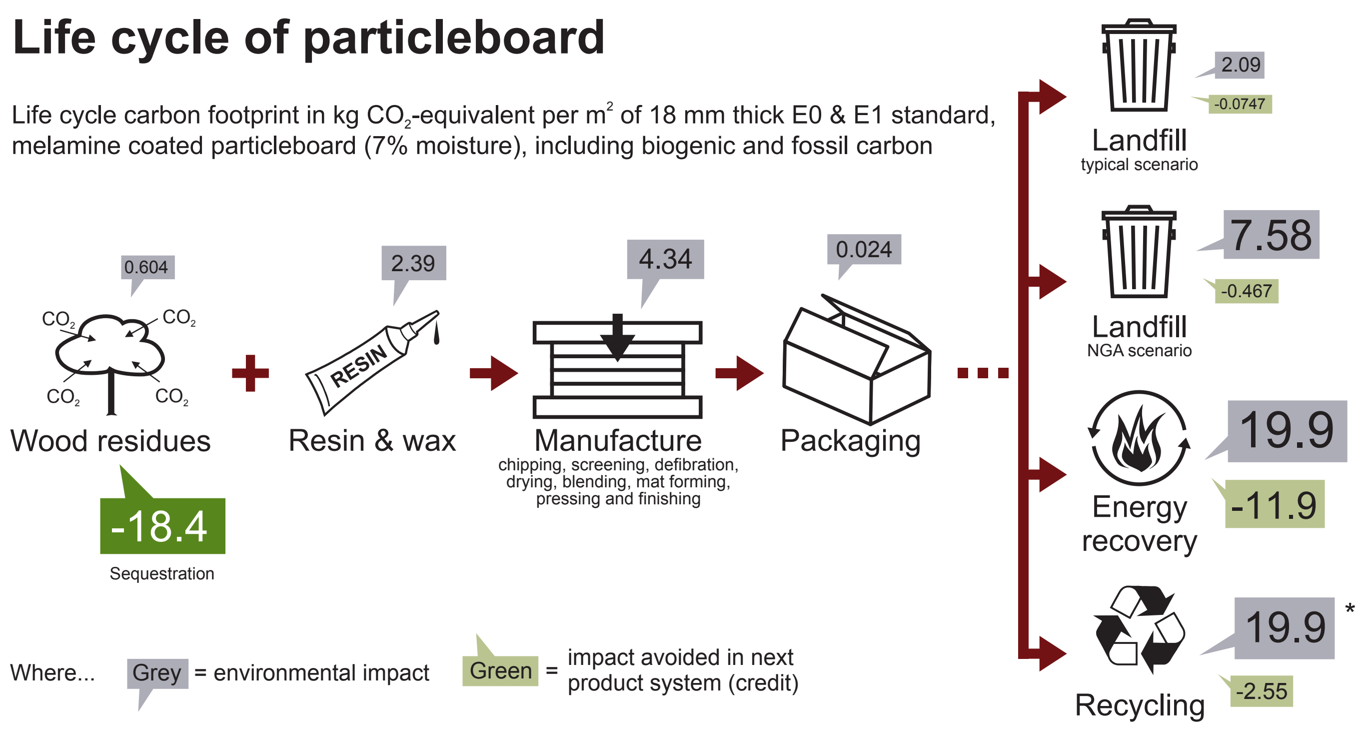
Table 22: Waste categories, 1 m² of particleboard, 22 mm flooring.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	5.77E-08	6.84E-08	6.84E-08	3.49E-09	3.49E-09
NHWD [kg]	0.363	15.6	13.4	1.45E-05	1.45E-05
RWD [kg]	0.00183	1.34E-04	1.34E-04	1.26E-07	1.26E-07
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	15.9
MER [kg]	0	0	0	15.9	0
EEE [MJ]	0	0.369	2.31	0	0
EET [MJ]	0	0	0	0	0

Table 23: Waste categories, 1 m² of particleboard, 25 mm flooring.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	6.51E-08	7.82E-08	7.82E-08	4.01E-09	4.01E-09
NHWD [kg]	0.417	17.9	15.3	1.66E-05	1.66E-05
RWD [kg]	0.00208	1.52E-04	1.52E-04	1.45E-07	1.45E-07
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	18.3
MER [kg]	0	0	0	18.3	0
EEE [MJ]	0	0.424	2.65	0	0
EET [MJ]	0	0	0	0	0

Understanding the Life Cycle of Particleboard



* While carbon is not released directly through recycling, it is passed to another product system and is therefore counted as being released

Variation in Results

The variation between sites used to create the average shown in this EPD are given in Table 24 below for the environmental impact indicators in modules A1-A3.

Table 24: Inter-site variability for standard particleboard (modules A1-A3).

	Standard 16 mm			Standard 18 mm		
Parameter [Unit]	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**
GWP [kg CO_2-eq.]	-6.5%	+2.4%	±2.0%	-4.1%	+1.4%	±1.4%
GWPF [kg CO_2-eq.]	-10.7%	+3.2%	±3.8%	-5.9%	+4.4%	±0.8%
GWPB [kg CO_2-eq.]	-0.3%	+0.0%	±0.2%	-0.1%	+0.9%	±0.5%
ODP [kg CFC11-eq.]	-4.9%	+22.0%	±13.5%	-4.5%	+0.6%	±2.5%
AP [kg SO_2-eq.]	-24.2%	+7.2%	±8.5%	-17.5%	+7.7%	±4.9%
EP [kg PO_4^{3-}-eq.]	-8.3%	+9.8%	±9.1%	-8.8%	+2.3%	±3.2%
POCP [kg C_2H_4-eq.]	-3.4%	+8.0%	±5.7%	-6.1%	+1.1%	±2.5%
ADPE [kg Sb-eq.]	-17.6%	+18.5%	±0.5%	-0.7%	+12.7%	±6.0%
ADPF [MJ]	-7.3%	+5.5%	±6.4%	-2.0%	+1.1%	±0.5%

***Min** = (minimum - average) / average; **Max** = (maximum - average) / average;*
***CV** = coefficient of variation = standard deviation / average*

Table 25: Inter-site variability for moisture resistant particleboard (modules A1-A3).

	Moisture resistant 16 mm			Moisture resistant 18 mm		
Parameter [Unit]	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**
GWP [kg CO_2-eq.]	-12.5%	+8.0%	±10.2%	-12.4%	+3.4%	±4.5%
GWPF [kg CO_2-eq.]	-12.9%	+7.1%	±10.0%	-12.6%	+2.9%	±4.8%
GWPB [kg CO_2-eq.]	-0.4%	+0.8%	±0.6%	-0.1%	+0.5%	±0.3%
ODP [kg CFC11-eq.]	-13.3%	+32.9%	±23.1%	-15.8%	+3.6%	±9.7%
AP [kg SO_2-eq.]	-24.7%	+5.2%	±9.7%	-21.3%	+7.2%	±7.0%
EP [kg PO_4^{3-}-eq.]	-12.0%	+15.7%	±13.8%	-14.7%	+0.0%	±7.4%
POCP [kg C_2H_4-eq.]	-3.7%	+3.1%	±3.4%	-4.5%	+1.5%	±1.5%
ADPE [kg Sb-eq.]	-2.9%	+32.2%	±17.6%	-11.3%	+4.3%	±7.8%
ADPF [MJ]	-10.9%	+14.8%	±12.9%	-11.0%	+1.1%	±6.1%

Table 26: Inter-site variability for particleboard flooring (modules A1-A3).

	Flooring 19 mm			Flooring 22 mm			Flooring 25 mm		
Parameter [Unit]	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**
GWP [kg CO_2-eq.]	-20.4%	+8.9%	±5.8%	-20.8%	+4.5%	±8.1%	-10.6%	+7.1%	±1.7%
GWPF [kg CO_2-eq.]	-9.6%	+5.7%	±2.0%	-13.3%	+3.5%	±4.9%	-9.6%	+4.2%	±2.7%
GWPB [kg CO_2-eq.]	-1.7%	+0.2%	±0.9%	-0.4%	+0.3%	±0.3%	-0.4%	+1.5%	±0.9%
ODP [kg CFC11-eq.]	-53.5%	+5.2%	±29.4%	-53.6%	+15.9%	±34.8%	-49.1%	+17.3%	±33.2%
AP [kg SO_2-eq.]	-19.1%	+13.6%	±2.7%	-17.4%	+15.6%	±0.9%	-17.6%	+13.2%	±2.2%
EP [kg PO_4^{3-}-eq.]	-14.0%	+1.9%	±6.1%	-16.8%	+1.3%	±9.1%	-12.9%	+0.8%	±6.8%
POCP [kg C_2H_4-eq.]	-6.7%	+82.6%	±37.9%	-3.9%	+80.9%	±38.5%	-4.5%	+79.8%	±37.7%
ADPE [kg Sb-eq.]	-12.5%	+4.2%	±8.3%	-15.7%	+7.7%	±11.7%	-14.0%	+8.0%	±11.0%
ADPF [MJ]	-6.2%	+2.9%	±1.7%	-10.3%	+0.6%	±4.8%	-6.4%	+1.4%	±2.5%

Carbon Dioxide Sequestration

During growth, trees absorb carbon dioxide (CO_2) from the atmosphere through the process of photosynthesis and convert this into carbon-based compounds that constitute various components of a tree, including wood. On average, half the dry weight of all wood is made up of the element carbon (Gifford 2000).

All major Australian production forests and plantations are independently certified to one or both of the internationally recognised forest management certification systems: the Australian Standard for Sustainable Forest Management (AS 4708), which is recognised under the Programme for the Endorsement of Forest Certification (PEFC), and/or one of the Forest Stewardship Council's (FSC®) interim forest management standards. It is therefore appropriate to include biogenic CO_2 sequestration in this EPD in line with EN 16485 (Section 6.3.4.2).

Module D: Recycling, Reuse and Recovery Potentials

Table 27: Module D, 1 m^2 of particleboard, 16 mm E0 & E1 standard melamine coated.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0664	-0.415	-10.7	-2.27
GWPF [kg CO_2-eq.]	-0.0664	-0.415	-10.7	-2.17
GWPB [kg CO_2-eq.]	-1.36E-06	-8.48E-06	0.0265	-0.1000
ODP [kg CFC11-eq.]	-1.90E-15	-1.19E-14	2.08E-13	-1.89E-13
AP [kg SO_2-eq.]	-2.93E-04	-0.00183	0.00362	-0.0167
EP [kg PO_4^{3-}-eq.]	-2.47E-05	-1.54E-04	5.97E-04	-0.00386
POCP [kg C_2H_4-eq.]	-1.53E-05	-9.54E-05	0.00208	-0.00686
ADPE [kg Sb-eq.]	-4.94E-09	-3.09E-08	-6.91E-07	-4.12E-07
ADPF [MJ]	-0.757	-4.73	-205	-27.7
Resource Use				
PERE [MJ]	-0.0850	-0.532	0.0696	-40.1
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.0850	-0.532	0.0696	-40.1
PENRE [MJ]	-0.757	-4.73	-205	-27.8
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.757	-4.73	-205	-27.8
SM [kg]	0	0	0	10.6
RSF [MJ]	0	0	173	0
NRSF [MJ]	0	0	14.2	0
FW [m^3]	-3.93E-04	-0.00245	0.00310	-0.00853
Wastes and Outputs				
HWD [kg]	-9.99E-11	-6.24E-10	-1.55E-08	-8.14E-09
NHWD [kg]	-1.93E-04	-0.00121	0.487	-0.285
RWD [kg]	-9.33E-08	-5.83E-07	2.61E-05	-1.00E-05
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 28: Module D, 1 m² of particleboard, 18 mm E0 & E1 standard melamine coated.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0747	-0.467	-11.9	-2.55
GWPF [kg CO_2-eq.]	-0.0747	-0.467	-11.9	-2.44
GWPB [kg CO_2-eq.]	-1.53E-06	-9.54E-06	0.0296	-0.113
ODP [kg CFC11-eq.]	-2.13E-15	-1.33E-14	3.08E-13	-2.12E-13
AP [kg SO_2-eq.]	-3.29E-04	-0.00206	0.00531	-0.0188
EP [kg PO_4^{3-}-eq.]	-2.78E-05	-1.74E-04	0.00101	-0.00434
POCP [kg C_2H_4-eq.]	-1.72E-05	-1.07E-04	0.00239	-0.00771
ADPE [kg Sb-eq.]	-5.55E-09	-3.47E-08	-7.74E-07	-4.63E-07
ADPF [MJ]	-0.852	-5.32	-231	-31.2
Resource Use				
PERE [MJ]	-0.0957	-0.598	0.105	-45.1
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.0957	-0.598	0.105	-45.1
PENRE [MJ]	-0.852	-5.32	-231	-31.2
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.852	-5.32	-231	-31.2
SM [kg]	0	0	0	11.8
RSF [MJ]	0	0	193	0
NRSF [MJ]	0	0	18.2	0
FW [m^3]	-4.42E-04	-0.00276	0.00415	-0.00959
Wastes and Outputs				
HWD [kg]	-1.12E-10	-7.02E-10	-1.74E-08	-9.16E-09
NHWD [kg]	-2.17E-04	-0.00136	0.543	-0.321
RWD [kg]	-1.05E-07	-6.56E-07	3.69E-05	-1.13E-05
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 29: Module D, 1 m² of particleboard, 16 mm E0 & E1 moisture resistant (MR) melamine coated.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0667	-0.417	-10.6	-2.27
GWPF [kg CO_2-eq.]	-0.0667	-0.417	-10.7	-2.17
GWPB [kg CO_2-eq.]	-1.36E-06	-8.52E-06	0.0264	-0.1000
ODP [kg CFC11-eq.]	-1.91E-15	-1.19E-14	2.38E-13	-1.89E-13
AP [kg SO_2-eq.]	-2.94E-04	-0.00184	0.00442	-0.0167
EP [kg PO_4^{3-}-eq.]	-2.48E-05	-1.55E-04	8.13E-04	-0.00386
POCP [kg C_2H_4-eq.]	-1.53E-05	-9.59E-05	0.00211	-0.00686
ADPE [kg Sb-eq.]	-4.96E-09	-3.10E-08	-6.94E-07	-4.12E-07
ADPF [MJ]	-0.761	-4.76	-207	-27.7
Resource Use				
PERE [MJ]	-0.0855	-0.534	0.0847	-40.1
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.0855	-0.534	0.0847	-40.1
PENRE [MJ]	-0.761	-4.76	-207	-27.8
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.761	-4.76	-207	-27.8
SM [kg]	0	0	0	10.6
RSF [MJ]	0	0	172	0
NRSF [MJ]	0	0	17.0	0
FW [m^3]	-3.95E-04	-0.00247	0.00343	-0.00853
Wastes and Outputs				
HWD [kg]	-1.00E-10	-6.27E-10	-1.55E-08	-8.14E-09
NHWD [kg]	-1.94E-04	-0.00121	0.484	-0.285
RWD [kg]	-9.38E-08	-5.86E-07	3.00E-05	-1.00E-05
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 30: Module D, 1 m² of particleboard, 18 mm E0 & E1 moisture resistant (MR) melamine coated.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0750	-0.469	-11.8	-2.55
GWPF [kg CO_2-eq.]	-0.0750	-0.469	-11.8	-2.44
GWPB [kg CO_2-eq.]	-1.53E-06	-9.58E-06	0.0295	-0.113
ODP [kg CFC11-eq.]	-2.14E-15	-1.34E-14	3.45E-13	-2.12E-13
AP [kg SO_2-eq.]	-3.31E-04	-0.00207	0.00634	-0.0188
EP [kg PO_4^{3-}-eq.]	-2.79E-05	-1.74E-04	0.00129	-0.00434
POCP [kg C_2H_4-eq.]	-1.72E-05	-1.08E-04	0.00242	-0.00771
ADPE [kg Sb-eq.]	-5.58E-09	-3.48E-08	-7.75E-07	-4.63E-07
ADPF [MJ]	-0.855	-5.34	-232	-31.2
Resource Use				
PERE [MJ]	-0.0961	-0.600	0.124	-45.1
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.0961	-0.600	0.124	-45.1
PENRE [MJ]	-0.855	-5.35	-232	-31.2
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.855	-5.35	-232	-31.2
SM [kg]	0	0	0	11.8
RSF [MJ]	0	0	191	0
NRSF [MJ]	0	0	21.4	0
FW [m^3]	-4.44E-04	-0.00277	0.00457	-0.00959
Wastes and Outputs				
HWD [kg]	-1.13E-10	-7.05E-10	-1.74E-08	-9.16E-09
NHWD [kg]	-2.18E-04	-0.00136	0.539	-0.321
RWD [kg]	-1.05E-07	-6.59E-07	4.18E-05	-1.13E-05
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 31: Module D, 1 m² of particleboard, 19 mm flooring.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0840	-0.525	-12.7	-2.69
GWPF [kg CO_2-eq.]	-0.0840	-0.525	-12.7	-2.57
GWPB [kg CO_2-eq.]	-1.72E-06	-1.07E-05	0.0323	-0.119
ODP [kg CFC11-eq.]	-2.40E-15	-1.50E-14	5.92E-13	-2.24E-13
AP [kg SO_2-eq.]	-3.70E-04	-0.00231	0.0111	-0.0198
EP [kg PO_4^{3-}-eq.]	-3.13E-05	-1.95E-04	0.00252	-0.00458
POCP [kg C_2H_4-eq.]	-1.93E-05	-1.21E-04	0.00285	-0.00814
ADPE [kg Sb-eq.]	-6.24E-09	-3.90E-08	-8.51E-07	-4.89E-07
ADPF [MJ]	-0.958	-5.98	-259	-32.9
Resource Use				
PERE [MJ]	-0.108	-0.672	0.219	-47.6
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.108	-0.672	0.219	-47.6
PENRE [MJ]	-0.958	-5.99	-259	-33.0
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.958	-5.99	-259	-33.0
SM [kg]	0	0	0	13.6
RSF [MJ]	0	0	203	0
NRSF [MJ]	0	0	35.3	0
FW [m³]	-4.97E-04	-0.00310	0.00690	-0.0101
Wastes and Outputs				
HWD [kg]	-1.26E-10	-7.90E-10	-1.93E-08	-9.67E-09
NHWD [kg]	-2.44E-04	-0.00153	0.583	-0.339
RWD [kg]	-1.18E-07	-7.38E-07	6.92E-05	-1.19E-05
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 32: Module D, 1 m² of particleboard, 22 mm flooring.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0988	-0.617	-15.1	-3.12
GWPF [kg CO_2-eq.]	-0.0988	-0.617	-15.1	-2.98
GWPB [kg CO_2-eq.]	-2.02E-06	-1.26E-05	0.0380	-0.138
ODP [kg CFC11-eq.]	-2.82E-15	-1.76E-14	6.58E-13	-2.59E-13
AP [kg SO_2-eq.]	-4.35E-04	-0.00272	0.0123	-0.0229
EP [kg PO_4^{3-}-eq.]	-3.68E-05	-2.30E-04	0.00277	-0.00530
POCP [kg C_2H_4-eq.]	-2.27E-05	-1.42E-04	0.00331	-0.00943
ADPE [kg Sb-eq.]	-7.34E-09	-4.59E-08	-1.00E-06	-5.66E-07
ADPF [MJ]	-1.13	-7.04	-305	-38.1
Resource Use				
PERE [MJ]	-0.126	-0.790	0.244	-55.1
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.126	-0.790	0.244	-55.1
PENRE [MJ]	-1.13	-7.04	-305	-38.2
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-1.13	-7.04	-305	-38.2
SM [kg]	0	0	0	15.9
RSF [MJ]	0	0	240	0
NRSF [MJ]	0	0	40.2	0
FW [m^3]	-5.84E-04	-0.00365	0.00775	-0.0117
Wastes and Outputs				
HWD [kg]	-1.49E-10	-9.28E-10	-2.27E-08	-1.12E-08
NHWD [kg]	-2.87E-04	-0.00180	0.686	-0.392
RWD [kg]	-1.39E-07	-8.67E-07	7.74E-05	-1.38E-05
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 33: Module D, 1 m² of particleboard, 25 mm flooring.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.113	-0.708	-17.3	-3.54
GWPF [kg CO_2-eq.]	-0.113	-0.708	-17.3	-3.38
GWPB [kg CO_2-eq.]	-2.31E-06	-1.45E-05	0.0436	-0.156
ODP [kg CFC11-eq.]	-3.24E-15	-2.02E-14	7.67E-13	-2.95E-13
AP [kg SO_2-eq.]	-4.99E-04	-0.00312	0.0144	-0.0261
EP [kg PO_4^{3-}-eq.]	-4.22E-05	-2.64E-04	0.00325	-0.00603
POCP [kg C_2H_4-eq.]	-2.60E-05	-1.63E-04	0.00381	-0.0107
ADPE [kg Sb-eq.]	-8.42E-09	-5.26E-08	-1.15E-06	-6.44E-07
ADPF [MJ]	-1.29	-8.07	-350	-43.3
Resource Use				
PERE [MJ]	-0.145	-0.907	0.284	-62.6
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.145	-0.907	0.284	-62.6
PENRE [MJ]	-1.29	-8.08	-350	-43.4
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-1.29	-8.08	-350	-43.4
SM [kg]	0	0	0	18.3
RSF [MJ]	0	0	276	0
NRSF [MJ]	0	0	46.5	0
FW [m³]	-6.70E-04	-0.00419	0.00900	-0.0133
Wastes and Outputs				
HWD [kg]	-1.70E-10	-1.07E-09	-2.60E-08	-1.27E-08
NHWD [kg]	-3.30E-04	-0.00206	0.789	-0.445
RWD [kg]	-1.59E-07	-9.95E-07	9.01E-05	-1.57E-05
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Water Consumption

The "FW" indicator in the EPD results tables reports consumption (i.e. net use) of 'blue water' (which includes river water, lake water and ground water). This indicator deliberately excludes consumption of 'green' water (rain water).

PCR 2012:01 (Section 16.1) states that all water loss from a drainage basin is considered consumption, including any net loss of rain water. According to the PCR, net loss should be interpreted as any additional water loss beyond what would occur in the original, natural system. For plantation softwood forestry, the natural system might be a native forest or a grassland (Quinteiro et al. 2015).

The initial version of this EPD (v1.0) included estimated losses of rain water in the main results tables, labelled as green water consumption. These values were based on calculated differences in water flow between plantation forests and a base case land use (pasture) from the original CSIRO LCI study (CSIRO 2009).

Table 34 reports green water consumption calculated by CSIRO using 2005-08 data. These values have not been updated and are now reported here rather than in the main results tables to reflect their uncertainty. At the time of writing, there is no internationally agreed method for calculating green water consumption due to evapotranspiration relative to a hypothetical natural state (Manzardo et al. 2016). As such, different calculation methods may yield significantly different results, introducing a high level of uncertainty.

The reader should also be aware that water consumption does not account for relative water stress in the catchment(s) where the forest is located, meaning that it provides no information about the potential impacts of any water consumption that does occur.

Table 34: Green water consumption estimates for modules A1-A3 from CSIRO (2009).

	Std 16 mm	Std 18 mm	MR 16 mm	MR 18 mm	Floor 19 mm	Floor 222 mm	Floor 25 mm
Parameter [Unit]	A1-A3	A1-A3	A1-A3	A1-A3	A1-A3	A1-A3	A1-A3
Green water consumption in forest [m^3]	1.30	1.82	1.39	1.79	1.14	1.47	1.71

Timber & Forest Certification

Many Australian timber and reconstituted wood products are certified to a forest certification scheme. This certification is an independent auditing process that provides:

- Assurance that the timber is from well-managed forests certified to internationally and nationally accepted forest management standards
- Assurance that the timber is from legally harvested sources
- Chain of custody (CoC) certification extending from the forest to the end user, which is traceable throughout the supply chain.

Two schemes apply to Australian wood production forests. One is administered by the Australian Forestry Standard Ltd (AFS). The AFS scheme is also endorsed by the international Programme for Endorsement of Forest Certification (PEFC). The other scheme is administered by

Forest Stewardship Council (FSC®) Australia.

If a Green Star project elects to use the timber credit as part of their Green Star submission, the Green Building Council of Australia recognises PEFC-endorsed forest certification schemes (such as the Australian Forest Certification Scheme, AFCS) as well as FSC®. Compliance with the chain of custody certification rules of either forest certification scheme for at least 95% by value of timber products used in the project will meet the requirements for this credit point (GBCA 2014).

As of 2017, there are more than 26.7 million hectares of native and plantation forests certified under AFS (AFS 2017) and 1.2 million hectares certified under FSC® interim national standards (FSC 2017).

All Australian particleboard manufacturers are chain of custody certified and can therefore supply certified products.

Land Use and Biodiversity

Like other land uses, forestry operations for timber and wood production can have both positive and negative effects on biodiversity. However, as biodiversity varies considerably by region and as data are often limited, assessing potential biodiversity impacts within LCA is challenging.

An Australian study completed shortly before initial publication of this EPD (Turner et al. 2014) demonstrated a new method – BioImpact – to discern the biodiversity impacts of different land uses. A trial of this method was conducted using case studies in three different regions and four production systems in New South Wales: native hardwood forestry, plantation softwood forestry, mixed cropping and rangeland grazing. Managed forestry resulted in biodiversity impacts equivalent to or better than those of cropping/grazing systems.

Indoor Environment Quality – Formaldehyde Emissions Minimisation

Formaldehyde is a colourless, strong-smelling gas that occurs naturally in the environment. It is present in the air that we breathe at natural background levels of about 0.03 parts per million (ppm) with recent studies showing formaldehyde concentrations often up to 0.08 ppm in outdoor urban air (EWPAA 2012). Formaldehyde is used as an ingredient in synthetic resins, industrial chemicals and preservatives, and in the production of paper, textiles, cosmetics, disinfectants, medicines, paints, varnishes and lubricants.

Particleboard manufactured in Australia uses one of two modern low formaldehyde emitting amino plastics: urea formaldehyde (UF) or melamine urea formaldehyde (MUF).

To assure end users that their particleboard has the lowest possible formaldehyde emissions, a formaldehyde testing and labelling program is run by the Engineered Wood Products Association of Australasia. Participating mills are required to forward samples to EWPAA's National Laboratory on a regular basis for formaldehyde emission testing. On the basis of laboratory tests and audits of the manufacturing process, participating Australian particleboard mills are permitted to brand a formaldehyde emission class on their particleboard products as detailed in Table 31 below.

Table 31: Formaldehyde emission classes for Australian manufactured particleboard

Emission Class	Emission Limit (mg/litre)	Emission Limit (ppm)*
E0	Less than or equal to 0.5	Less than or equal to 0.04
E1	Less than or equal to 1.0	Less than or equal to 0.08

** Based on a test chamber volume of 10litre, zero airflow during the 24hr test cycle, molecular weight of formaldehyde 30.03 and the number of microlitres of formaldehyde gas in 1 micromole at 101KPa and 298K.*

All Australian manufacturers listed in this EPD can supply test certificates that support their emissions class. Please contact your manufacturer individually for further definite information.

Particleboard with formaldehyde emissions of less than or equal to E1 are compliant with the Green Star Formaldehyde credit. To achieve credit points all engineered wood products such as particleboard, MDF and plywood used in the construction project must be in accordance with these requirements.

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4

Environmental Product Declaration
Medium Density Fibreboard (MDF)

Environmental Product Declaration (EPD)
in accordance with ISO 14025 and EN 15804

EPD Registration No. S-P-00563 | Version 1.2
Issued 21 October 2015 | Revised 8 December 2017 | Valid until 8 December 2022

Geographical Scope: Australia

Environmental Product Declarations

WoodSolutions has developed a suite of EPDs for industry-average, Australian-produced timber products.

These EPDs help to showcase the environmental credentials of Australian wood products. They also provide life cycle data for calculating the impacts of wood products at a building level.

EPDs include:

#01 Softwood Timber

#02 Hardwood Timber

#03 Particleboard

#04 Medium Density Fibreboard (MDF)

#05 Plywood

#06 Glued Laminated Timber (Glulam)

Wood Solutions™
design and build
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WoodSolutions is an industry initiative designed to provide independent, non-proprietary information about timber and wood products to professionals and companies involved in building design and construction.

WoodSolutions is resourced by Forest and Wood Products Australia (FWPA). It is a collaborative effort between FWPA members and levy payers, supported by industry peak bodies and technical associations.

This work is supported by funding provided to FWPA by the Commonwealth Government.

978-1-925213-17-1

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Version history

V1.0 Initial version based on 2005/06 data from CSIRO and produced by thinkstep Pty Ltd and the Timber Development Association (NSW) Ltd.

V1.1 Revised version incorporating 2015/16 data from a new industry survey, as well as updates to Global Warming Potential (GWP) and fresh water indicators.

V1.2 - Revised version for correction of the validity period, documentation of the forestry carbon modelling assumptions and correction of minor typographical errors.

Produced: December 2020

EPD Details

An Environmental Product Declaration, or EPD, is a standardised and verified way of quantifying the environmental impacts of a product that is based on a consistent set of rules known as a PCR (Product Category Rules).

EPDs within the same product category from different programs may not be comparable. EPDs of construction products may not be comparable if they do not comply with EN 15804.

Declaration owner:

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CEN standard EN 15804 served as the core PCR

PCR:
PCR 2012:01 Construction products and Construction services, Version 2.2, 2017-05-30

PCR review was conducted by:
The Technical Committee of the International EPD® System.
Chair: Massimo Marino. Contact via info@environdec.com.

Independent verification of the declaration and data, according to ISO 14025:
☐ EPD process certification (Internal)
☑ EPD verification (External)

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Introduction

This Environmental Product Declaration presents the average performance of medium density fibreboard (MDF) manufactured in Australia from Australian grown wood residues by members of Forest and Wood Products Australia (FWPA). It recognises the importance of transparency by providing information on the raw materials, production and environmental impacts of Australian MDF.

This EPD has been prepared in accordance with ISO 14025:2006, EN 15804:2013 and PCR 2012:01 (IEPDS 2017). It covers standard and moisture resistant MDF panels that have a decorative overlay produced in accordance with the following standards:

- AS/NZS 1859.2:2004 Reconstituted wood-based panels – Specifications – Dry-processed fibreboard
- AS/NZS 1859.3:2005 Reconstituted wood-based panels – Specifications – Decorative overlaid wood panels

The environmental data presented in this document are primarily derived from a survey of industry members covering the 2015/16 financial year conducted by thinkstep and Stephen Mitchell Associates on behalf of FWPA. This updates an earlier survey conducted by CSIRO (2009) based on the 2005/06 financial year, which was used in the first version of this EPD. The current survey covers 100% of total MDF production in Australia.

The production of this EPD has been facilitated by FWPA with participation of its current MDF producer members (listed below) and the Engineered Wood Products Association of Australasia (EWPAA).

The following companies contributed to this EPD financially and by contributing data:

Company	Financial contributor	Data contributor
Alpine MDF Industries Pty Ltd	X	X
Borg Panels	X	X
The Laminex Group	X	X

Description of the Australian MDF Industry

The Australian MDF industry is an important contributor to the Australian economy – particularly to the regional economies where mills are based. The overall contribution of the wood products industries to the Australian GDP in 2015-16 was 0.5% [ABARES 2017]. In 2015-2016 Australian MDF manufacturers produced 615,708 cubic metres of MDF products in three different facilities.

Description of MDF Products

MDF is a composite panel valued for its homogeneity that allows precision joinery work and finishing. These properties have led to MDF being widely used to manufacture furniture, kitchen cabinets, doors and mouldings. MDF panels are composed of wood residues (from softwood plantation management thinnings, timber harvesting and softwood manufacturing), resin and wax.

Use of EPDs in Building and Infrastructure Rating Systems

This document complies with the requirements for an industry-wide EPD under the Green Building Council of Australia's Green Star rating system given that:

1. It conforms with ISO 14025 and EN 15804.
2. It has been verified by an independent third party.
3. It has at least a cradle-to-gate scope.
4. The participants in the EPD are listed (see Introduction).

It may be used by project teams using the Design & As Built and Interiors rating tools to obtain Green Star points under the following credits:

- Materials > Product Transparency and Sustainability.
- Materials > Life Cycle Assessment: By providing data for an EN 15978 compliant whole-of-building whole-of-life assessment.
- Innovation Challenge > Responsible Carbon Impact: By providing embodied carbon impacts (i.e. data on Global Warming Potential) which can be used in the calculation and reduction of the total embodied carbon impacts of a project.

This EPD is also recognised for credits in the Infrastructure Sustainability (IS) rating scheme of the Infrastructure Sustainability Council of Australia (ISCA).

Scope

Products

This Sector EPD describes the following average products (declared units) manufactured in Australia by the FWPA members listed in the Introduction:

- 1 m^2 of MDF, 16 mm E0 & E1 standard melamine coated
- 1 m^2 of MDF, 18 mm E0 & E1 standard melamine coated
- 1 m^2 of MDF, 25 mm E0 & E1 standard melamine coated
- 1 m^2 of MDF, 16 mm E0 & E1 moisture resistant (MR) melamine coated
- 1 m^2 of MDF, 18 mm E0 & E1 moisture resistant (MR) melamine coated
- 1 m^2 of MDF, 25 mm E0 & E1 moisture resistant (MR) melamine coated

Wood used in these products is from Australian native and exotic (non-native) softwood species grown in plantations. The dominant softwood species used to produce particleboard in Australia is *Pinus radiata* (radiata pine). Other softwood species used are *Araucaria cunninghami* (hoop pine), *Pinus pinaster* (maritime pine) and the Southern Pines: *Pinus elliottii* (slash pine), *Pinus caribaea* (Caribbean pine) and hybrids thereof.

The properties and material composition of these particleboard products are defined in Table 1 and Table 2 below.

Table 1: Properties of MDF products included in this EPD

Properties	Std 16mm	Std 18 mm	Std 25 mm	MR 16 mm	MR 18 mm	MR 25 mm
Area density (kg per m^2)	11.6	13.0	17.5	11.7	13.0	17.6
Density (kg per m^3)	724	722	701	732	721	705
Moisture content (dry basis)	7%	7%	7%	7%	7%	7%
Gross calorific value (MJ/kg)	20.6	20.5	20.6	20.7	20.7	20.6
Net calorific value (MJ/kg)	17.7	17.7	17.8	17.8	17.8	17.8
CO_2 sequestered (kg CO_2e)	17.5	19.8	26.1	17.5	19.4	26.1

Table 2: Composition of MDF products included in this EPD

Materials	Std 16mm	Std 18 mm	Std 25 mm	MR 16 mm	MR 18 mm	MR 25 mm
Softwood (dry)	81.8%	82.4%	80.7%	80.8%	81.0%	80.3%
Urea formaldehyde	4.7%	7.2%	3.3%	0.0%	0.0%	0.0%
Melamine formaldehyde	0.8%	0.7%	0.6%	0.7%	0.6%	0.6%
Melamine urea formaldehyde	4.7%	1.9%	7.7%	10.3%	10.5%	11.5%
Paraffin wax	0.6%	0.5%	0.6%	0.7%	0.6%	0.6%
Lamination paper (dry)	0.7%	0.6%	0.5%	0.6%	0.6%	0.5%
Water	6.7%	6.6%	6.6%	6.8%	6.6%	6.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

The declared units above represent an entire product category rather than a specific product from a specific manufacturer. The values represent a production volume weighted average. As such, a specific product purchased on the market may have a lesser or greater environmental impact than the average presented in this EPD. Some products may also undergo further processing (e.g. sawing) before being used in a building.

Representativeness

Market coverage: The data in this EPD are from detailed surveys of three of the three MDF plants in Australia. These plants collectively produced 615,708 m3 of MDF in 2015/16, which is 100% of total Australian production.

Temporal representativeness: Primary data were collected from participating sites for the 2015/16 Australian financial year (1st July 2015 to 30th June 2016). Following EN 15804, site-specific data are valid for 5 years (to 30th June 2021), meaning that these datasets are valid until the end of this EPD's validity period.

Geographical and technological representativeness: The data are representative of the three sites surveyed, which collectively produce all Australian-produced MDF, thus the EPD is valid for all MDF produced in Australia. More detailed information can be found in the "Variation in Results" section later in this EPD.

Industry Classifications

Product	Classification	Code	Category
All	UN CPC Ver.2	31440	Fibreboard of wood or other ligneous materials
All	ANZSIC 2006	1494	Reconstituted Wood Product Manufacturing

LCA Calculation Rules

System Boundary

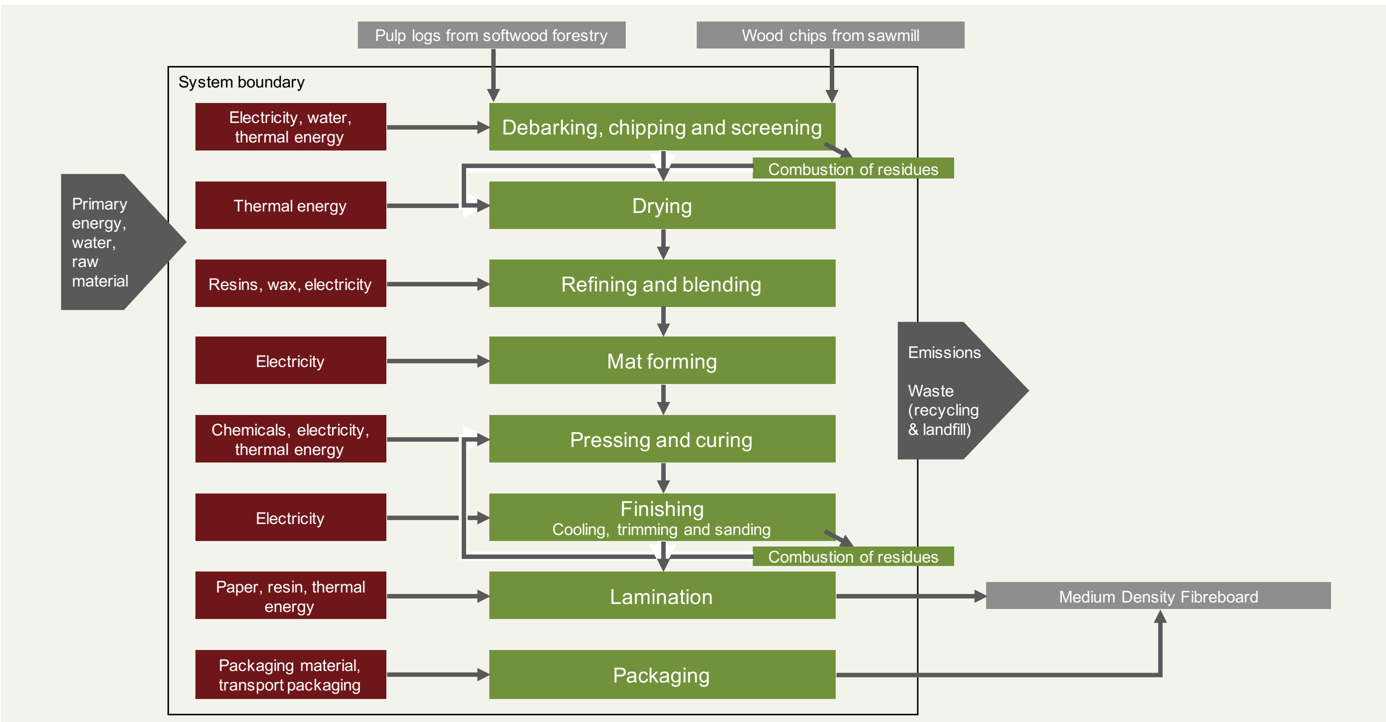
This EPD is of the 'cradle-to-gate' type with options. The options include the end-of-life stage, which is modelled through the use of scenarios.

Product stage			Construction process stage		Use stage							End-of-life stage				Benefits and loads beyond the system boundary
Raw material supply	Transport of raw materials	Manufacturing	Transport to customer	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport to waste processing	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	X	X	X

Key: X = included in the EPD
MND = module not declared (such a declaration shall not be regarded as an indicator result of zero)

Production

The production stage includes growth and harvesting of wood inputs, production of resin and wax, blending of wood particles with resin and wax, pressing of the mixture to create the MDF substrate, cutting, sanding and then laminating a melamine-impregnated paper layer on the top and bottom surfaces.



End-of-Life

When a wood product reaches the end of its useful life, it may either be reused, recycled, landfilled or combusted to produce energy. Landfill is currently the most common end-of-life route for wood products in Australia. Reuse is not included in this EPD as it is not common for MDF. All other scenarios are in use in certain regions (Forsythe Consultants 2007; National Timber Product Stewardship Group) and have been included within this EPD.

Each scenario assumes that 100% of the wood is sent to that scenario. To create an end-of-life mix for a given region or end use, the reader should take a weighted sum of these scenarios. Where no data are available, the 'landfill (typical)' scenario should be used for 100% of the waste.

Landfill

This EPD includes two scenarios for landfill, each with a different value for the degradable organic carbon fraction (DOCf) of wood. The two values are based on bioreactor laboratory research. This experimental work involves the testing of a range of waste types in reactors operated to obtain maximum methane yields. As the laboratory work optimises the conditions for anaerobic decay, the results can be considered as estimates of the DOCf value that would apply over very long time horizons (Australian Government 2014a, p. 17).

- **Landfill (typical):** DOCf = 0.7%. This is based on bioreactor laboratory research by Ximenes et al. (2013).
- **Landfill (NGA)**: DOCf = 10%. This is the value chosen for Australia's National Greenhouse Accounts (NGA) (Australian Government 2017). This is a reduction from the previous value of 23% (Australian Government 2014b) that was derived from early bioreactor laboratory research from the 1990s (e.g. Barlaz 1998) that investigated the degradability of wood tree branches ground to a fine powder under anaerobic conditions (Australian Government 2014a, p. 17). This DOCf value can be considered extremely conservative when compared to values from later research (as used in the typical scenario above) and effectively assumes that at least part of the wood waste is ground into a powder to accelerate degradation.

The impacts associated with the landfill are declared in module C4. All landfill gas that is combusted for energy recovery (module C4) is assumed to occur in a power plant with an electrical conversion efficiency of 36% (Australian Government 2014c, p.189) and the resulting electricity receives a credit for offsetting average electricity from the Australian grid (module D) in line with EN 16485:2014 (Section 6.3.4.5).

Both landfill scenarios assume the following for carbon emissions:

- Of the gases formed from any degradation of wood in landfill, 50% is methane and 50% is carbon dioxide (Australian Government 2016, Table 43).
- All carbon dioxide is released directly to the atmosphere.
- 36% of the methane is captured, based on forecasted average methane capture in Australian landfills by 2020 (Hyder Consulting 2007). The year 2020 was chosen as landfill will take place in the future and this was the last year for which forecasts were available.
- Of this 36% captured, one-quarter (9% of the total) is flared and three-quarters (27% of the total) are used for energy recovery (Carre 2011).
- Of the 64% of methane that is not captured, 10% (6.4% of the total) is oxidised (Australian Government 2016, Table 43).) and 90% (57.6%) is released to the atmosphere.
- In summary, for every kilogram of carbon converted to landfill gas, 71.2% is released as carbon dioxide and 28.8% is released as methane.

Energy recovery

This scenario includes shredding (module C3) and combustion with recovered energy offset against average thermal energy from natural gas (module D) in line with EN 16485:2014 (Section 6.3.4.5). Note that other options are also in use within Australia, including replacement of coal, replacement of electricity, and replacement of both electricity and thermal energy (via co-generation).

Recycling

MDF may be recycled in many different ways. This scenario considers shredding and effectively downcycling into wood chips. Wood waste is chipped (module C3) and assigned credits relative to the avoided production of woodchips from virgin softwood (module D). The sequestered CO_2 and the energy content of the wood are assumed to leave the system boundary at C3 so that future product systems can also claim these without double-counting (EN 16485:2014, Section 6.3.4.2).

Key Assumptions

Energy: Thermal energy and transport fuels have been modelled as the Australian average (see thinkstep 2017 for documentation). Electricity for production (modules A1-A3) has been modelled as a state-specific split based upon the electricity consumption of the manufacturers who contributed data to this study. Electricity at end-of-life (module C) has been modelled using an average Australian electricity mix as the location where the product reaches end-of-life is unknown.

Forestry: All breakdown of forest matter after harvest is modelled as aerobic and therefore carbon neutral as carbon sequestered is released as carbon dioxide. Any burning of forestry material left behind after logging is modelled as being carbon neutral, aside from the trace emissions of various organic gases (Commonwealth of Australia, 2016). All forestry is assumed to be sustainably managed and as such there are no carbon emissions associated with land use change. Loss of carbon from the soil is assumed to be zero (i.e. no significant erosion). It is assumed that all timber will be replanted (plantation forest) or will regrow (native forest) after bushfires.

Cut-off Criteria

Environmental impacts relating to personnel, infrastructure, and production equipment not directly consumed in the process are excluded from the system boundary as per the PCR (IEPDS 2017, Section 7.5.4). All other reported data were incorporated and modelled using the best available life cycle inventory data.

Allocation

Upstream data: For refinery products, allocation is done by mass and net calorific value. Inventories for electricity and thermal energy generation include allocation by economic value for some by-products (e.g. gypsum, boiler ash and fly ash). Allocation by energy is applied for co-generation of heat and power. For materials and chemicals, the allocation rule most suitable for the product is applied (see thinkstep 2017).

Co-products (i.e. different MDF products): Wood particles and energy are allocated per cubic metre of board produced. Decorative overlays are allocated by square metre applied. Resins and waxes are allocated based on the dry mass required in average recipes supplied by manufacturers.

Background Data

Data for primary wood inputs (pulplog and wood chips from sawmills) use the same forestry and sawmilling data as FWPA EPD #01 for Softwood Timber, but with different economic allocation factors.

Data for all energy inputs, transport processes and raw materials are from GaBi Databases 2017 (thinkstep 2017). Most datasets have a reference year between 2013 and 2015 and all fall within the 10-year limit allowable for generic data under EN 15804 (Section 6.3.7).

EPD Results

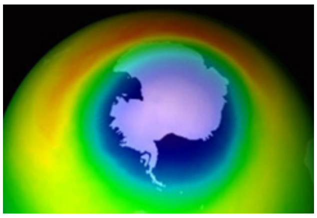
Note: these tables show the impacts associated with production and end-of-life. Any potential credits to future products from recycling or energy recovery are presented in the Other Environmental Information section.

Environmental Impact Indicators

An introduction to each environmental impact indicator is provided below. The best-known effect of each indicator is listed to the right of its name.

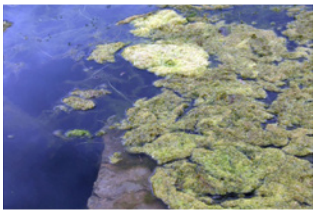
Global Warming Potential (GWP) → Climate Change
A measure of greenhouse gas emissions, such as carbon dioxide and methane. These emissions increase absorption of radiation emitted by the earth, intensifying the natural greenhouse effect. Contributions to GWP can come from either fossil or biogenic sources, e.g. burning fossil fuels or burning wood. GWP is reported as a total as well as being separated into biogenic carbon (GWPB) and fossil carbon (GWPF).

Ozone Depletion Potential (ODP) → Ozone Hole
A measure of air emissions that contribute to the depletion of the stratospheric ozone layer, causing higher levels of ultraviolet B (UVB) to reach the earth's surface with detrimental effects on humans, animals and plants.



Acidification Potential (AP) → Acid Rain
A measure of emissions that cause acidifying effects to the environment. Acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H^+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline and the deterioration of building materials.

Eutrophication Potential (EP) → Algal Blooms
A measure of nutrient enrichment that may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. It includes potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P).



Photochemical Ozone Creation Potential (POCP) → Smog
A measure of emissions of precursors that contribute to ground level smog formation (mainly ozone O_3), produced by the reaction of VOCs and carbon monoxide in the presence of nitrogen oxides under the influence of UV light. Ground level ozone may be harmful to human and ecosystem health and may also damage crops.

Abiotic Depletion Potential → Resource Consumption
The consumption of non-renewable resources leads to a decrease in the future availability of the functions supplied by these resources. Depletion of mineral resource elements (ADPE) and non-renewable fossil energy resources (ADPF) are reported separately.

Table 3: Environmental impacts, 1 m² of 16 mm E0 & E1 standard melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-7.66	1.38	7.31	19.4	19.4
GWPF [kg CO_2-eq.]	9.68	0.942	1.05	1.86	1.86
GWPB [kg CO_2-eq.]	-17.3	0.438	6.26	17.5	17.5
ODP [kg CFC11-eq.]	3.72E-11	4.49E-13	4.49E-13	5.07E-15	5.07E-15
AP [kg SO_2-eq.]	0.0396	0.00300	0.00339	7.40E-04	7.40E-04
EP [kg PO_4^{3}-eq.]	0.00798	0.00127	0.0129	1.73E-04	1.73E-04
POCP [kg C_2H_4-eq.]	0.0196	2.69E-04	0.00142	6.42E-05	6.42E-05
ADPE [kg Sb-eq.]	2.34E-06	1.86E-07	1.86E-07	1.47E-09	1.47E-09
ADPF [MJ]	130	13.5	13.5	1.53	1.53

Table 4: Environmental impacts, 1 m² of 18 mm E0 & E1 standard melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-9.29	1.55	8.19	21.7	21.7
GWPF [kg CO_2-eq.]	10.3	1.06	1.17	1.93	1.93
GWPB [kg CO_2-eq.]	-19.6	0.491	7.02	19.8	19.8
ODP [kg CFC11-eq.]	3.45E-11	5.05E-13	5.05E-13	5.68E-15	5.68E-15
AP [kg SO_2-eq.]	0.0454	0.00337	0.00381	8.30E-04	8.30E-04
EP [kg PO_4^{3}-eq.]	0.00838	0.00136	0.0137	1.94E-04	1.94E-04
POCP [kg C_2H_4-eq.]	0.0225	3.02E-04	0.00159	7.20E-05	7.20E-05
ADPE [kg Sb-eq.]	1.84E-06	2.09E-07	2.09E-07	1.64E-09	1.64E-09
ADPF [MJ]	136	15.2	15.2	1.72	1.72

Table 5: Environmental impacts, 1 m² of 25 mm E0 & E1 standard melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-7.90	2.13	11.1	29.3	29.3
GWPF [kg CO_2-eq.]	18.0	1.47	1.65	3.16	3.16
GWPB [kg CO_2-eq.]	-25.9	0.660	9.43	26.1	26.1
ODP [kg CFC11-eq.]	7.28E-11	7.01E-13	7.01E-13	7.66E-15	7.66E-15
AP [kg SO_2-eq.]	0.0685	0.00467	0.00525	0.00112	0.00112
EP [kg PO_4^{3}-eq.]	0.0142	0.00214	0.0225	2.62E-04	2.62E-04
POCP [kg C_2H_4-eq.]	0.0308	4.13E-04	0.00216	9.71E-05	9.71E-05
ADPE [kg Sb-eq.]	4.92E-06	2.90E-07	2.90E-07	2.22E-09	2.22E-09
ADPF [MJ]	243	21.1	21.1	2.32	2.32

Table 6: Environmental impacts, 1 m² of 16 mm E0 & E1 moisture resistant (MR) melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-5.20	1.39	7.38	19.6	19.6
GWPF [kg CO_2-eq.]	12.1	0.944	1.06	2.11	2.11
GWPB [kg CO_2-eq.]	-17.3	0.442	6.31	17.5	17.5
ODP [kg CFC11-eq.]	5.21E-11	4.49E-13	4.49E-13	5.12E-15	5.12E-15
AP [kg SO_2-eq.]	0.0434	0.00300	0.00339	7.47E-04	7.47E-04
EP [kg PO_4^{3}-eq.]	0.00962	0.00138	0.0146	1.75E-04	1.75E-04
POCP [kg C_2H_4-eq.]	0.0192	2.70E-04	0.00144	6.48E-05	6.48E-05
ADPE [kg Sb-eq.]	3.89E-06	1.86E-07	1.86E-07	1.48E-09	1.48E-09
ADPF [MJ]	165	13.5	13.5	1.55	1.55

Table 7: Environmental impacts, 1 m² of 18 mm E0 & E1 moisture resistant (MR) melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-3.55	1.55	8.20	21.7	21.7
GWPF [kg CO_2-eq.]	15.7	1.06	1.19	2.33	2.33
GWPB [kg CO_2-eq.]	-19.2	0.490	7.01	19.4	19.4
ODP [kg CFC11-eq.]	6.16E-11	5.05E-13	5.05E-13	5.67E-15	5.67E-15
AP [kg SO_2-eq.]	0.0568	0.00337	0.00381	8.28E-04	8.28E-04
EP [kg PO_4^{3}-eq.]	0.0117	0.00155	0.0164	1.94E-04	1.94E-04
POCP [kg C_2H_4-eq.]	0.0221	3.02E-04	0.00160	7.19E-05	7.19E-05
ADPE [kg Sb-eq.]	4.61E-06	2.09E-07	2.09E-07	1.64E-09	1.64E-09
ADPF [MJ]	211	15.2	15.2	1.72	1.72

Table 8: Environmental impacts, 1 m² of 25 mm E0 & E1 moisture resistant (MR) melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-4.67	2.14	11.2	29.5	29.5
GWPF [kg CO_2-eq.]	21.2	1.47	1.66	3.38	3.38
GWPB [kg CO_2-eq.]	-25.9	0.664	9.49	26.1	26.1
ODP [kg CFC11-eq.]	8.96E-11	7.01E-13	7.01E-13	7.71E-15	7.71E-15
AP [kg SO_2-eq.]	0.0751	0.00467	0.00526	0.00113	0.00113
EP [kg PO_4^{3}-eq.]	0.0162	0.00225	0.0241	2.63E-04	2.63E-04
POCP [kg C_2H_4-eq.]	0.0304	4.15E-04	0.00217	9.76E-05	9.76E-05
ADPE [kg Sb-eq.]	6.66E-06	2.90E-07	2.90E-07	2.23E-09	2.23E-09
ADPF [MJ]	288	21.1	21.1	2.33	2.33

Resource Use

Table 9: Resource use, 1 m² of 16 mm E0 & E1 standard melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	58.2	0.852	0.852	0.0278	0.0278
PERM [MJ]	183	0	0	-183	-183
PERT [MJ]	242	0.852	0.852	-183	-183
PENRE [MJ]	132	13.8	13.8	1.53	1.53
PENRM [MJ]	23.9	0	0	-23.9	-23.9
PENRT [MJ]	156	13.8	13.8	-22.4	-22.4
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.0438	1.43E-04	8.03E-04	1.68E-05	1.68E-05

__PERE__ = Use of renewable primary energy excluding renewable primary energy resources used as raw materials;
__PERM__ = Use of renewable primary energy resources used as raw materials; __PERT__ = Total use of renewable primary energy resources;
__PENRE__ = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials;
__PENRM__ = Use of non-renewable primary energy resources used as raw materials; __PENRT__ = Total use of non-renewable primary energy resources; __SM__ = Use of secondary material; __RSF__ = Use of non-renewable secondary fuels; __NRSF__ = Use of non-renewable secondary fuels; __FW__ = Net use of fresh water

Table 10: Resource use, 1 m² of 18 mm E0 & E1 standard melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	69.2	0.958	0.958	0.0312	0.0312
PERM [MJ]	207	0	0	-207	-207
PERT [MJ]	276	0.958	0.958	-207	-207
PENRE [MJ]	138	15.5	15.5	1.72	1.72
PENRM [MJ]	24.8	0	0	-24.8	-24.8
PENRT [MJ]	162	15.5	15.5	-23.1	-23.1
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.0434	1.60E-04	8.99E-04	1.88E-05	1.88E-05

Table 11: Resource use, 1 m² of 25 mm E0 & E1 standard melamine coated MDF

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	82.2	1.33	1.33	0.0421	0.0421
PERM [MJ]	273	0	0	-273	-273
PERT [MJ]	356	1.33	1.33	-273	-273
PENRE [MJ]	247	21.5	21.5	2.32	2.32
PENRM [MJ]	41.0	0	0	-41.0	-41.0
PENRT [MJ]	288	21.5	21.5	-38.7	-38.7
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.0845	2.18E-04	0.00121	2.54E-05	2.54E-05

Table 12: Resource use, 1 m² of 16 mm E0 & E1 moisture resistant (MR) melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	50.8	0.852	0.852	0.0281	0.0281
PERM [MJ]	183	0	0	-183	-183
PERT [MJ]	234	0.852	0.852	-183	-183
PENRE [MJ]	167	13.8	13.8	1.55	1.55
PENRM [MJ]	27.3	0	0	-27.3	-27.3
PENRT [MJ]	195	13.8	13.8	-25.8	-25.8
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.0597	1.44E-04	8.11E-04	1.70E-05	1.70E-05

Table 13: Resource use, 1 m² of 18 mm E0 & E1 moisture resistant (MR) melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	56.9	0.958	0.958	0.0311	0.0311
PERM [MJ]	203	0	0	-203	-203
PERT [MJ]	260	0.958	0.958	-203	-203
PENRE [MJ]	214	15.5	15.5	1.72	1.72
PENRM [MJ]	30.1	0	0	-30.1	-30.1
PENRT [MJ]	244	15.5	15.5	-28.4	-28.4
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.0759	1.60E-04	9.00E-04	1.88E-05	1.88E-05

Table 14: Resource use, 1 m² of 25 mm E0 & E1 moisture resistant (MR) melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	77.8	1.33	1.33	0.0423	0.0423
PERM [MJ]	273	0	0	-273	-273
PERT [MJ]	351	1.33	1.33	-273	-273
PENRE [MJ]	292	21.5	21.5	2.33	2.33
PENRM [MJ]	43.9	0	0	-43.9	-43.9
PENRT [MJ]	336	21.5	21.5	-41.6	-41.6
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.105	2.19E-04	0.00122	2.56E-05	2.56E-05

Waste and Output Flows

Table 15: Waste categories, 1 m² of 16 mm E0 & E1 standard melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	6.84E-08	4.98E-08	4.98E-08	2.54E-09	2.54E-09
NHWD [kg]	0.438	11.5	9.70	1.06E-05	1.06E-05
RWD [kg]	7.82E-04	9.74E-05	9.74E-05	9.21E-08	9.21E-08
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	11.6
MER [kg]	0	0	0	11.6	0
EEE [MJ]	0	0.119	1.70	0	0
EET [MJ]	0	0	0	0	0

***HWD** = Hazardous waste disposed; **NHWD** = Non-hazardous waste disposed; **RWD** = Radioactive waste disposed;*
***CRU** = Components for reuse; **MFR** = Materials for recycling; **MER** = Materials for energy recovery;*
***EEE** = Exported electrical energy; **EET** = Exported thermal energy*

Table 16: Waste categories, 1 m² of 18 mm E0 & E1 standard melamine coated MDF

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	7.55E-08	5.59E-08	5.59E-08	2.85E-09	2.85E-09
NHWD [kg]	0.421	12.9	10.9	1.18E-05	1.18E-05
RWD [kg]	7.26E-04	1.10E-04	1.10E-04	1.03E-07	1.03E-07
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	13.0
MER [kg]	0	0	0	13.0	0
EEE [MJ]	0	0.134	1.91	0	0
EET [MJ]	0	0	0	0	0

Table 17: Waste categories, 1 m² of 25 mm E0 & E1 standard melamine coated MDF

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	9.45E-08	7.64E-08	7.64E-08	3.84E-09	3.84E-09
NHWD [kg]	0.660	17.4	14.7	1.60E-05	1.60E-05
RWD [kg]	0.00149	1.52E-04	1.52E-04	1.39E-07	1.39E-07
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	17.5
MER [kg]	0	0	0	17.5	0
EEE [MJ]	0	0.180	2.57	0	0
EET [MJ]	0	0	0	0	0

Table 18: Waste categories, 1 m² of 16 mm E0 & E1 moisture resistant melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	6.62E-08	5.01E-08	5.01E-08	2.57E-09	2.57E-09
NHWD [kg]	0.505	11.6	9.79	1.07E-05	1.07E-05
RWD [kg]	0.00108	9.74E-05	9.74E-05	9.30E-08	9.30E-08
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	11.7
MER [kg]	0	0	0	11.7	0
EEE [MJ]	0	0.120	1.72	0	0
EET [MJ]	0	0	0	0	0

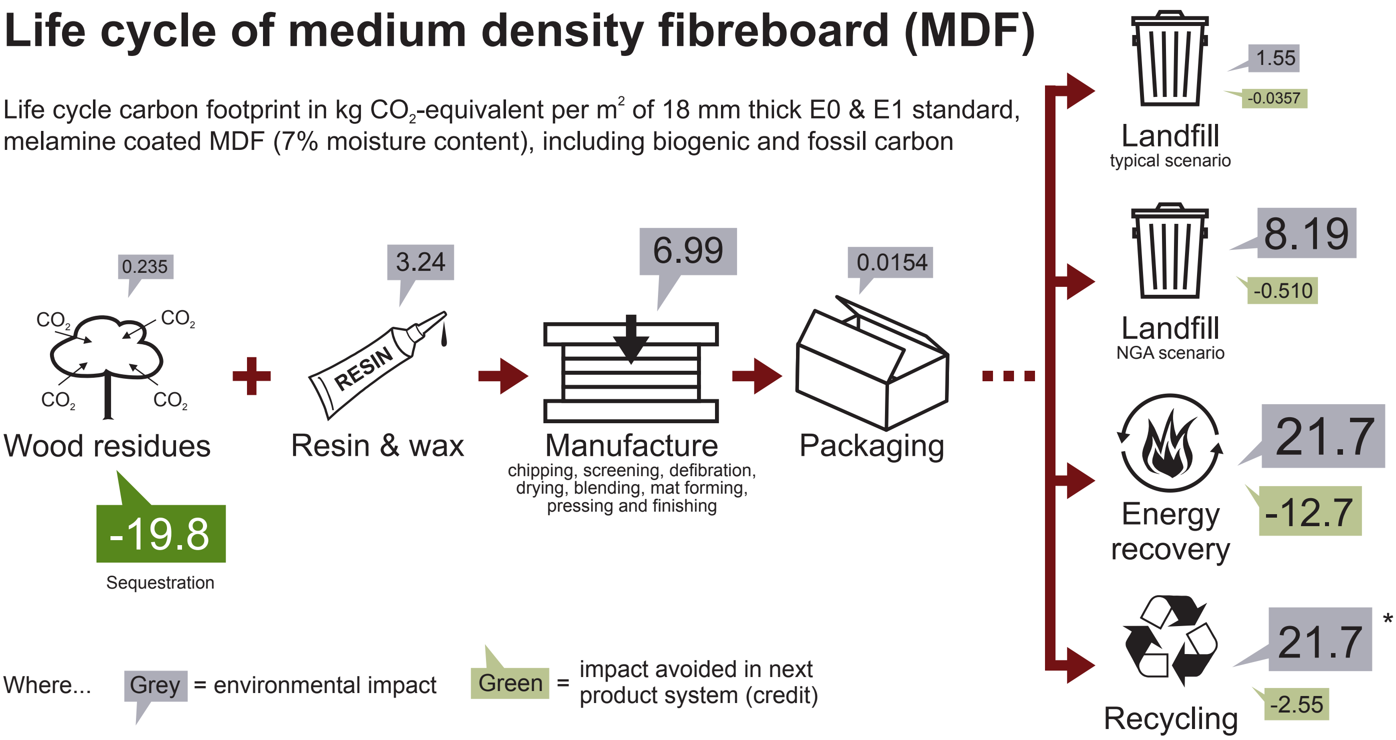
Table 19: Waste categories, 1 m² of 18 mm E0 & E1 moisture resistant melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	7.44E-08	5.59E-08	5.59E-08	2.84E-09	2.84E-09
NHWD [kg]	0.478	12.9	10.8	1.18E-05	1.18E-05
RWD [kg]	0.00126	1.10E-04	1.10E-04	1.03E-07	1.03E-07
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	13.0
MER [kg]	0	0	0	13.0	0
EEE [MJ]	0	0.134	1.91	0	0
EET [MJ]	0	0	0	0	0

Table 20: Waste categories, 1 m² of 25 mm E0 & E1 moisture resistant melamine coated MDF.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	9.45E-08	7.67E-08	7.67E-08	3.87E-09	3.87E-09
NHWD [kg]	0.694	17.5	14.7	1.61E-05	1.61E-05
RWD [kg]	0.00182	1.52E-04	1.52E-04	1.40E-07	1.40E-07
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	17.6
MER [kg]	0	0	0	17.6	0
EEE [MJ]	0	0.181	2.59	0	0
EET [MJ]	0	0	0	0	0

Understanding the Life Cycle of MDF



* While carbon is not released directly through recycling, it is passed to another product system and is therefore counted as being released

Variation in Results

The variation between sites used to create the average shown in this EPD are given in Table 24 below for the environmental impact indicators in modules A1-A3.

Table 21: Inter-site variability for standard MDF (modules A1-A3).

	Standard 16 mm			Standard 18 mm			Standard 25 mm		
Parameter [Unit]	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**
GWP [kg CO_2-eq.]	-2.1%	+47.8%	±19.7%	-8.9%	+46.4%	±15.9%	-26.5%	+46.6%	±30.9%
GWPF [kg CO_2-eq.]	-3.7%	+38.6%	±15.8%	-8.9%	+42.5%	±15.0%	-10.3%	+25.3%	±16.4%
GWPB [kg CO_2-eq.]	-1.2%	+1.4%	±1.1%	-0.5%	+2.1%	±1.2%	-3.3%	+3.8%	±3.0%
ODP [kg CFC11-eq.]	-29.1%	+33.7%	±26.9%	-14.8%	+62.2%	±32.0%	-34.0%	+16.8%	±23.3%
AP [kg SO_2-eq.]	-6.5%	+37.7%	±20.5%	-8.5%	+33.3%	±19.3%	-16.7%	+29.2%	±20.9%
EP [kg PO_4^{3}-eq.]	-18.7%	+22.5%	±17.8%	-13.2%	+27.6%	±18.2%	-23.8%	+17.4%	±17.0%
POCP [kg C_2H_4-eq.]	-3.8%	+3.7%	±3.1%	-5.6%	+1.6%	±3.0%	-5.1%	+5.9%	±4.5%
ADPE [kg Sb-eq.]	-44.9%	+56.9%	±45.5%	-22.1%	+124.4%	±63.5%	-55.6%	+27.3%	±38.7%
ADPF [MJ]	-3.2%	+37.0%	±16.7%	-3.2%	+42.5%	±16.1%	-15.6%	+23.9%	±16.7%

***Min** = (minimum - average) / average; **Max** = (maximum - average) / average;*
***CV** = coefficient of variation = standard deviation / average*

Table 22: Inter-site variability for moisture resistant MDF (modules A1-A3).

	MR 16 mm			MR 18 mm			MR 25 mm		
Parameter [Unit]	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**
GWP [kg CO_2-eq.]	-36.5%	+62.9%	±40.9%	-124.8%	+37.3%	±66.8%	-83.1%	+47.4%	±54.1%
GWPF [kg CO_2-eq.]	-14.5%	+24.6%	±16.0%	-25.9%	+7.5%	±13.7%	-22.5%	+12.9%	±14.5%
GWPB [kg CO_2-eq.]	-0.8%	+1.8%	±1.2%	-1.9%	+0.7%	±1.2%	-2.0%	+3.4%	±2.3%
ODP [kg CFC11-eq.]	-13.7%	+10.8%	±10.1%	-18.3%	+5.0%	±9.6%	-13.6%	+5.4%	±7.8%
AP [kg SO_2-eq.]	-13.4%	+33.6%	±22.1%	-25.7%	+14.7%	±19.0%	-24.0%	+21.9%	±21.2%
EP [kg PO_4^{3}-eq.]	-17.8%	+15.7%	±13.8%	-24.1%	+7.0%	±12.8%	-20.5%	+10.3%	±12.8%
POCP [kg C_2H_4-eq.]	-3.5%	+3.5%	±3.0%	-5.6%	+1.2%	±2.9%	-4.8%	+2.5%	±3.2%
ADPE [kg Sb-eq.]	-11.9%	+10.9%	±9.6%	-16.8%	+5.0%	±9.1%	-12.3%	+5.9%	±7.6%
ADPF [MJ]	-12.7%	+23.5%	±15.5%	-23.4%	+7.8%	±13.4%	-19.5%	+12.3%	±13.6%

Carbon Dioxide Sequestration

During growth, trees absorb carbon dioxide (CO_2) from the atmosphere through the process of photosynthesis and convert this into carbon-based compounds that constitute various components of a tree, including wood. On average, half the dry weight of all wood is made up of the element carbon (Gifford 2000).

All major Australian production forests and plantations are independently certified to one or both of the internationally recognised forest management certification systems: the Australian Standard for Sustainable Forest Management (AS 4708), which is recognised under the Programme for the Endorsement of Forest Certification (PEFC), and/or one of the Forest Stewardship Council's (FSC®) interim forest management standards. It is therefore appropriate to include biogenic CO_2 sequestration in this EPD in line with EN 16485 (Section 6.3.4.2).

Module D: Recycling, Reuse and Recovery Potentials

Table 23: Module D, 1 m^2 of 16 mm E0 & E1 standard melamine coated MDF.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0319	-0.455	-11.2	-2.27
GWPF [kg CO_2-eq.]	-0.0319	-0.455	-11.2	-2.17
GWPB [kg CO_2-eq.]	-6.51E-07	-9.30E-06	0.0283	-0.1000
ODP [kg CFC11-eq.]	-9.10E-16	-1.30E-14	4.33E-13	-1.89E-13
AP [kg SO_2-eq.]	-1.40E-04	-0.00201	0.00725	-0.0167
EP [kg PO_4^{3-}-eq.]	-1.19E-05	-1.69E-04	0.00155	-0.00386
POCP [kg C_2H_4-eq.]	-7.32E-06	-1.05E-04	0.00238	-0.00686
ADPE [kg Sb-eq.]	-2.37E-09	-3.38E-08	-7.49E-07	-4.12E-07
ADPF [MJ]	-0.363	-5.19	-226	-27.7
Resource Use				
PERE [MJ]	-0.0408	-0.583	0.150	-40.1
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.0408	-0.583	0.150	-40.1
PENRE [MJ]	-0.363	-5.19	-226	-27.8
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.363	-5.19	-226	-27.8
SM [kg]	0	0	0	11.6
RSF [MJ]	0	0	183	0
NRSF [MJ]	0	0	23.9	0
FW [m^3]	-1.88E-04	-0.00269	0.00537	-0.00853
Wastes and Outputs				
HWD [kg]	-4.79E-11	-6.85E-10	-1.69E-08	-8.14E-09
NHWD [kg]	-9.27E-05	-0.00132	0.515	-0.285
RWD [kg]	-4.48E-08	-6.40E-07	4.96E-05	-1.00E-05
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 24: Module D, 1 m² of 18 mm E0 & E1 standard melamine coated MDF.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0357	-0.510	-12.7	-2.55
GWPF [kg CO_2-eq.]	-0.0357	-0.510	-12.7	-2.44
GWPB [kg CO_2-eq.]	-7.29E-07	-1.04E-05	0.0319	-0.113
ODP [kg CFC11-eq.]	-1.02E-15	-1.46E-14	4.60E-13	-2.12E-13
AP [kg SO_2-eq.]	-1.57E-04	-0.00225	0.00760	-0.0188
EP [kg PO_4^{3-}-eq.]	-1.33E-05	-1.90E-04	0.00159	-0.00434
POCP [kg C_2H_4-eq.]	-8.21E-06	-1.17E-04	0.00265	-0.00771
ADPE [kg Sb-eq.]	-2.65E-09	-3.79E-08	-8.40E-07	-4.63E-07
ADPF [MJ]	-0.407	-5.82	-253	-31.2
Resource Use				
PERE [MJ]	-0.0457	-0.653	0.157	-45.1
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.0457	-0.653	0.157	-45.1
PENRE [MJ]	-0.407	-5.82	-253	-31.2
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.407	-5.82	-253	-31.2
SM [kg]	0	0	0	13.0
RSF [MJ]	0	0	207	0
NRSF [MJ]	0	0	24.8	0
FW [m^3]	-2.11E-04	-0.00302	0.00574	-0.00959
Wastes and Outputs				
HWD [kg]	-5.37E-11	-7.67E-10	-1.89E-08	-9.16E-09
NHWD [kg]	-1.04E-04	-0.00148	0.581	-0.321
RWD [kg]	-5.02E-08	-7.17E-07	5.27E-05	-1.13E-05
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 25: Module D, 1 m² of 25 mm E0 & E1 standard melamine coated MDF.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0481	-0.688	-16.7	-3.54
GWPF [kg CO_2-eq.]	-0.0481	-0.688	-16.7	-3.38
GWPB [kg CO_2-eq.]	-9.84E-07	-1.41E-05	0.0424	-0.156
ODP [kg CFC11-eq.]	-1.37E-15	-1.96E-14	7.75E-13	-2.95E-13
AP [kg SO_2-eq.]	-2.12E-04	-0.00303	0.0133	-0.0261
EP [kg PO_4^{3-}-eq.]	-1.79E-05	-2.56E-04	0.00297	-0.00603
POCP [kg C_2H_4-eq.]	-1.11E-05	-1.58E-04	0.00367	-0.0107
ADPE [kg Sb-eq.]	-3.58E-09	-5.11E-08	-1.12E-06	-6.44E-07
ADPF [MJ]	-0.549	-7.84	-342	-43.3
Resource Use				
PERE [MJ]	-0.0617	-0.881	0.274	-62.6
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.0617	-0.881	0.274	-62.6
PENRE [MJ]	-0.549	-7.84	-342	-43.4
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.549	-7.84	-342	-43.4
SM [kg]	0	0	0	17.5
RSF [MJ]	0	0	273	0
NRSF [MJ]	0	0	41.0	0
FW [m^3]	-2.85E-04	-0.00407	0.00921	-0.0133
Wastes and Outputs				
HWD [kg]	-7.24E-11	-1.03E-09	-2.55E-08	-1.27E-08
NHWD [kg]	-1.40E-04	-0.00200	0.767	-0.445
RWD [kg]	-6.76E-08	-9.66E-07	8.82E-05	-1.57E-05
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 26: Module D, 1 m² of 16 mm E0 & E1 moisture resistant (MR) melamine coated MDF.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0322	-0.460	-11.2	-2.27
GWPF [kg CO_2-eq.]	-0.0322	-0.460	-11.2	-2.17
GWPB [kg CO_2-eq.]	-6.58E-07	-9.40E-06	0.0284	-0.1000
ODP [kg CFC11-eq.]	-9.20E-16	-1.31E-14	4.87E-13	-1.89E-13
AP [kg SO_2-eq.]	-1.42E-04	-0.00203	0.00847	-0.0167
EP [kg PO_4^{3-}-eq.]	-1.20E-05	-1.71E-04	0.00188	-0.00386
POCP [kg C_2H_4-eq.]	-7.41E-06	-1.06E-04	0.00243	-0.00686
ADPE [kg Sb-eq.]	-2.40E-09	-3.42E-08	-7.55E-07	-4.12E-07
ADPF [MJ]	-0.367	-5.25	-229	-27.7
Resource Use				
PERE [MJ]	-0.0413	-0.590	0.174	-40.1
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.0413	-0.590	0.174	-40.1
PENRE [MJ]	-0.368	-5.25	-229	-27.8
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.368	-5.25	-229	-27.8
SM [kg]	0	0	0	11.7
RSF [MJ]	0	0	183	0
NRSF [MJ]	0	0	27.3	0
FW [m^3]	-1.91E-04	-0.00272	0.00592	-0.00853
Wastes and Outputs				
HWD [kg]	-4.85E-11	-6.92E-10	-1.71E-08	-8.14E-09
NHWD [kg]	-9.37E-05	-0.00134	0.514	-0.285
RWD [kg]	-4.53E-08	-6.47E-07	5.61E-05	-1.00E-05
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 27: Module D, 1 m² of 18 mm E0 & E1 moisture resistant (MR) melamine coated MDF.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0358	-0.511	-12.4	-2.55
GWPF [kg CO_2-eq.]	-0.0358	-0.511	-12.4	-2.44
GWPB [kg CO_2-eq.]	-7.30E-07	-1.04E-05	0.0315	-0.113
ODP [kg CFC11-eq.]	-1.02E-15	-1.46E-14	5.50E-13	-2.12E-13
AP [kg SO_2-eq.]	-1.58E-04	-0.00225	0.00964	-0.0188
EP [kg PO_4^{3-}-eq.]	-1.33E-05	-1.90E-04	0.00215	-0.00434
POCP [kg C_2H_4-eq.]	-8.22E-06	-1.17E-04	0.00271	-0.00771
ADPE [kg Sb-eq.]	-2.66E-09	-3.80E-08	-8.36E-07	-4.63E-07
ADPF [MJ]	-0.408	-5.82	-254	-31.2
Resource Use				
PERE [MJ]	-0.0458	-0.654	0.197	-45.1
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.0458	-0.654	0.197	-45.1
PENRE [MJ]	-0.408	-5.82	-254	-31.2
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.408	-5.82	-254	-31.2
SM [kg]	0	0	0	13.0
RSF [MJ]	0	0	203	0
NRSF [MJ]	0	0	30.1	0
FW [m³]	-2.11E-04	-0.00302	0.00664	-0.00959
Wastes and Outputs				
HWD [kg]	-5.38E-11	-7.68E-10	-1.89E-08	-9.16E-09
NHWD [kg]	-1.04E-04	-0.00149	0.570	-0.321
RWD [kg]	-5.02E-08	-7.18E-07	6.34E-05	-1.13E-05
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 28: Module D, 1 m² of 25 mm E0 & E1 moisture resistant (MR) melamine coated MDF.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0485	-0.693	-16.6	-3.54
GWPF [kg CO_2-eq.]	-0.0485	-0.693	-16.7	-3.38
GWPB [kg CO_2-eq.]	-9.90E-07	-1.41E-05	0.0425	-0.156
ODP [kg CFC11-eq.]	-1.38E-15	-1.98E-14	8.25E-13	-2.95E-13
AP [kg SO_2-eq.]	-2.14E-04	-0.00305	0.0145	-0.0261
EP [kg PO_4^{3-}-eq.]	-1.80E-05	-2.58E-04	0.00329	-0.00603
POCP [kg C_2H_4-eq.]	-1.11E-05	-1.59E-04	0.00373	-0.0107
ADPE [kg Sb-eq.]	-3.60E-09	-5.15E-08	-1.13E-06	-6.44E-07
ADPF [MJ]	-0.553	-7.90	-345	-43.3
Resource Use				
PERE [MJ]	-0.0621	-0.887	0.297	-62.6
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.0621	-0.887	0.297	-62.6
PENRE [MJ]	-0.553	-7.90	-344	-43.4
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.553	-7.90	-344	-43.4
SM [kg]	0	0	0	17.6
RSF [MJ]	0	0	273	0
NRSF [MJ]	0	0	43.9	0
FW [m^3]	-2.87E-04	-0.00410	0.00973	-0.0133
Wastes and Outputs				
HWD [kg]	-7.29E-11	-1.04E-09	-2.56E-08	-1.27E-08
NHWD [kg]	-1.41E-04	-0.00201	0.767	-0.445
RWD [kg]	-6.81E-08	-9.73E-07	9.43E-05	-1.57E-05
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Water Consumption

The “FW” indicator in the EPD results tables reports consumption (i.e. net use) of ‘blue’ water (which includes river water, lake water and ground water). This indicator deliberately excludes consumption of ‘green’ water (rain water).

PCR 2012:01 (Section 16.1) states that all water loss from a drainage basin is considered consumption, including any net loss of rain water. According to the PCR, net loss should be interpreted as any additional water loss beyond what would occur in the original, natural system. For plantation softwood forestry, the natural system might be a native forest or a grassland (Quinteiro et al. 2015).

The initial version of this EPD (v1.0) included estimated losses of rain water in the main results tables, labelled as green water consumption. These values were based on calculated differences in water flow between plantation forests and a base case land use (pasture) from the original CSIRO LCI study (CSIRO 2009).

Table 39 reports green water consumption calculated by CSIRO using 2005-08 data. These values have not been updated and are now reported here rather than in the main results tables to reflect their uncertainty. At the time of writing, there is no internationally agreed method for calculating green water consumption due to evapotranspiration relative to a hypothetical natural state (Manzardo et al. 2016). As such, different calculation methods may yield significantly different results, introducing a high level of uncertainty.

The reader should also be aware that water consumption does not account for relative water stress in the catchment(s) where the forest is located, meaning that it provides no information about the potential impacts of any water consumption that does occur.

Table 29: Green water consumption estimates for modules A1-A3 following CSIRO (2009).

	Std 16 mm	**Std 18 mm**	**Std 25 mm**	**MR 16 mm**	**MR 18 mm**	**MR 25 mm**
Parameter [Unit]	A1-A3	A1-A3	A1-A3	A1-A3	A1-A3	A1-A3
Green water consumption [m^3]	1.24	1.25	2.03	1.49	1.66	2.22

Timber & Forest Certification

Many Australian timber and reconstituted wood products are certified to a forest certification scheme. This certification is an independent auditing process that provides:

- Assurance that the timber is from well-managed forests certified to internationally and nationally accepted forest management standards
- Assurance that the timber is from legally harvested sources
- Chain of custody (CoC) certification extending from the forest to the end user, which is traceable throughout the supply chain.

Two schemes apply to Australian wood production forests. One is administered by the Australian Forestry Standard Ltd (AFS). The AFS scheme is also endorsed by the international Programme for Endorsement of Forest Certification (PEFC). The other scheme is administered by Forest Stewardship Council (FSC®) Australia.

If a Green Star project elects to use the timber credit as part of their Green Star submission, the Green Building Council of Australia recognises PEFC-endorsed forest certification schemes (such as the Australian Forest Certification Scheme, AFCS) as well as FSC®. Compliance with the chain of custody certification rules of either forest certification scheme for at least 95% by value of timber products used in the project will meet the requirements for this credit point (GBCA 2014).

As of 2017, there are more than 26.7million hectares of native and plantation forests certified under AFS (AFS 2017) and 1.2 million hectares certified under FSC® interim national standards (FSC 2017).

All Australian MDF manufacturers are chain of custody certified so they can supply certified products.

Land Use and Biodiversity

Like other land uses, forestry operations for timber and wood production can have both positive and negative effects on biodiversity. However, as biodiversity varies considerably by region and as data are often limited, assessing potential biodiversity impacts within LCA is challenging.

An Australian study completed shortly before initial publication of this EPD (Turner et al. 2014) demonstrated a new method – BioImpact – to discern the biodiversity impacts of different land uses. A trial of this method was conducted using case studies in three different regions and four production systems in New South Wales: native hardwood forestry, plantation softwood forestry, mixed cropping and rangeland grazing. Managed forestry resulted in biodiversity impacts equivalent to or better than those of cropping/grazing systems.

Indoor Environment Quality – Formaldehyde Emissions Minimisation

Formaldehyde is a colourless, strong-smelling gas that occurs naturally in the environment. It is present in the air that we breathe at natural background levels of about 0.03 parts per million (ppm) with recent studies showing formaldehyde concentrations often up to 0.08 ppm in outdoor urban air (EWPAA 2012). Formaldehyde is used as an ingredient in synthetic resins, industrial chemicals and preservatives, and in the production of paper, textiles, cosmetics, disinfectants, medicines, paints, varnishes and lubricants.

MDF manufactured in Australia uses one of two low formaldehyde emitting amino plastics: urea formaldehyde (UF) or melamine urea formaldehyde (MUF) (EWPAA 2012).

To assure end users that they are using MDF with the lowest possible formaldehyde emissions, an industry-wide formaldehyde testing and labelling program is run by the Engineered Wood Products Association of Australasia. All mills are required to forward samples to EWPAA's National Laboratory on a regular basis for formaldehyde emission testing. On the basis of laboratory tests, all Australian MDF mills are permitted to brand a formaldehyde emission class on their MDF products as detailed in Table 30 below.

Table 30: Formaldehyde emission classes for Australian manufactured MDF

Emission Class	Emission Limit (mg/litre)	Emission Limit (ppm)*
E0	Less than or equal to 0.5	Less than or equal to 0.04
E1	Less than or equal to 1.0	Less than or equal to 0.08

** Based on a test chamber volume of 10litre, zero airflow during the 24hr test cycle, molecular weight of formaldehyde 30.03 and the number of microlitres of formaldehyde gas in 1 micromole at 101KPa and 298K.*

All Australian manufacturers listed in this EPD can supply test certificates that support the Emission Class.

MDF with formaldehyde emissions of less than or equal to E1 are compliant with the Green Star Formaldehyde credit. To achieve credit points, all engineered wood products such as particleboard, MDF and plywood used in the project must be in accordance with these requirements.

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Environmental Product Declaration
Plywood

Environmental Product Declaration (EPD)
in accordance with ISO 14025 and EN 15804

EPD Registration No. S-P-00564 | Version 1.2
Issued 14 October 2015 | Revised 8 December 2017 | Valid until 8 December 2022

Geographical Scope: Australia

AUSTRALASIA EPD®
ENVIRONMENTAL PRODUCT DECLARATION

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#02 Hardwood Timber

#03 Particleboard

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WoodSolutions is an industry initiative designed to provide independent, non-proprietary information about timber and wood products to professionals and companies involved in building design and construction.

WoodSolutions is resourced by Forest and Wood Products Australia (FWPA). It is a collaborative effort between FWPA members and levy payers, supported by industry peak bodies and technical associations.

This work is supported by funding provided to FWPA by the Commonwealth Government.

978-1-925213-18-8

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Version history

v1.0 Initial version based on 2005/06 data from CSIRO and produced by thinkstep Pty Ltd and the Timber Development Association (NSW) Ltd.

V1.1 Revised version incorporating 2015/16 data from a new industry survey, as well as updates to Global Warming Potential (GWP) and fresh water indicators.

V1.2 - Revised version for correction of the validity period, documentation of the forestry carbon modelling assumptions, correction of minor typographical errors. Fixed the double counting of the artificial release of biogenic carbon that occurred in Module C and D of the Reuse EOL scenario (now the release is only included in Module C).

Produced: December 2020

EPD Details

An Environmental Product Declaration, or EPD, is a standardised and verified way of quantifying the environmental impacts of a product that is based on a consistent set of rules known as a PCR (Product Category Rules).

EPDs within the same product category from different programs may not be comparable. EPDs of construction products may not be comparable if they do not comply with EN 15804.

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CEN standard EN 15804 served as the core PCR

PCR:
PCR 2012:01 Construction products and Construction services, Version 2.2, 2017-05-30

PCR review was conducted by:
The Technical Committee of the International EPD® System.
Chair: Massimo Marino. Contact via info@environdec.com.

Independent verification of the declaration and data, according to ISO 14025:
☐ EPD process certification (Internal)
☑ EPD verification (External)

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Introduction

This Environmental Product Declaration presents the average performance of plywood manufactured in Australia from Australian grown wood by members of Forest and Wood Products Australia (FWPA). It recognises the importance of transparency by providing information on the raw materials, production and environmental impacts of Australian plywood.

This EPD has been prepared in accordance with ISO 14025:2006, EN 15804:2013 and PCR 2012:01 (IEPDS 2017). It covers plywood panels produced in accordance with the following standards:

- AS/NZS 2269: 2012 Plywood – Structural – Specifications
- AS/NZS 2270: 2006 Plywood and Blockboard for Interior Use
- AS/NZS 2271: 2004 Plywood and Blockboard for Exterior Use
- AS/NZS 2272: 2006 Plywood – Marine
- AS 6669: 2007 Plywood Formwork

The environmental data presented in this document were primarily derived from a survey of industry members covering the 2015/16 financial year conducted by thinkstep and Stephen Mitchell Associates on behalf of FWPA. This updates an earlier survey conducted by CSIRO (2009) based on the 2005/06 financial year, which was used in the first version of this EPD. The current survey covers 100% of plywood production in Australia.

Production of this EPD has been facilitated by FWPA with the participation of its current plywood producer members (listed below) and the Engineered Wood Products Association of Australasia (EWPAA).

Company	Financial contributor	Data contributor
Ausply Pty Ltd	X	X
Austral Plywoods Pty Ltd	X	X
Big River Group Pty Ltd	X	X
Carter Holt Harvey Woodproducts Australia	X	X
Ta Ann Tasmania Pty Ltd	X	X

Description of the Australian Plywood Industry

The Australian plywood manufacturing industry is an important contributor to the Australian economy – particularly in the regional areas where many plywood mills are based. The overall contribution of the wood products industries to the Australian GDP in 2015-16 was 0.5% [ABARES 2017]. In 2015-2016, Australian plywood manufacturers produced 142,000 cubic metres of plywood products in five different facilities.

Description of Plywood Products

Plywood is a panel product made of thin veneers of wood peeled from softwood and hardwood logs and bonded by resin. Plywood products are either engineered wood panels (such as structural plywood and formwork plywood) or non-structural panels (such as interior and exterior plywood). The difference between the engineered products and the non-structural products is that engineered products have standardised structural properties, such as strength, stiffness and dimensional stability.

Plywood is used in many application areas, such as structural bracing, concrete formwork, cladding, flooring, webbed beams, boats, aircraft, door skins, furniture, wall panels and architectural joinery in exterior and interior environments.

Use of EPDs within Green Star

This document complies with the requirements for an industry-wide EPD under the Green Building Council of Australia's Green Star rating system given that:

1. It conforms with ISO 14025 and EN 15804.
2. It has been verified by an independent third party.
3. It has at least a cradle-to-gate scope.
4. The participants in the EPD are listed (see Introduction).

It may be used by project teams using the Design & As Built and Interiors rating tools to obtain Green Star points under the following credits:

- Materials > Product Transparency and Sustainability.
- Materials > Life Cycle Assessment: By providing data for an EN 15978 compliant whole-of-building whole-of-life assessment.
- Innovation Challenge > Responsible Carbon Impact: By providing embodied carbon impacts (i.e. data on Global Warming Potential) which can be used in the calculation and reduction of the total embodied carbon impacts of a project.

This EPD is also recognised for credits in the Infrastructure Sustainability (IS) rating scheme of the Infrastructure Sustainability Council of Australia (ISCA).

Scope

Products

This Sector EPD describes the following average products (declared units) manufactured in Australia by the FWPA members listed in the Introduction:

- 1 m^2 of exterior plywood, A-bond, 7 mm (bracing)
- 1 m^2 of exterior plywood, A-bond, 9 mm (structural)
- 1 m^2 of formply, A-bond, 17 mm (formwork)
- 1 m^2 of formply, B-bond, 17 mm (formwork)
- 1 m^2 of plywood flooring, tongue and groove, A-bond, 15 mm (residential)
- 1 m^2 of plywood flooring, tongue and groove, A-bond, 25 mm (commercial)

Wood used in these products is from Australian grown native and exotic (non-native) softwood species grown in plantations as well as hardwood species grown in native forests. The dominant softwood species used to produce plywood in Australia is *Pinus radiata* (radiata pine). Other softwood species used are *Araucaria cunninghami* (hoop pine), *Pinus pinaster* (maritime pine) and the Southern Pines: *Pinus elliottii* (slash pine), *Pinus caribaea* (Caribbean pine) and hybrids thereof. Hardwood species are a variety of species harvested in NSW, Queensland, Victoria and Tasmania.

The properties and material composition of these products are defined in Table 1 and Table 2 below.

Table 1: Properties of plywood products included in this EPD.

Properties	Ext 7 mm	Ext 9 mm	Form A-Bond 17 mm	Form B-Bond 17 mm	Floor 15 mm	Floor 25 mm
Area density (kg per m^2)	3.45	4.44	8.75	9.28	7.40	12.3
Density (kg per m^3)	493	493	514	546	493	493
Moisture content (dry basis)	8%	8%	8%	8%	8%	8%
Gross calorific value (MJ/kg)	21.1	21.1	21.2	20.5	21.2	21.2
Net calorific value (MJ/kg)	18.1	18.0	18.2	17.5	18.1	18.1
CO_2 sequestered (kg CO_2e)	5.61	7.24	14.0	14.6	12.0	20.0

Table 2: Composition of plywood products included in this EPD.

Materials	Ext 7 mm	Ext 9 mm	Form A-Bond 17 mm	Form B-Bond 17 mm	Floor 15 mm	Floor 25 mm
Softwood veneer (dry)	88.6%	89.0%	72.4%	55.6%	88.8%	88.5%
Hardwood veneer (dry)	0.0%	0.0%	12.9%	28.7%	0.0%	0.0%
Paper (dry)	0.0%	0.0%	2.3%	1.7%	0.0%	0.0%
Phenol formaldehyde	3.5%	3.2%	5.2%	1.1%	3.2%	3.9%
Melamine urea formaldehyde	0.0%	0.0%	0.0%	5.6%	0.0%	0.0%
Acrylic putty	0.6%	0.5%	0.0%	0.0%	0.3%	0.1%
Polypropylene (tongue)	0.0%	0.0%	0.0%	0.0%	0.3%	0.2%
Water	7.4%	7.3%	7.2%	7.4%	7.3%	7.4%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

The data in Table 1 and Table 2 exclude packaging and any markings applied to the surface of the board. On average, packaging comprises 0.0065 m^3 softwood gluts and less than 1 kg in total of other packaging materials product (plastic strapping, steel strapping, paper labels, etc.) per cubic metre of product.

The declared units above represent an entire product category rather than a specific product from a specific manufacturer. The values represent a production volume weighted average. As such, a specific product purchased on the market may have a lesser or greater environmental impact than the average presented in this EPD. Some products may also undergo further processing (e.g. sawing) before being used in a building.

Representativeness

Market coverage: The data in this EPD are from detailed surveys of three of the five plywood plants in Australia. These plants collectively produced 142,391 m3 of plywood in 2015/16, which is 100% of total Australian production.

Temporal representativeness: Primary data were collected from participating sites for the 2015/16 Australian financial year (1st July 2015 to 30th June 2016). Following EN 15804, site-specific data are valid for 5 years (to 30th June 2021), meaning that these datasets are valid until the end of this EPD's validity period.

Geographical and technological representativeness: The data are representative of the five sites surveyed, which collectively produce all Australian-produced plywood, thus the EPD is valid for all plywood produced in Australia. More detailed information can be found in the "Variation in Results" section later in this EPD.

Industry Classifications

Product	Classification	Code	Category
All	UN CPC Ver.2	31410	Plywood consisting solely of sheets of wood, except of bamboo
All	ANZSIC 2006	1493	Veneer and Plywood Manufacturing

LCA Calculation Rules

System Boundary

This EPD is of the 'cradle-to-gate' type with options. The options include the end-of-life stage, which is modelled through the use of scenarios.

Product stage			Con-struction process stage		Use stage							End-of-life stage				Benefits and loads beyond the system boundary
Raw material supply	Transport of raw materials	Manufacturing	Transport to customer	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport to waste processing	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	X	X	X

Key: X = included in the EPD
MND = module not declared (such a declaration shall not be regarded as an indicator result of zero)

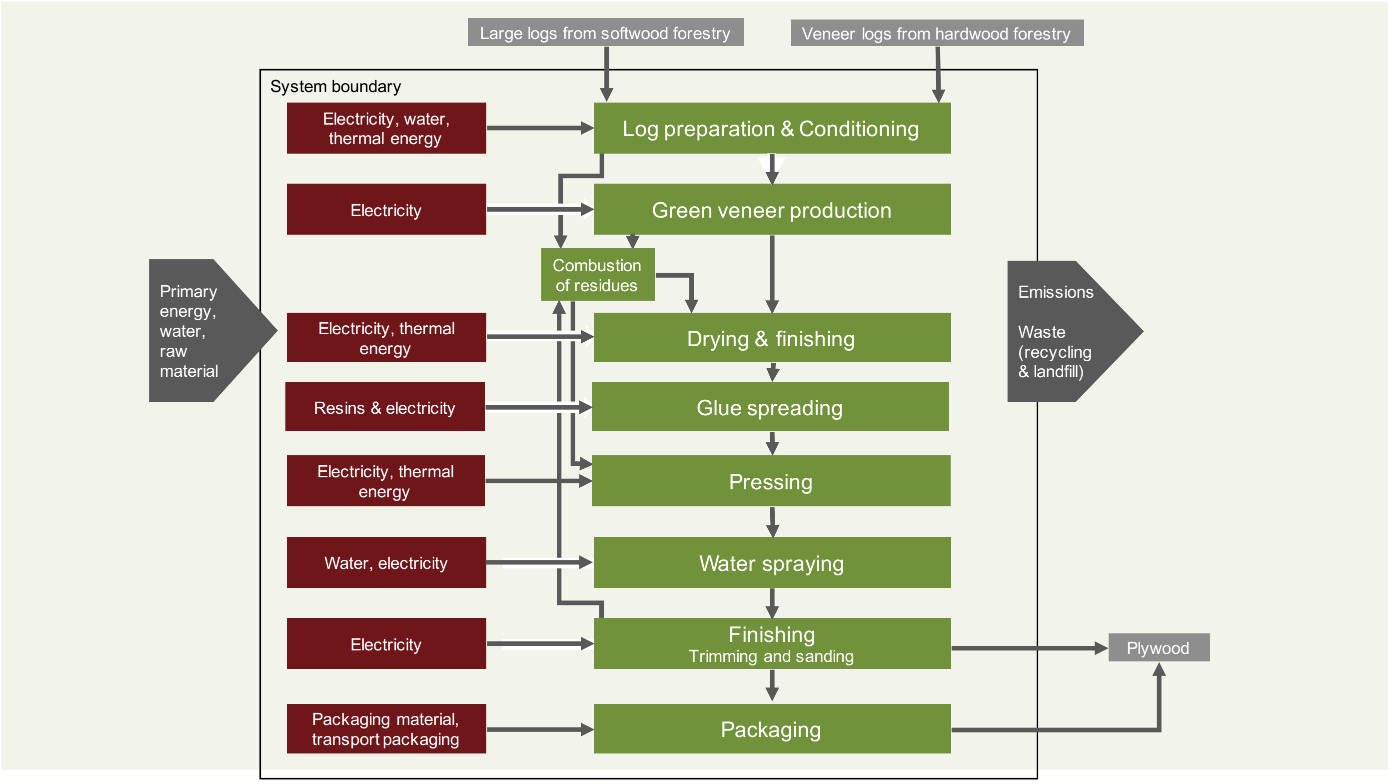
Production

Australian plywood can be produced from softwood or hardwood, with softwood plywood being the most common. This EPD represents average conditions, which includes a mixture of softwood veneer and hardwood veneer depending on the product type.

The manufacturing process starts by debarking and softening logs. Logs are then cut into billets and rotary peeled to produce veneers approximately 1.5 to 3 mm in thickness. The veneers are clipped, dried and then graded by appearance. Defects are repaired using putty.

Finished veneers are resin-bonded with the grain direction of each layer perpendicular to that of the previous layer and then hot pressed into a panel. A-bond (phenol formaldehyde) resin is most common, with B-bond (melamine urea formaldehyde) resin, used for formwork made from some hardwood species. The final board is cut to size, sanded, finished (e.g. with added grooves and polypropylene tongue for flooring) and then labelled/branded using ink or paint.

Plywood sheets are stacked in packs, held together with strapping. Some packs are also wrapped in plastic. A weighted average of all options is considered within this EPD.



End-of-Life

When a wood product reaches the end of its useful life, it may either be reused, recycled, landfilled or combusted to produce energy. Landfill is currently the most common end-of-life route for wood products in Australia. Reuse is also common for plywood formwork. All other scenarios are in use in certain regions (Forsythe Consultants 2007; National Timber Product Stewardship Group) and have been included within this EPD.

Each scenario assumes that 100% of the wood is sent to that scenario. To create an end-of-life mix for a given region or end use, the reader should take a weighted sum of these scenarios. Where no data are available, the 'landfill (typical)' scenario should be used for 100% of the waste.

Landfill

This EPD includes two scenarios for landfill, each with a different value for the degradable organic carbon fraction (DOCf) of wood. The two values are based on bioreactor laboratory research. This experimental work involves the testing of a range of waste types in reactors operated to obtain maximum methane yields. As the laboratory work optimises the conditions for anaerobic decay, the results can be considered as true estimates of the DOCf value that would apply over very long time horizons (Australian Government 2014a, p. 17).

- **Landfill (typical):** DOCf = 1.4%. This is based on bioreactor laboratory research by Wang et al. (2011). This value can be considered as an upper limit for degradation of carbon in solid wood placed in a landfill.
- **Landfill (NGA)**: DOCf = 10%. This is the value chosen for Australia's National Greenhouse Accounts (NGA) (Australian Government 2017). This is a reduction from the previous value of 23% (Australian Government 2014b) that was derived from early bioreactor laboratory research from the 1990s (e.g. Barlaz 1998) that investigated the degradability of wood tree branches ground to a fine powder under anaerobic conditions (Australian Government 2014a, p. 17). This DOCf value can be considered extremely conservative when compared to values from later research (as used in the typical scenario above) and effectively assumes that at least part of the wood waste is ground into a powder to accelerate degradation.

The impacts associated with the landfill are declared in module C4. All landfill gas that is combusted for energy recovery (module C4) is assumed to occur in a power plant with an electrical conversion efficiency of 36% (Australian Government 2014c, p. 189) and the resulting electricity receives a credit for offsetting average electricity from the Australian grid (module D) in line with EN 16485:2014 (Section 6.3.4.5).

Both landfill scenarios assume the following for carbon emissions:

- Of the gases formed from any degradation of wood in landfill, 50% is methane and 50% is carbon dioxide (Australian Government 2016, Table 43).
- All carbon dioxide is released directly to the atmosphere.
- 36% of the methane is captured, based on forecasted average methane capture in Australian landfills by
- 2020 (Hyder Consulting 2007). The year 2020 was chosen as landfill will take place in the future and this was the last year for which forecasts were available.
- Of this 36% captured, one quarter (9% of the total) is flared and three quarters (27% of the total) are used for energy recovery (Carre 2011).
- Of the 64% of methane that is not captured, 10% (6.4% of the total) is oxidised (Australian Government 2016, Table 43) and 90% (57.6%) is released to the atmosphere.
- In summary, for every kilogram of carbon converted to landfill gas, 71.2% is released as carbon dioxide and 28.8% is released as methane.

Energy recovery

This scenario includes shredding (module C3) and combustion with recovered energy offset against average thermal energy from natural gas (module D) in line with EN 16485:2014 (Section 6.3.4.5). Note that other options are also in use within Australia, including replacement of coal, replacement of electricity, and replacement of both electricity and thermal energy (via co-generation). The modelling assumes that the product waste has value after it has been sorted.

Recycling

Plywood may be recycled in many different ways. This scenario considers shredding and effectively downcycling into wood chips. Wood waste is chipped (module C3) and assigned credits relative to the avoided production of woodchips from virgin softwood, the primary material used for the veneers (module D). The sequestered CO_2 and energy content of the wood are assumed to leave the system boundary at C3 so that future product systems can also claim these without double-counting (EN 16485:2014, Section 6.3.4.2).

Reuse (for plywood formwork only)

The product is assumed to be removed from a building manually and reused with no further processing (i.e. direct reuse). Transport and wastage are excluded and only one reuse cycle is considered. The second life is assumed to be the same (or very similar) to the first, meaning that a credit is given for production of 1 m^2 of primary plywood formwork in module D. The sequestered CO_2 and energy content of the wood are assumed to leave the system boundary at module C3 so that future product systems can also claim these without double-counting in line with EN 16485:2014 (Section 6.3.4.2). Any further processing, waste or transport would need to be modelled and included separately.

Key Assumptions

Energy: Thermal energy and transport fuels have been modelled as the Australian average (see thinkstep 2017 for documentation). Electricity for production (modules A1-A3) has been modelled as a state-specific split based upon the electricity consumption of the manufacturers who contributed data to this study. Electricity at end-of-life (module C) has been modelled using an average Australian electricity mix as the location where the product reaches end-of-life is unknown.

Forestry: All breakdown of forest matter after harvest is modelled as aerobic and therefore carbon neutral as carbon sequestered is released as carbon dioxide. Any burning of forestry material left behind after logging is modelled as being carbon neutral, aside from the trace emissions of various organic gases (Commonwealth of Australia, 2016). All forestry is assumed to be sustainably managed and as such there are no carbon emissions associated with land use change. Loss of carbon from the soil is assumed to be zero (i.e. no significant erosion). It is assumed that all timber will be replanted (plantation forest) or will regrow (native forest) after bushfires.

Cut-off Criteria

Environmental impacts relating to personnel, infrastructure, and production equipment not directly consumed in the process are excluded from the system boundary as per the PCR (IEPDS 2017, Section 7.5.4). All other reported data were incorporated and modelled using the best available life cycle inventory data.

Allocation

Upstream data: For refinery products, allocation is done by mass and net calorific value. Inventories for electricity and thermal energy generation include allocation by economic value for some by-products (e.g. gypsum, boiler ash and fly ash). Allocation by energy is applied for co-generation of heat and power. For materials and chemicals, the allocation rule most suitable for the product is applied (see thinkstep 2017).

Co-products (e.g. veneer, clippings and sawdust): As the difference in economic value of the co-products is high (>25% as per EN 15804, Section 6.4.3.2), allocation has been done by economic value. Economic data were supplied by the plywood manufacturers.

Background Data

Data for primary wood inputs use the same forestry data as FWPA EPD #01 for Softwood Timber and EPD #02 for Hardwood Timber, but with different economic allocation factors.

Data for all energy inputs, transport processes and raw materials are from GaBi Databases 2017 (thinkstep 2017). Most datasets have a reference year between 2013 and 2015 and all fall within the 10-year limit allowable for generic data under EN 15804 (Section 6.3.7).

EPD Results

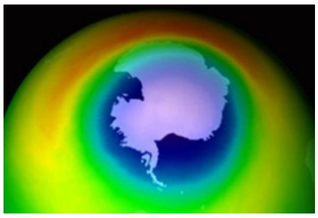
Note: these tables show the impacts associated with production and end-of-life. Any potential credits to future products from recycling or energy recovery are presented in the Other Environmental Information section.

Environmental Impact Indicators

An introduction to each environmental impact indicator is provided below. The best-known effect of each indicator is listed to the right of its name.

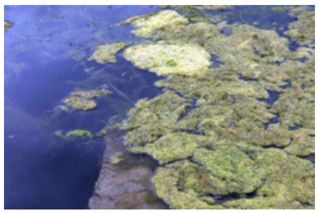
Global Warming Potential (GWP) → Climate Change
A measure of greenhouse gas emissions, such as carbon dioxide and methane. These emissions increase absorption of radiation emitted by the earth, intensifying the natural greenhouse effect. Contributions to GWP can come from either fossil or biogenic sources, e.g. burning fossil fuels or burning wood. GWP is reported as a total as well as being separated into biogenic carbon (GWPB) and fossil carbon (GWPF).

Ozone Depletion Potential (ODP) → Ozone Hole
A measure of air emissions that contribute to the depletion of the stratospheric ozone layer, causing higher levels of ultraviolet B (UVB) to reach the earth's surface with detrimental effects on humans, animals and plants.



Acidification Potential (AP) → Acid Rain
A measure of emissions that cause acidifying effects to the environment. Acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H^+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline and the deterioration of building materials.

Eutrophication Potential (EP) → Algal Blooms
A measure of nutrient enrichment that may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. It includes potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P).



Photochemical Ozone Creation Potential (POCP) → Smog
A measure of emissions of precursors that contribute to ground level smog formation (mainly ozone O_3), produced by the reaction of VOCs and carbon monoxide in the presence of nitrogen oxides under the influence of UV light. Ground level ozone may be harmful to human and ecosystem health and may also damage crops.

Abiotic Depletion Potential → Resource Consumption
The consumption of non-renewable resources leads to a decrease in the future availability of the functions supplied by these resources. Depletion of mineral resource elements (ADPE) and non-renewable fossil energy resources (ADPF) are reported separately.

Table 3: Environmental impacts, 1 m² of exterior plywood, A-bond, 7 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-2.32	0.682	2.39	6.04	6.04
GWPF [kg CO_2-eq.]	3.08	0.407	0.430	0.437	0.437
GWPB [kg CO_2-eq.]	-5.40	0.275	1.96	5.61	5.61
ODP [kg CFC11-eq.]	9.74E-12	1.95E-13	1.95E-13	1.51E-15	1.51E-15
AP [kg SO_2-eq.]	0.0143	0.00128	0.00139	2.20E-04	2.20E-04
EP [kg PO_4^{3}-eq.]	0.00368	1.64E-04	1.93E-04	5.16E-05	5.16E-05
POCP [kg C_2H_4-eq.]	0.00679	1.29E-04	4.62E-04	1.91E-05	1.91E-05
ADPE [kg Sb-eq.]	1.60E-06	8.09E-08	8.09E-08	4.37E-10	4.37E-10
ADPF [MJ]	50.9	5.85	5.85	0.457	0.457

Table 4: Environmental impacts, 1 m² of exterior plywood, A-bond, 9 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-3.18	0.876	3.07	7.75	7.75
GWPF [kg CO_2-eq.]	3.80	0.523	0.549	0.508	0.508
GWPB [kg CO_2-eq.]	-6.98	0.353	2.52	7.24	7.24
ODP [kg CFC11-eq.]	1.10E-11	2.50E-13	2.50E-13	1.94E-15	1.94E-15
AP [kg SO_2-eq.]	0.0182	0.00164	0.00178	2.83E-04	2.83E-04
EP [kg PO_4^{3}-eq.]	0.00464	2.11E-04	2.48E-04	6.63E-05	6.63E-05
POCP [kg C_2H_4-eq.]	0.00852	1.66E-04	5.93E-04	2.46E-05	2.46E-05
ADPE [kg Sb-eq.]	1.94E-06	1.04E-07	1.04E-07	5.61E-10	5.61E-10
ADPF [MJ]	61.0	7.52	7.52	0.587	0.587

Table 5: Environmental impacts, 1 m² of formply, A-bond, 17 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
GWP [kg CO_2-eq.]	-4.22	1.69	6.06	15.4	15.4	14.0
GWPF [kg CO_2-eq.]	8.95	0.993	1.07	1.43	1.43	0
GWPB [kg CO_2-eq.]	-13.2	0.699	5.00	14.0	14.0	14.0
ODP [kg CFC11-eq.]	3.83E-11	4.73E-13	4.73E-13	3.82E-15	3.82E-15	0
AP [kg SO_2-eq.]	0.0414	0.00311	0.00339	5.58E-04	5.58E-04	0
EP [kg PO_4^{3}-eq.]	0.0107	4.04E-04	4.89E-04	1.31E-04	1.31E-04	0
POCP [kg C_2H_4-eq.]	0.0258	3.22E-04	0.00117	4.84E-05	4.84E-05	0
ADPE [kg Sb-eq.]	4.81E-06	1.97E-07	1.97E-07	1.11E-09	1.11E-09	0
ADPF [MJ]	160	14.2	14.2	1.16	1.16	0

Table 6: Environmental impacts, 1 m² of formply, B-bond, 17 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
GWP [kg CO_2-eq.]	-5.06	1.71	6.15	15.7	15.7	14.6
GWPF [kg CO_2-eq.]	8.49	0.992	1.05	1.10	1.10	0
GWPB [kg CO_2-eq.]	-13.5	0.714	5.10	14.6	14.6	14.6
ODP [kg CFC11-eq.]	3.44E-11	4.74E-13	4.74E-13	4.06E-15	4.06E-15	0
AP [kg SO_2-eq.]	0.0439	0.00312	0.00341	5.93E-04	5.93E-04	0
EP [kg PO_4^{3}-eq.]	0.0128	0.00124	0.00646	1.39E-04	1.39E-04	0
POCP [kg C_2H_4-eq.]	0.0311	3.25E-04	0.00119	5.14E-05	5.14E-05	0
ADPE [kg Sb-eq.]	4.36E-06	1.97E-07	1.97E-07	1.17E-09	1.17E-09	0
ADPF [MJ]	120	14.2	14.2	1.23	1.23	0

Table 7: Environmental impacts, 1 m² of plywood flooring, A-bond, 15 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-5.45	1.46	5.12	12.9	12.9
GWPF [kg CO_2-eq.]	6.16	0.872	0.918	0.896	0.896
GWPB [kg CO_2-eq.]	-11.6	0.589	4.20	12.0	12.0
ODP [kg CFC11-eq.]	1.74E-11	4.17E-13	4.17E-13	3.23E-15	3.23E-15
AP [kg SO_2-eq.]	0.0293	0.00273	0.00297	4.72E-04	4.72E-04
EP [kg PO_4^{3}-eq.]	0.00762	3.52E-04	4.13E-04	1.10E-04	1.10E-04
POCP [kg C_2H_4-eq.]	0.0141	2.77E-04	9.90E-04	4.10E-05	4.10E-05
ADPE [kg Sb-eq.]	4.22E-06	1.73E-07	1.73E-07	9.35E-10	9.35E-10
ADPF [MJ]	100.0	12.5	12.5	0.978	0.978

Table 8: Environmental impacts, 1 m² of plywood flooring, A-bond, 25 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-8.41	2.44	8.56	21.6	21.6
GWPF [kg CO_2-eq.]	10.8	1.46	1.54	1.63	1.63
GWPB [kg CO_2-eq.]	-19.3	0.982	7.02	20.0	20.0
ODP [kg CFC11-eq.]	3.39E-11	6.96E-13	6.96E-13	5.39E-15	5.39E-15
AP [kg SO_2-eq.]	0.0494	0.00455	0.00495	7.87E-04	7.87E-04
EP [kg PO_4^{3}-eq.]	0.0129	5.87E-04	6.89E-04	1.84E-04	1.84E-04
POCP [kg C_2H_4-eq.]	0.0241	4.62E-04	0.00165	6.83E-05	6.83E-05
ADPE [kg Sb-eq.]	6.59E-06	2.89E-07	2.89E-07	1.56E-09	1.56E-09
ADPF [MJ]	182	20.9	20.9	1.63	1.63

Resource Use

Table 9: Resource use, 1 m² of exterior plywood, A-bond, 7 mm

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	40.8	0.369	0.369	0.00829	0.00829
PERM [MJ]	58.7	0	0	-58.7	-58.7
PERT [MJ]	99.5	0.369	0.369	-58.7	-58.7
PENRE [MJ]	51.3	5.96	5.96	0.457	0.457
PENRM [MJ]	4.36	0	0	-4.36	-4.36
PENRT [MJ]	55.7	5.96	5.96	-3.90	-3.90
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.0314	6.52E-05	2.56E-04	5.01E-06	5.01E-06

***PERE** = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; **PERM** = Use of renewable primary energy resources used as raw materials; **PERT** = Total use of renewable primary energy resources; **PENRE** = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; **PENRM** = Use of non-renewable primary energy resources used as raw materials; **PENRT** = Total use of non-renewable primary energy resources; **SM** = Use of secondary material; **RSF** = Use of renewable secondary fuels; **NRSF** = Use of non-renewable secondary fuels; **FW** = Net use of fresh water*

Table 10: Resource use, 1 m² of exterior plywood, A-bond, 9 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	51.4	0.475	0.475	0.0107	0.0107
PERM [MJ]	75.9	0	0	-75.9	-75.9
PERT [MJ]	127	0.475	0.475	-75.9	-75.9
PENRE [MJ]	61.5	7.66	7.66	0.587	0.587
PENRM [MJ]	5.01	0	0	-5.01	-5.01
PENRT [MJ]	66.5	7.66	7.66	-4.42	-4.42
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.0398	8.37E-05	3.28E-04	6.44E-06	6.44E-06

Table 11: Resource use, 1 m² of exterior plywood, A-bond, 17 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
PERE [MJ]	117	0.897	0.897	0.0210	0.0210	0
PERM [MJ]	146	0	0	-146	-146	-146
PERT [MJ]	264	0.897	0.897	-146	-146	-146
PENRE [MJ]	162	14.5	14.5	1.16	1.16	0
PENRM [MJ]	14.4	0	0	-14.4	-14.4	-14.4
PENRT [MJ]	176	14.5	14.5	-13.2	-13.2	-14.4
SM [kg]	0	0	0	0	0	0
RSF [MJ]	0	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0	0
FW [m³]	0.0904	1.64E-04	6.50E-04	1.27E-05	1.27E-05	0

Table 12: Resource use, 1 m² of formply, B-bond, 17 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
PERE [MJ]	97.9	0.898	0.898	0.0223	0.0223	0
PERM [MJ]	152	0	0	-152	-152	-152
PERT [MJ]	249	0.898	0.898	-152	-152	-152
PENRE [MJ]	121	14.5	14.5	1.23	1.23	0
PENRM [MJ]	12.9	0	0	-12.9	-12.9	-12.9
PENRT [MJ]	134	14.5	14.5	-11.7	-11.7	-12.9
SM [kg]	0	0	0	0	0	0
RSF [MJ]	0	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0	0
FW [m³]	0.0935	1.67E-04	6.61E-04	1.35E-05	1.35E-05	0

Table 13: Resource use, 1 m² of plywood flooring, A-bond, 15 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	85.4	0.791	0.791	0.0177	0.0177
PERM [MJ]	132	0	0	-132	-132
PERT [MJ]	218	0.791	0.791	-132	-132
PENRE [MJ]	101	12.8	12.8	0.978	0.978
PENRM [MJ]	9.53	0	0	-9.53	-9.53
PENRT [MJ]	111	12.8	12.8	-8.56	-8.56
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.0638	1.40E-04	5.47E-04	1.07E-05	1.07E-05

Table 14: Resource use, 1 m² of plywood flooring, A-bond, 25 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	146	1.32	1.32	0.0296	0.0296
PERM [MJ]	210	0	0	-210	-210
PERT [MJ]	356	1.32	1.32	-210	-210
PENRE [MJ]	184	21.3	21.3	1.63	1.63
PENRM [MJ]	16.5	0	0	-16.5	-16.5
PENRT [MJ]	200	21.3	21.3	-14.8	-14.8
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.109	2.33E-04	9.14E-04	1.79E-05	1.79E-05

Waste and Output Flows

Table 15: Waste categories, 1 m² of interior plywood, A-bond, 7 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	2.60E-08	1.80E-08	1.80E-08	7.57E-10	7.57E-10
NHWD [kg]	0.305	3.39	2.89	3.15E-06	3.15E-06
RWD [kg]	1.55E-04	4.25E-05	4.25E-05	2.74E-08	2.74E-08
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	3.45
MER [kg]	0	0	0	3.45	0
EEE [MJ]	0	0.0744	0.531	0	0
EET [MJ]	0	0	0	0	0

***HWD** = Hazardous waste disposed; **NHWD** = Non-hazardous waste disposed; **RWD** = Radioactive waste disposed;*
***CRU** = Components for reuse; **MFR** = Materials for recycling; **MER** = Materials for energy recovery;*
***EEE** = Exported electrical energy; **EET** = Exported thermal energy*

Table 16: Waste categories, 1 m2 of exterior plywood, A-bond, 9 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	3.15E-08	2.32E-08	2.32E-08	9.73E-10	9.73E-10
NHWD [kg]	0.386	4.36	3.72	4.04E-06	4.04E-06
RWD [kg]	1.78E-04	5.47E-05	5.47E-05	3.53E-08	3.53E-08
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	4.44
MER [kg]	0	0	0	4.44	0
EEE [MJ]	0	0.0954	0.681	0	0
EET [MJ]	0	0	0	0	0

Table 17: Waste categories, 1 m² of formply, A-bond, 17 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
HWD [kg]	1.96E-07	4.46E-08	4.46E-08	1.92E-09	1.92E-09	0
NHWD [kg]	0.804	8.58	7.30	7.97E-06	7.97E-06	0
RWD [kg]	6.19E-04	1.03E-04	1.03E-04	6.95E-08	6.95E-08	0
CRU [kg]	0	0	0	0	0	8.75
MFR [kg]	0	0	0	0	8.75	0
MER [kg]	0	0	0	8.75	0	0
EEE [MJ]	0	0.190	1.36	0	0	0
EET [MJ]	0	0	0	0	0	0

Table 18: Waste categories, 1 m² of formply, B-bond, 17 mm.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
HWD [kg]	1.29E-07	4.59E-08	4.59E-08	2.04E-09	2.04E-09	0
NHWD [kg]	0.765	9.11	7.79	8.46E-06	8.46E-06	0
RWD [kg]	6.93E-04	1.03E-04	1.03E-04	7.38E-08	7.38E-08	0
CRU [kg]	0	0	0	0	0	9.28
MFR [kg]	0	0	0	0	9.28	0
MER [kg]	0	0	0	9.28	0	0
EEE [MJ]	0	0.193	1.38	0	0	0
EET [MJ]	0	0	0	0	0	0

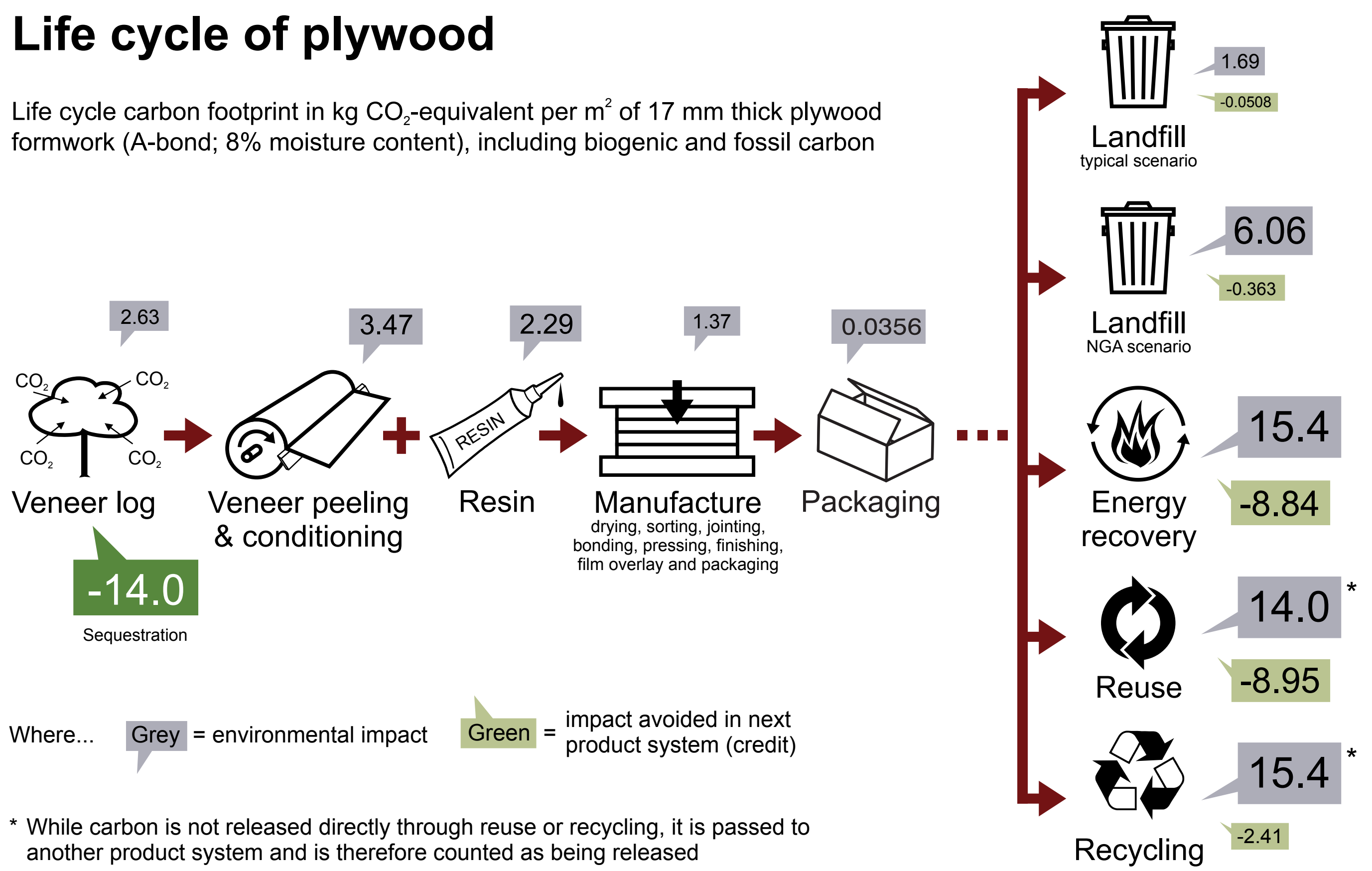
Table 19: Waste categories, 1 m² of plywood flooring, A-bond, 15 mm

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	5.24E-08	3.86E-08	3.86E-08	1.62E-09	1.62E-09
NHWD [kg]	0.634	7.26	6.19	6.74E-06	6.74E-06
RWD [kg]	3.19E-04	9.11E-05	9.11E-05	5.88E-08	5.88E-08
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	7.40
MER [kg]	0	0	0	7.40	0
EEE [MJ]	0	0.159	1.14	0	0
EET [MJ]	0	0	0	0	0

Table 20: Waste categories, 1 m² of plywood flooring, A-bond, 25 mm

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	9.39E-08	6.44E-08	6.44E-08	2.70E-09	2.70E-09
NHWD [kg]	1.06	12.1	10.3	1.12E-05	1.12E-05
RWD [kg]	5.73E-04	1.52E-04	1.52E-04	9.79E-08	9.79E-08
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	12.3
MER [kg]	0	0	0	12.3	0
EEE [MJ]	0	0.266	1.90	0	0
EET [MJ]	0	0	0	0	0

Understanding the Life Cycle of Plywood



Variation in Results

The data in this EPD are an average from multiple producers; however, there can be considerable variation between producers. Please contact your timber supplier if you require data on a specific product from that supplier.

Table 21: Inter-site variability for exterior plywood (modules A1-A3).

	Ext 7 mm			Ext 9 mm		
Parameter [Unit]	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**
GWP [kg CO_2-eq.]	-16.3%	+80.5%	±28.1%	-8.3%	+91.3%	±40.7%
GWPF [kg CO_2-eq.]	-2.0%	+48.2%	±22.1%	-7.8%	+76.1%	±34.3%
GWPB [kg CO_2-eq.]	-6.8%	+8.1%	±0.6%	-0.9%	+0.4%	±0.6%
ODP [kg CFC11-eq.]	-6.1%	+96.1%	±47.6%	-15.5%	+159.9%	±82.1%
AP [kg SO_2-eq.]	-17.5%	+28.6%	±19.2%	-20.4%	+47.5%	±27.8%
EP [kg PO_4^{3}-eq.]	-15.3%	+11.2%	±11.5%	-16.6%	+22.0%	±16.0%
POCP [kg C_2H_4-eq.]	-22.6%	+13.2%	±14.6%	-23.5%	+11.5%	±16.0%
ADPE [kg Sb-eq.]	-1.1%	+30.2%	±14.5%	-4.9%	+56.1%	±28.3%
ADPF [MJ]	-12.7%	+62.8%	±34.7%	-18.5%	+99.0%	±48.5%

***Min** = (minimum - average) / average; **Max** = (maximum - average) / average;*
***CV** = coefficient of variation = standard deviation / average*

Table 22: Inter-site variability for formply (modules A1-A3).

	Form A-Bond 17 mm			Form B-Bond 17 mm		
Parameter [Unit]	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**
GWP [kg CO_2-eq.]	-134.3%	+109.3%	±99.5%	-40.4%	+40.4%	±0.0%
GWPF [kg CO_2-eq.]	-43.3%	+47.8%	±37.2%	-22.8%	+22.8%	±0.0%
GWPB [kg CO_2-eq.]	-13.6%	+2.5%	±7.0%	-0.8%	+0.8%	±0.0%
ODP [kg CFC11-eq.]	-42.1%	+13.5%	±23.3%	-1.0%	+1.0%	±0.0%
AP [kg SO_2-eq.]	-13.9%	+8.3%	±9.7%	-17.4%	+17.4%	±0.0%
EP [kg PO_4^{3}-eq.]	-13.1%	+18.1%	±12.9%	-19.2%	+19.2%	±0.0%
POCP [kg C_2H_4-eq.]	-39.9%	+121.6%	±71.5%	-17.6%	+17.6%	±0.0%
ADPE [kg Sb-eq.]	-25.2%	+4.5%	±13.2%	-8.2%	+8.2%	±0.0%
ADPF [MJ]	-46.0%	+59.1%	±43.4%	-19.3%	+19.3%	±0.0%

Table 23: Inter-site variability for plywood flooring (modules A1-A3).

	Floor 15 mm			Floor 25 mm		
Parameter [Unit]	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**
GWP [kg CO_2-eq.]	-0.5%	+49.4%	±24.5%	-14.6%	+81.6%	±33.5%
GWPF [kg CO_2-eq.]	-0.5%	+45.3%	±22.9%	-2.3%	+51.3%	±26.8%
GWPB [kg CO_2-eq.]	-0.9%	+0.5%	±0.7%	-6.7%	+7.7%	±0.5%
ODP [kg CFC11-eq.]	-5.0%	+8.3%	±6.6%	-9.9%	+10.1%	±10.0%
AP [kg SO_2-eq.]	-16.5%	+14.4%	±15.4%	-9.8%	+13.5%	±11.7%
EP [kg PO_4^{3}-eq.]	-14.8%	+10.8%	±12.8%	-9.4%	+8.7%	±9.0%
POCP [kg C_2H_4-eq.]	-22.5%	+12.8%	±17.7%	-18.2%	+9.9%	±14.0%
ADPE [kg Sb-eq.]	-22.9%	+8.5%	±15.7%	-8.1%	+5.7%	±6.9%
ADPF [MJ]	-11.0%	+66.1%	±38.6%	-14.1%	+69.7%	±41.9%

Carbon Dioxide Sequestration

During growth, trees absorb carbon dioxide (CO2) from the atmosphere through the process of photosynthesis and convert this into carbon-based compounds that constitute various components of a tree, including wood. On average, half the dry weight of all wood is made up of the element carbon (Gifford 2000).

All major Australian production forests and plantations are independently certified to one or both of the internationally recognised forest management certification systems: the Australian Standard for Sustainable Forest Management (AS 4708), which is recognised under the Programme for the Endorsement of Forest Certification (PEFC), and/or one of the Forest Stewardship Council's (FSC®) interim forest management standards. It is therefore appropriate to include biogenic CO2 sequestration in this EPD in line with EN 16485 (Section 6.3.4.2).

Module D: Recycling, Reuse and Recovery Potentials

Table 24: Module D, 1 m² of exterior plywood, A-bond, 7 mm.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0199	-0.142	-3.63	-0.991
GWPF [kg CO_2-eq.]	-0.0199	-0.142	-3.64	-0.947
GWPB [kg CO_2-eq.]	-4.06E-07	-2.90E-06	0.00886	-0.0438
ODP [kg CFC11-eq.]	-5.68E-16	-4.06E-15	7.26E-15	-8.26E-14
AP [kg SO_2-eq.]	-8.77E-05	-6.26E-04	-5.35E-04	-0.00730
EP [kg PO_4^{3}-eq.]	-7.40E-06	-5.29E-05	-2.63E-04	-0.00169
POCP [kg C_2H_4-eq.]	-4.57E-06	-3.27E-05	6.06E-04	-0.00300
ADPE [kg Sb-eq.]	-1.48E-09	-1.06E-08	-2.39E-07	-1.80E-07
ADPF [MJ]	-0.227	-1.62	-69.7	-12.1
Resource Use				
PERE [MJ]	-0.0255	-0.182	-0.00511	-17.5
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.0255	-0.182	-0.00511	-17.5
PENRE [MJ]	-0.227	-1.62	-69.7	-12.1
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.227	-1.62	-69.7	-12.1
SM [kg]	0	0	0	3.45
RSF [MJ]	0	0	58.7	0
NRSF [MJ]	0	0	4.36	0
FW [m^3]	-1.18E-04	-8.40E-04	6.59E-04	-0.00373
Wastes and Outputs				
HWD [kg]	-2.99E-11	-2.14E-10	-5.33E-09	-3.56E-09
NHWD [kg]	-5.79E-05	-4.13E-04	0.165	-0.125
RWD [kg]	-2.79E-08	-2.00E-07	1.27E-06	-4.38E-06
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 25: Module D, 1 m² of exterior plywood, A-bond, 9 mm.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0255	-0.182	-4.70	-1.27
GWPF [kg CO_2-eq.]	-0.0255	-0.182	-4.71	-1.22
GWPB [kg CO_2-eq.]	-5.21E-07	-3.72E-06	0.0114	-0.0563
ODP [kg CFC11-eq.]	-7.29E-16	-5.20E-15	2.66E-15	-1.06E-13
AP [kg SO_2-eq.]	-1.12E-04	-8.03E-04	-6.37E-04	-0.00939
EP [kg PO_4^{3}-eq.]	-9.49E-06	-6.78E-05	-3.26E-04	-0.00217
POCP [kg C_2H_4-eq.]	-5.86E-06	-4.19E-05	7.87E-04	-0.00386
ADPE [kg Sb-eq.]	-1.90E-09	-1.35E-08	-3.07E-07	-2.32E-07
ADPF [MJ]	-0.291	-2.08	-89.4	-15.6
Resource Use				
PERE [MJ]	-0.0327	-0.233	-0.00749	-22.6
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.0327	-0.233	-0.00749	-22.6
PENRE [MJ]	-0.291	-2.08	-89.4	-15.6
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.291	-2.08	-89.4	-15.6
SM [kg]	0	0	0	4.44
RSF [MJ]	0	0	75.9	0
NRSF [MJ]	0	0	5.01	0
FW [m^3]	-1.51E-04	-0.00108	7.46E-04	-0.00480
Wastes and Outputs				
HWD [kg]	-3.84E-11	-2.74E-10	-6.84E-09	-4.58E-09
NHWD [kg]	-7.42E-05	-5.30E-04	0.213	-0.160
RWD [kg]	-3.58E-08	-2.56E-07	1.21E-06	-5.64E-06
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 26: Module D, 1 m² of formply, A-bond, 17 mm.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Environmental Impact					
GWP [kg CO_2-eq.]	-0.0508	-0.363	-8.84	-2.41	-8.95
GWPF [kg CO_2-eq.]	-0.0508	-0.363	-8.86	-2.30	-8.95
GWPB [kg CO_2-eq.]	-1.04E-06	-7.42E-06	0.0221	-0.106	0
ODP [kg CFC11-eq.]	-1.45E-15	-1.04E-14	7.29E-14	-2.00E-13	-3.83E-11
AP [kg SO_2-eq.]	-2.24E-04	-0.00160	-0.00165	-0.0177	-0.0414
EP [kg PO_4^{3}-eq.]	-1.89E-05	-1.35E-04	-7.34E-04	-0.00410	-0.0107
POCP [kg C_2H_4-eq.]	-1.17E-05	-8.35E-05	0.00148	-0.00728	-0.0258
ADPE [kg Sb-eq.]	-3.78E-09	-2.70E-08	-6.07E-07	-4.38E-07	-4.81E-06
ADPF [MJ]	-0.580	-4.14	-177	-29.5	-160
Resource Use					
PERE [MJ]	-0.0651	-0.465	-0.00521	-42.6	-117
PERM [MJ]	0	0	0	0	0
PERT [MJ]	-0.0651	-0.465	-0.00521	-42.6	-117
PENRE [MJ]	-0.580	-4.14	-177	-29.5	-162
PENRM [MJ]	0	0	0	0	-14.4
PENRT [MJ]	-0.580	-4.14	-177	-29.5	-176
SM [kg]	0	0	0	8.75	8.75
RSF [MJ]	0	0	146	0	0
NRSF [MJ]	0	0	14.4	0	0
FW [m^3]	-3.01E-04	-0.00215	0.00248	-0.00906	-0.0904
Wastes and Outputs					
HWD [kg]	-7.65E-11	-5.46E-10	-1.36E-08	-8.65E-09	-1.96E-07
NHWD [kg]	-1.48E-04	-0.00106	0.410	-0.303	-0.804
RWD [kg]	-7.14E-08	-5.10E-07	6.69E-06	-1.06E-05	-6.19E-04
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	0
MER [kg]	0	0	0	0	0
EEE [MJ]	0	0	0	0	0
EET [MJ]	0	0	0	0	0

Table 27: Module D, 1 m^2 of formply, B-bond, 17 mm.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling	Reuse
Environmental Impact					
GWP [kg CO_2-eq.]	-0.0517	-0.369	-9.28	-2.41	-8.49
GWPF [kg CO_2-eq.]	-0.0517	-0.369	-9.31	-2.30	-8.49
GWPB [kg CO_2-eq.]	-1.06E-06	-7.54E-06	0.0233	-0.106	0
ODP [kg CFC11-eq.]	-1.48E-15	-1.05E-14	1.85E-13	-2.00E-13	-3.44E-11
AP [kg SO_2-eq.]	-2.28E-04	-0.00163	0.00337	-0.0177	-0.0439
EP [kg PO_4^{3}-eq.]	-1.92E-05	-1.37E-04	5.75E-04	-0.00410	-0.0128
POCP [kg C_2H_4-eq.]	-1.19E-05	-8.48E-05	0.00184	-0.00728	-0.0311
ADPE [kg Sb-eq.]	-3.84E-09	-2.74E-08	-6.07E-07	-4.38E-07	-4.36E-06
ADPF [MJ]	-0.589	-4.21	-180	-29.5	-120
Resource Use					
PERE [MJ]	-0.0661	-0.472	0.0636	-42.6	-97.9
PERM [MJ]	0	0	0	0	0
PERT [MJ]	-0.0661	-0.472	0.0636	-42.6	-97.9
PENRE [MJ]	-0.589	-4.21	-180	-29.5	-121
PENRM [MJ]	0	0	0	0	-12.9
PENRT [MJ]	-0.589	-4.21	-180	-29.5	-134
SM [kg]	0	0	0	9.28	9.28
RSF [MJ]	0	0	152	0	0
NRSF [MJ]	0	0	12.9	0	0
FW [m^3]	-3.05E-04	-0.00218	0.00285	-0.00906	-0.0935
Wastes and Outputs					
HWD [kg]	-7.77E-11	-5.55E-10	-1.36E-08	-8.65E-09	-1.29E-07
NHWD [kg]	-1.50E-04	-0.00107	0.428	-0.303	-0.765
RWD [kg]	-7.26E-08	-5.18E-07	2.35E-05	-1.06E-05	-6.93E-04
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	0
MER [kg]	0	0	0	0	0
EEE [MJ]	0	0	0	0	0
EET [MJ]	0	0	0	0	0

Table 28: Module D, 1 m² of plywood flooring, A-bond, 15 mm.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0426	-0.304	-8.27	-2.12
GWPF [kg CO_2-eq.]	-0.0426	-0.304	-8.29	-2.03
GWPB [kg CO_2-eq.]	-8.70E-07	-6.22E-06	0.0191	-0.0938
ODP [kg CFC11-eq.]	-1.22E-15	-8.69E-15	9.46E-16	-1.77E-13
AP [kg SO_2-eq.]	-1.88E-04	-0.00134	-0.00175	-0.0156
EP [kg PO_4^{3}-eq.]	-1.59E-05	-1.13E-04	-7.11E-04	-0.00362
POCP [kg C_2H_4-eq.]	-9.79E-06	-6.99E-05	0.00125	-0.00643
ADPE [kg Sb-eq.]	-3.17E-09	-2.26E-08	-5.38E-07	-3.86E-07
ADPF [MJ]	-0.486	-3.47	-157	-26.0
Resource Use				
PERE [MJ]	-0.0545	-0.390	-0.0141	-37.6
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.0545	-0.390	-0.0141	-37.6
PENRE [MJ]	-0.486	-3.47	-157	-26.0
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.486	-3.47	-157	-26.0
SM [kg]	0	0	0	7.40
RSF [MJ]	0	0	132	0
NRSF [MJ]	0	0	9.53	0
FW [m^3]	-2.52E-04	-0.00180	0.00126	-0.00800
Wastes and Outputs				
HWD [kg]	-6.41E-11	-4.58E-10	-1.21E-08	-7.63E-09
NHWD [kg]	-1.24E-04	-8.85E-04	0.353	-0.267
RWD [kg]	-5.98E-08	-4.27E-07	1.84E-06	-9.39E-06
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 29: Module D, 1 m² of plywood flooring, A-bond, 25 mm.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
GWP [kg CO_2-eq.]	-0.0712	-0.508	-12.9	-3.54
GWPF [kg CO_2-eq.]	-0.0712	-0.508	-13.0	-3.38
GWPB [kg CO_2-eq.]	-1.45E-06	-1.04E-05	0.0315	-0.156
ODP [kg CFC11-eq.]	-2.03E-15	-1.45E-14	4.04E-14	-2.95E-13
AP [kg SO_2-eq.]	-3.14E-04	-0.00224	-0.00212	-0.0261
EP [kg PO_4^{3-}-eq.]	-2.65E-05	-1.89E-04	-9.88E-04	-0.00603
POCP [kg C_2H_4-eq.]	-1.64E-05	-1.17E-04	0.00213	-0.0107
ADPE [kg Sb-eq.]	-5.29E-09	-3.78E-08	-8.59E-07	-6.44E-07
ADPF [MJ]	-0.811	-5.80	-250	-43.3
Resource Use				
PERE [MJ]	-0.0911	-0.651	-0.0164	-62.6
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.0911	-0.651	-0.0164	-62.6
PENRE [MJ]	-0.812	-5.80	-250	-43.4
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-0.812	-5.80	-250	-43.4
SM [kg]	0	0	0	12.3
RSF [MJ]	0	0	210	0
NRSF [MJ]	0	0	16.5	0
FW [m^3]	-4.21E-04	-0.00301	0.00258	-0.0133
Wastes and Outputs				
HWD [kg]	-1.07E-10	-7.65E-10	-1.92E-08	-1.27E-08
NHWD [kg]	-2.07E-04	-0.00148	0.586	-0.445
RWD [kg]	-1.00E-07	-7.14E-07	5.47E-06	-1.57E-05
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Water Consumption

The "FW" indicator in the EPD results tables reports consumption (i.e. net use) of 'blue' water (which includes river water, lake water and ground water). This indicator deliberately excludes consumption of 'green' water (rain water).

PCR 2012:01 (Section 16.1) states that all water loss from a drainage basin is considered consumption, including any net loss of rain water. According to the PCR, net loss should be interpreted as any additional water loss beyond what would occur in the original, natural system. For plantation softwood forestry, the natural system might be a native forest or a grassland (Quinteiro et al. 2015).

The initial version of this EPD (v1.0) included estimated losses of rain water in the main results tables, labelled as green water consumption. These values were based on calculated differences in water flow between plantation forests and a base case land use (pasture) from the original CSIRO LCI study (CSIRO 2009).

Table 30 reports green water consumption calculated by CSIRO using 2005-08 data. These values have not been updated and are now reported here rather than in the main results tables to reflect their uncertainty. At the time of writing, there is no internationally agreed method for calculating green water consumption due to evapotranspiration relative to a hypothetical natural state (Manzardo et al. 2016). As such, different calculation methods may yield significantly different results, introducing a high level of uncertainty.

The reader should also be aware that water consumption does not account for relative water stress in the catchment(s) where the forest is located, meaning that it provides no information about the potential impacts of any water consumption that does occur.

Table 30: Green water consumption estimates for modules A1-A3 from CSIRO (2009).

	Ext 7 mm	**Ext 9 mm**	**Form A-Bond 17 mm**	**Form B-Bond 17 mm**	**Floor 15 mm**	**Floor 25 mm**
Parameter [Unit]	A1-A3	A1-A3	A1-A3	A1-A3	A1-A3	A1-A3
Green water consumption in forest [m3]	4.69	5.88	14.7	15.1	9.81	16.8

Timber & Forest Certification

Many Australian timber and reconstituted wood products are certified to a forest certification scheme. This certification is an independent auditing process that provides:

- Assurance that the timber is from well-managed forests certified to internationally and nationally accepted forest management standards
- Assurance that the timber is from legally harvested sources
- Chain of custody (CoC) certification extending from the forest to the end user, which is traceable throughout the supply chain.

Two schemes apply to Australian wood production forests. One is administered by the Australian Forestry Standard Ltd (AFS). The AFS scheme is also endorsed by the international Programme for Endorsement of Forest Certification (PEFC). The other scheme is administered by the Forest Stewardship Council (FSC®) Australia.

If a Green Star project elects to use the timber credit as part of their Green Star submission, the Green Building Council of Australia recognises PEFC-endorsed forest certification schemes (such as the Australian Forest Certification Scheme, AFCS) as well as FSC®. Compliance with the chain of custody certification rules of either forest certification scheme for at least 95% by value of timber products used in the project will meet the requirements for this credit point (GBCA 2014).

As of 2017, there are more than 26.7million hectares of native and plantation forests certified under AFS (AFS 2017) and 1.2 million hectares certified under FSC® interim national standards (FSC 2017).

All Australian plywood manufacturers are chain of custody certified so they can supply certified products.

Land Use and Biodiversity

Like other land uses, forestry operations for timber and wood production can have both positive and negative effects on biodiversity. However, as biodiversity varies considerably by region and as data are often limited, assessing potential biodiversity impacts within LCA is challenging.

An Australian study completed shortly before initial publication of this EPD (Turner et al. 2014) demonstrated a new method – BioImpact – to discern the biodiversity impacts of different land uses. A trial of this method was conducted using case studies in three different regions and four production systems in New South Wales: native hardwood forestry, plantation softwood forestry, mixed cropping and rangeland grazing. Managed forestry resulted in biodiversity impacts equivalent to or better than those of cropping/grazing systems.

Indoor Environment Quality – Formaldehyde Emissions Minimisation

Formaldehyde is a colourless, strong-smelling gas that occurs naturally in the environment. It is present in the air that we breathe at natural background levels of about 0.03 parts per million (ppm) and up to 0.08 ppm in outdoor urban air (EWPAA 2012). Formaldehyde is used as an ingredient in synthetic resins, industrial chemicals and preservatives, and in the production of paper, textiles, cosmetics, disinfectants, medicines, paints, varnishes and lubricants.

The majority (>90%) of plywood products are manufactured in Australia using the adhesive phenol formaldehyde (PF). A small volume (<10%) is produced using an amino plastic, which includes melamine urea formaldehyde (MUF) and urea formaldehyde (UF).

To assure end users that they are using plywood with the lowest possible formaldehyde emissions, an industry-wide formaldehyde testing and labelling program is run by the Engineered Wood Products Association of Australasia. All mills are required to forward samples to EWPAA's National Laboratory on a regular basis for formaldehyde emission testing. On the basis of these laboratory tests, certified mills are permitted to brand a formaldehyde emission class on their plywood products as detailed in Table 27.

Table 31: Formaldehyde emission classes.

Emission class	Emission limit (mg/litre)	Emission limit (ppm)*	Adhesive associated with emission class
Super E0 / (equivalent to F☆☆☆☆)	Less than or equal to 0.3	Less than or equal to 0.03	A-bond (phenol formaldehyde)
E0	Less than or equal to 0.5	Less than or equal to 0.04	B and C bonds (melamine urea formaldehyde and urea formaldehyde)
E1	Less than or equal to 1.0	Less than or equal to 0.08	B and C bonds (melamine urea formaldehyde and urea formaldehyde)

** Based on a test chamber volume of 10litre, zero airflow during the 24hr test cycle, molecular weight of formaldehyde 30.03 and the number of microlitres of formaldehyde gas in 1 micromole at 101KPa and 298K.*

All Australian manufacturers listed in this EPD can supply test certificates that support their emission class.

Plywood with formaldehyde emissions less than or equal to Super E0 (the majority of Australian produced plywood products) are compliant with the Green Star Formaldehyde credit. Other plywood products, which have emissions less than or equal to E1, are also compliant. To achieve credit point(s) all engineered wood products such as particleboard, MDF and plywood used in the project must be in accordance with these requirements.

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Environmental Product Declaration
Glued Laminated Timber (Glulam)

Environmental Product Declaration (EPD)
in accordance with ISO 14025 and EN 15804

EPD Registration No. S-P-00565 | Version 1
Issued 8 December 2017 | Valid until 8 December 2022

Geographical Scope: Australia

WoodSolutions
design and build
woodsolutions.com.au

Environmental Product Declarations

WoodSolutions has developed a suite of EPDs for industry-average, Australian-produced timber products.

These EPDs help to showcase the environmental credentials of Australian wood products. They also provide life cycle data for calculating the impacts of wood products at a building level.

EPDs include:

#01 Softwood Timber

#02 Hardwood Timber

#03 Particleboard

#04 Medium Density Fibreboard (MDF)

#05 Plywood

#06 Glued Laminated Timber (Glulam)

WoodSolutions is an industry initiative designed to provide independent, non-proprietary information about timber and wood products to professionals and companies involved in building design and construction.

WoodSolutions is resourced by Forest and Wood Products Australia (FWPA). It is a collaborative effort between FWPA members and levy payers, supported by industry peak bodies and technical associations.

This work is supported by funding provided to FWPA by the Commonwealth Government.

ISBN: 978-1-925213-48-5

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Produced: December 2017

EPD Details

An Environmental Product Declaration, or EPD, is a standardised and verified way of quantifying the environmental impacts of a product that is based on a consistent set of rules known as a PCR (Product Category Rules).

EPDs within the same product category from different programs may not be comparable. EPDs of construction products may not be comparable if they do not comply with EN 15804.

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CEN standard EN 15804 served as the core PCR

PCR:
PCR 2012:01 Construction products and Construction services, Version 2.2, 2017-05-30

PCR review was conducted by:
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Independent verification of the declaration and data, according to ISO 14025:
☐ EPD process certification (Internal)
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Introduction

This Environmental Product Declaration presents the average performance of glued-laminated timber (glulam) manufactured in Australia from Australian grown wood. It recognises the importance of transparency by providing information on the raw materials, production and environmental impacts of Australian glulam.

This EPD has been prepared in accordance with ISO 14025:2006, EN 15804:2013 and PCR 2012:01 (IEPDS 2017). In addition to decorative glulam it covers structural glulam timbers produced in accordance with the following standard:

- *AS/NZS 1328.1:1998 Glued laminated structural timber - Performance requirements and minimum production requirements*

The environmental data presented in this document are primarily derived from a survey of industry members covering the 2015/16 financial year conducted by thinkstep and Stephen Mitchell Associates on behalf of FWPA. This study covers approximately 64% of total glulam production in Australia.

Production of this EPD has been facilitated by FWPA with the participation of its current glulam-producing members and producer members of the Glued Laminated Timber Association of Australia (GLTAA).

The following companies contributed to this EPD:

Company	Financial contributor	Data contributor
Australasian Sustainable Hardwoods	X	X
Hyne	X	X
VicBeam		X
Warrnambool Timber Industries		X

Description of the Australian Glulam Industry

The Australian glulam manufacturing industry grew out of the need to make better use of short fall down sawn timber and to add value to that resource. Annual glulam consumption in Australia is approximately 30,000 cubic metres, which is 0.6% of total timber consumption (GLTAA 2017). In 2015-16, Australian structural glulam was primarily produced in six different facilities. These producers also produce decorative glulam. There are numerous other producers of decorative glulam products in Australia.

Description of Glulam Products

Glulam is a type of engineered wood product made up of a number of layers of sawn timber bonded together with adhesives. This process produces larger size and longer length members, which can be curved or straight. Timbers used in the production of glulam are typically finger-jointed into continuous lengths and available in a range of both softwood and hardwood species. The thickness of the laminates depends on the application and species used.

Glulam products are either structural or decorative (non-structural) for use in domestic, commercial, and industrial buildings in indoor or outdoor applications. The manufacturing process for both decorative and structural glulam is the same. The major difference is that structural products are graded against standardised structural properties, such as strength, stiffness and dimensional stability.

Common structural glulam applications include:

- Lintels
- Bearers
- Roof beams
- Rafters
- Curves
- Columns
- Portal frames
- Garage beams.

Structural glulam is also increasingly finding applications in midrise residential apartments and commercial construction projects. It can be used in combination with other timber products, such as cross-laminated timber (CLT), as was done in C2 International House Barangaroo, Australia's first engineered timber office building.

Common decorative glulam products include:

- Kitchen benchtops and countertops
- Commercial and domestic joinery
- External screening
- Stair treads and stringers
- Cabinet doors
- Furniture, such as seating and tables.

Glulam can be made from naturally durable timber species and preservative treated softwood species for additional external uses.

Use of EPDs in Building and Infrastructure Rating Systems

This EPD complies with the requirements for an industry-wide EPD under the Green Building Council of Australia's Green Star rating system given that:

1. It conforms with ISO 14025 and EN 15804.
2. It has been verified by an independent third party.
3. It has at least a cradle-to-gate scope.
4. The participants in the EPD are listed.

It may be used by project teams using the *Design & As Built* and *Interiors* rating tools to obtain Green Star points under the following credits:

- Materials > Product Transparency and Sustainability.
- Materials > Life Cycle Assessment: By providing data for an EN 15978 compliant whole-of-building whole-of-life assessment.
- Innovation Challenge > Responsible Carbon Impact: By providing embodied carbon impacts (i.e. data on Global Warming Potential) which can be used in the calculation and reduction of the total embodied carbon impacts of a project.

The use of structural glulam as a part of a substantially timber structure may also make a project eligible for points under the Materials/Life Cycle Impacts – Structural Timber pathway in the *Design & As Built* tool.

This EPD is also recognised for credits in the Infrastructure Sustainability (IS) rating scheme of the Infrastructure Sustainability Council of Australia (ISCA).

Scope

Products

This Sector EPD describes the following average products (declared units) manufactured in Australia by the companies listed in the Introduction:

- 1 m^3 of untreated softwood glulam
- 1 m^3 of hardwood or cypress pine glulam

The results in the main body of this EPD are for untreated glulam. Information on preservative treatment can be found in the Additional Environmental Information section. The results for the specific treatment type used can be added to the results for untreated glulam to calculate the environment profile for treated glulam.

The declared units above represent an entire product category rather than a specific product from a specific manufacturer. The values represent a production volume weighted average. As such, a specific product purchased on the market may have a lesser or greater environmental impact than the average presented in this EPD. Some products may also undergo further processing (e.g. fabrication into an engineered roof truss) before being used in a building.

Wood used in these products is Australian-grown exotic (non-native) softwood species grown in plantations as well as native hardwood and cypress species grown in native forests.

The dominant softwood species used to produce softwood glulam in Australia is *Pinus elliottii* (slash pine) followed by *Pinus radiata* (radiata pine). Another softwood species that may be used is *Pinus caribaea* (Caribbean pine) and its hybrids.

The native hardwood species are a variety of species harvested in NSW, Queensland, Victoria and Tasmania. The most common species used for structural glulam are those known as Victorian ash (*Eucalyptus delegatensis* and *Eucalyptus regnans*). Spotted gum (*Corymbia maculata, Corymbia citriodora* and *Corymbia henrii*), Tasmanian oak (*Eucalyptus delegatensis, Eucalyptus regnans*, and *Eucalyptus obliqua*) and other south-east Queensland hardwood species may also be used.

Cypress pine (*Callitris glauca*), a native softwood harvested in NSW and Queensland, is also used for glulam products. It is included together with hardwood glulam as it is also harvested in native forests, not plantations.

The properties and material composition of these products are defined in Table 1 and Table 2. Packaging is defined in Table 3.

Table 1: Properties of industry-average glulam included in this EPD

Properties	Softwood	Hardwood/Cypress
Density (kg per m^3)	621	674
Moisture content (dry basis)	12%	10.5%
Gross calorific value (MJ/kg)	20	20
Net calorific value (MJ/kg)	16.4	16.7
CO_2 sequestered (kg CO_2e)	1017	1118

Table 2: Composition of glulam products included in this EPD

Materials	Softwood	Hardwood/Cypress
Softwood (dry)	88.5%	0.0%
Hardwood or cypress pine (dry)	0.0%	90.2%
Polyurethane*	0.3%	0.3%
Phenol resorcinol formaldehyde (PRF)*	0.5%	0.03%
Water	10.7%	9.5%
Total	100.00%	100.00%

** Two resin types (polyurethane and PRF) are indicated as this EPD declares an industry-average product produced by multiple manufacturers. For a specific product from a specific manufacturer, only one resin type will be used. Check your manufacturer's safety data sheet or technical specification sheet to find out which resin type is used.*

Table 3: Packaging

Materials	Softwood (kg/m³)	Hardwood/Cypress (kg/m³)
Softwood gluts	5.71	0.33
Hardwood gluts	-	6.35
LDPE wrap	0.14	0.06
Plastic strapping	0.18	0.18
Steel strapping	-	0.07
Paper labels	-	0.002
Inks	0.05	0.05
Total	6.09	7.05

Representativeness

Market coverage: The data in this EPD are from detailed surveys of four of the six significant glulam plants in Australia. These plants collectively produced 19,052 m^3 of structural and decorative glulam in 2015/16, which is approximately 64% of total Australian production.

Temporal representativeness: Primary data were collected from participating sites for the 2015/16 Australian financial year (1 July 2015 to 30 June 2016).

Geographical and technological representativeness: The data are representative of the four sites surveyed, which collectively produce two-thirds of all Australian-produced glulam. Given that the glue-laminating step contributes a relatively small share to the total results (as shown in the 'Understanding the Life Cycle of Glulam' section), this EPD is representative of glulam manufactured from average timber grown and sawn in Australia. More detailed information can be found in the 'Variation in Results' section later in this EPD.

Industry Classifications

Product	Classification	Code	Category
All	UN CPC Ver.2	31600	Builders' joinery and carpentry of wood (including cellular wood panels, assembled parquet panels, shingles and shakes)*
All	ANZSIC 2006	1493	Veneer and Plywood Manufacturing

*This is the closest-matching category under the UN CPC v2 classification system. The description provided is not accurate for structural glulam.

LCA Calculation Rules

System Boundary

This EPD is of the 'cradle-to-gate' type with options. The options include the end-of-life stage, which is modelled through the use of scenarios.

Product stage			Con-struction process stage		Use stage							End-of-life stage				Benefits and loads beyond the system boundary
Raw material supply	Transport of raw materials	Manufacturing	Transport to customer	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport to waste processing	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	X	X	X

Key: X = included in the EPD
MND = module not declared (such a declaration shall not be regarded as an indicator result of zero)

Production

The manufacturing process starts using kiln-dried softwood or hardwood, often rough sawn. All timber is accurately dressed to exact and uniform thickness. The dressed timber is then typically finger-jointed with adhesive into continuous lengths. Short-length products such as stair treads are not usually finger-jointed.

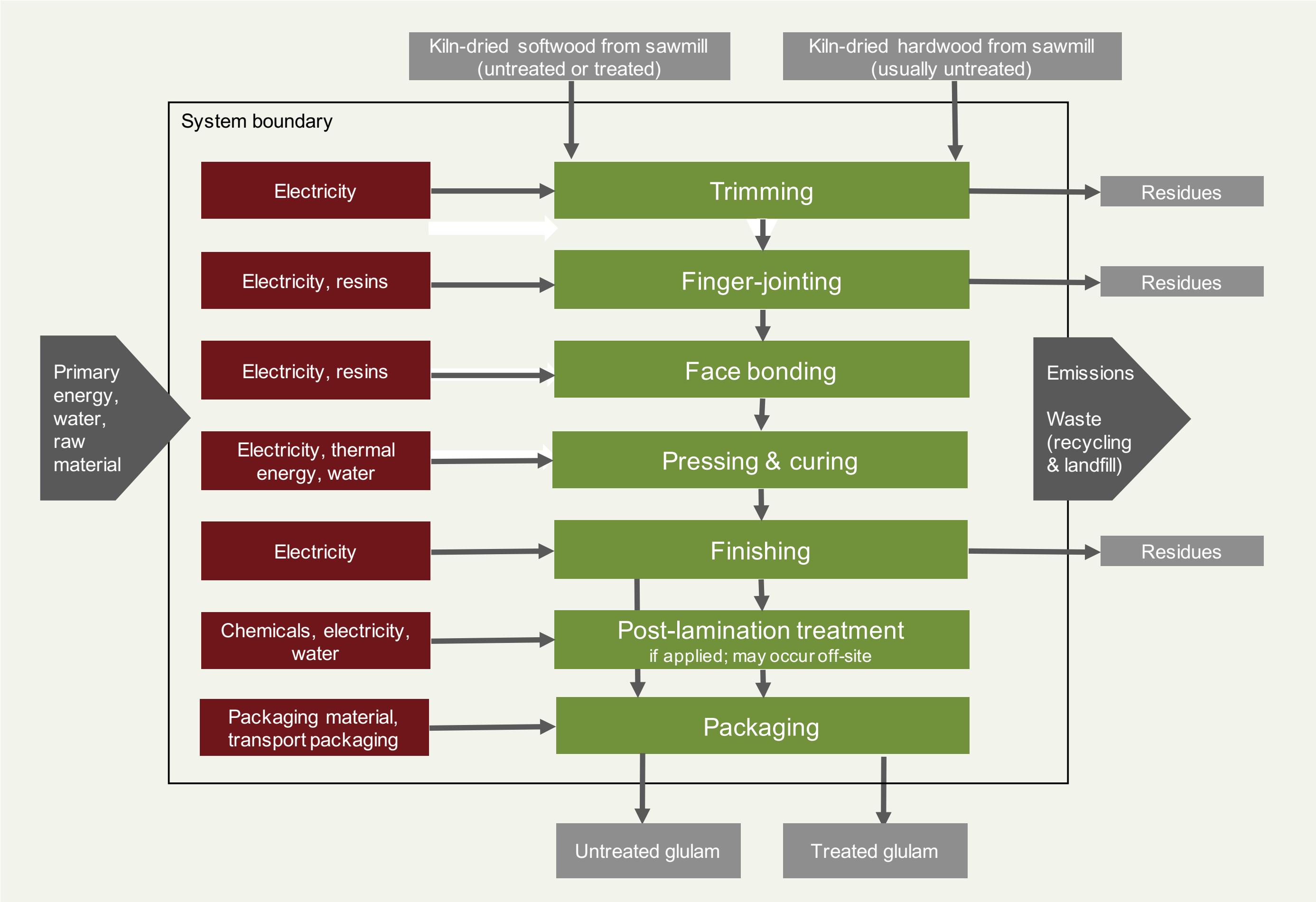
Glulam may be produced as standard straight dimensions or custom-made in various shapes and profiles. The dressed thickness of the timber to be laminated will depend on the application and species used. Curved members require thinner laminates. This EPD assumes straight members.

The sides of the dressed timber that will come into contact with each other are then spread with adhesive. The laminate is then clamped together under constant pressure until the glue has cured. Manufacturers using phenol resorcinol formaldehyde cure the glulam with heat while those using polyurethane cure the glulam at room temperature.

Polyurethane is used by three of the four manufacturers in this study, with phenol resorcinol formaldehyde (PRF) used by one manufacturer. As a result, industry-average glulam includes a mix of both polyurethane and PRF, even though only one resin type is used in any specific product.

For protection during storage and delivery, glulam sections may be separated with wood gluts, secured with plastic strapping and wrapped in plastic film. A weighted average is considered within this EPD.

Preservative treatment has been included separately to glulam production within this EPD. Environmental profiles for a range of common treatment options are included in the Durability and Preservative Treatment section within this EPD.



End-of-Life

When a wood product reaches the end of its useful life, it may either be reused, recycled, landfilled or combusted to produce energy. Landfill is currently the most common end-of-life route for wood products in Australia. Reuse is also common for structural glulam, as is often larger-dimension timber. All other scenarios are in use in certain regions (Forsythe Consultants 2007; National Timber Product Stewardship Group) and have been included within this EPD.

Each scenario assumes that 100% of the wood is sent to that scenario. To create an end-of-life mix for a given region or end use, the reader should take a weighted sum of these scenarios. Where no data are available, the 'landfill (typical)' scenario should be used for 100% of the waste.

Landfill

This EPD includes two scenarios for landfill, each with a different value for the degradable organic carbon fraction (DOCf) of wood. The two values are based on bioreactor laboratory research. This experimental work involves the testing of a range of waste types in reactors operated to obtain maximum methane yields. As the laboratory work optimises the conditions for anaerobic decay, the results can be considered as true estimates of the DOCf value that would apply over very long time horizons (Australian Government 2014a, p. 17).

- **Landfill (typical):** DOCf = 0.1% for softwood glulam and 0.0% for hardwood glulam. This is based on bioreactor laboratory research by Wang et al. (2011) for *Pinus radiata*, Australia's dominant plantation softwood species, and *Eucalyptus pilularis* (blackbutt), an important native hardwood species.

- **Landfill (NGA)**: DOCf = 10%. This is the value chosen for Australia's National Greenhouse Accounts (NGA) (Australian Government 2017). This is a reduction from the previous value of 23% (Australian Government 2014b) that was derived from early bioreactor laboratory research from the 1990s (e.g. Barlaz 1998) that investigated the degradability of wood tree branches ground to a fine powder under anaerobic conditions (Australian Government 2014a, p. 17). This DOCf value can be considered extremely conservative when compared to values from later research (as used in the typical scenario above) and effectively assumes that at least part of the wood waste is ground into a powder to accelerate degradation.

The impacts associated with the landfill are declared in module C4. All landfill gas that is combusted for energy recovery (module C4) is assumed to occur in a power plant with an electrical conversion efficiency of 36% (Australian Government 2014c, p. 189) and the resulting electricity receives a credit for offsetting average electricity from the Australian grid (module D) in line with EN 16485:2014 (Section 6.3.4.5).

Both landfill scenarios assume the following for carbon emissions:

- Of the gases formed from any degradation of wood in landfill, 50% is methane and 50% is carbon dioxide (Australian Government 2016, Table 43).
- All carbon dioxide is released directly to the atmosphere.
- 36% of the methane is captured, based on forecasted average methane capture in Australian landfills by 2020 (Hyder Consulting 2007). The year 2020 was chosen as landfill will take place in the future and this was the last year for which forecasts were available.
- Of this 36% captured, one quarter (9% of the total) is flared and three quarters (27% of the total) are used for energy recovery (Carre 2011).
- Of the 64% of methane that is not captured, 10% (6.4% of the total) is oxidised (Australian Government 2016, Table 43) and 90% (57.6%) is released to the atmosphere.
- In summary, for every kilogram of carbon converted to landfill gas, 71.2% is released as carbon dioxide and 28.8% is released as methane.

Energy recovery

This scenario includes shredding (module C3) and combustion with recovered energy offset against average thermal energy from natural gas (module D) in line with EN 16485:2014 (Section 6.3.4.5). Note that other options are also in use within Australia, including replacement of coal, replacement of electricity, and replacement of both electricity and thermal energy (via co-generation).

Reuse

The glulam product is assumed to be removed from a building manually and reused with no further processing (i.e. direct reuse). Transport and wastage are excluded and only one reuse cycle is considered. The second life is assumed to be the same (or very similar) to the first, meaning that a credit is given for production of 1 m^3 of primary structural in module D. The CO_2 sequestered and energy content of the wood are assumed to leave the system boundary at module C3 so that future product systems can also claim these without double-counting in line with EN 16485:2014 (Section 6.3.4.2). Any further processing, waste or transport would need to be modelled and included separately.

Recycling

Glulam may be recycled in many different ways. This scenario considers shredding and effectively downcycling into wood chips. Wood waste is chipped (module C3) and assigned credits relative to the avoided production of woodchips from virgin softwood, the primary material used for glulam (module D). In line with the reuse scenario, the CO_2 sequestered and energy content of the wood are assumed to leave the system boundary at C3 so that future product systems can also claim these without double-counting (EN 16485:2014, Section 6.3.4.2).

Key Assumptions

Wood input: The input into glue-laminating is assumed to be either average kiln-dried dressed softwood (see EPD S-P-00560) or average kiln-dried dressed hardwood (see EPD S-P-00561), depending on the final product. Datasets for the specific supply chain of each glulam manufacturer were not always available, making it necessary to apply the Australian average.

Energy: Thermal energy and transport fuels have been modelled as the Australian average (see thinkstep 2017 for documentation). Electricity for glulam production (modules A1-A3) has been modelled as a state-specific split based on the electricity consumption of the four manufacturers that contributed data to this study. Electricity for sawn softwood and sawn hardwood production has been modelled at the state-level using total cubic metres of production per state (see EPDs S-P-00560 and S-P-00561). Electricity at end-of-life (module C) has been modelled using an average Australian electricity mix as the location where the product reaches end-of-life is unknown.

Cut-off Criteria

Environmental impacts relating to personnel, infrastructure, and production equipment not directly consumed in the process are excluded from the system boundary as per the PCR (IEPDS 2017, Section 7.5.4). All other reported data were incorporated and modelled using the best available life cycle inventory data.

Allocation

Upstream data: For refinery products, allocation is done by mass and net calorific value. Inventories for electricity and thermal energy generation include allocation by economic value for some by-products (e.g. gypsum, boiler ash and fly ash). Allocation by energy is applied for co-generation of heat and power. For materials and chemicals, the allocation rule most suitable for the product is applied (see thinkstep 2014).

Co-products (e.g. sawdust): As the difference in economic value of the co-products is high (>25% as per EN 15804, Section 6.4.3.2), allocation has been done by economic value.

Background Data

Data for wood inputs (kiln-dried dressed softwood and kiln-dried dressed hardwood) come from EPD #1 for Softwood Timber (S-P-00560) and EPD #2 for Hardwood Timber (S-P-00561).

Data for all energy inputs, transport processes and raw materials are from GaBi Databases 2017 (thinkstep 2017). Most datasets have a reference year between 2013 and 2015 and all fall within the 10-year limit allowable for generic data under EN 15804 (Section 6.3.7).

EPD Results

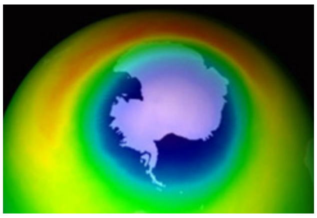
Note: These tables show the impacts associated with production and end-of-life. Any potential credits to future products from recycling or energy recovery are presented in the Other Environmental Information section.

Environmental Impact Indicators

An introduction to each environmental impact indicator is provided below.
The best-known effect of each indicator is listed to the right of its name.

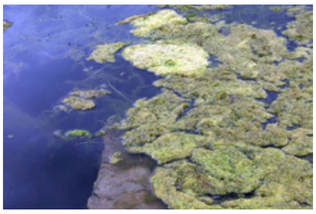
Global Warming Potential (GWP) → Climate Change
A measure of greenhouse gas emissions, such as carbon dioxide and methane. These emissions increase absorption of radiation emitted by the earth, intensifying the natural greenhouse effect. Contributions to GWP can come from either fossil or biogenic sources, e.g. burning fossil fuels or burning wood. GWP is reported as a total as well as being separated into biogenic carbon (GWPB) and fossil carbon (GWPF).

Ozone Depletion Potential (ODP) → Ozone Hole
A measure of air emissions that contribute to the depletion of the stratospheric ozone layer, causing higher levels of ultraviolet B (UVB) to reach the earth's surface with detrimental effects on humans, animals and plants.



Acidification Potential (AP) → Acid Rain
A measure of emissions that cause acidifying effects to the environment. Acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline and the deterioration of building materials.

Eutrophication Potential (EP) → Algal Blooms
A measure of nutrient enrichment that may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. It includes potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P).



Photochemical Ozone Creation Potential (POCP) → Smog
A measure of emissions of precursors that contribute to ground level smog formation (mainly ozone O3), produced by the reaction of VOCs and carbon monoxide in the presence of nitrogen oxides under the influence of UV light. Ground level ozone may be harmful to human and ecosystem health and may also damage crops.

Abiotic Depletion Potential (ADP)→ Resource Consumption
The consumption of non-renewable resources leads to a decrease in the future availability of the functions supplied by these resources. Depletion of mineral resource elements (ADPE) and non-renewable fossil energy resources (ADPF) are reported separately.

Table 4: Environmental impacts, 1 m³ of glulam, softwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Reuse	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
GWP [kg CO_2-eq.]	-612	61.8	435	1,020	1,020	1,020
GWPF [kg CO_2-eq.]	380	58.1	58.2	6.30	6.30	0
GWPB [kg CO_2-eq.]	-992	3.76	377	1,020	1,020	1,020
ODP [kg CFC11-eq.]	4.02E-10	2.80E-11	2.80E-11	2.72E-13	2.72E-13	0
AP [kg SO_2-eq.]	1.80	0.183	0.208	0.0397	0.0397	0
EP [kg PO_4^{3}-eq.]	0.378	0.0237	0.0299	0.00928	0.00928	0
POCP [kg C_2H_4-eq.]	0.812	0.0118	0.0845	0.00344	0.00344	0
ADPE [kg Sb-eq.]	1.51E-04	1.16E-05	1.16E-05	7.85E-08	7.85E-08	0
ADPF [MJ]	4,960	841	841	82.1	82.1	0

Table 5: Environmental impacts, 1 m³ of glulam, hardwood or cypress pine.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Reuse	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
GWP [kg CO_2-eq.]	-408	58.2	426	1,120	1,120	1,120
GWPF [kg CO_2-eq.]	527	58.2	58.4	6.83	6.83	0
GWPB [kg CO_2-eq.]	-935	-0.00614	368	1,120	1,120	1,120
ODP [kg CFC11-eq.]	1.57E-10	2.80E-11	2.80E-11	2.94E-13	2.94E-13	0
AP [kg SO_2-eq.]	3.41	0.184	0.208	0.0430	0.0430	0
EP [kg PO_4^{3}-eq.]	0.687	0.0240	0.0300	0.0101	0.0101	0
POCP [kg C_2H_4-eq.]	4.37	0.0112	0.0828	0.00373	0.00373	0
ADPE [kg Sb-eq.]	5.00E-05	1.16E-05	1.16E-05	8.52E-08	8.52E-08	0
ADPF [MJ]	6,140	843	843	89.1	89.1	0

Resource Use

Table 6: Resource use, 1 m³ of glulam, softwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Reuse	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
PERE [MJ]	3,600	53.0	53.0	1.49	1.49	0
PERM [MJ]	10,200	0	0	-10,200	-10,200	-10,200
PERT [MJ]	13,800	53.0	53.0	-10,200	-10,200	-10,200
PENRE [MJ]	4,980	857	857	82.1	82.1	0
PENRM [MJ]	0	0	0	0	0	0
PENRT [MJ]	4,980	857	857	82.1	82.1	0
SM [kg]	0	0	0	0	0	0
RSF [MJ]	0	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0	0
FW [m³]	2.43	0.00583	0.0474	9.01E-04	9.01E-04	0

__PERE__ = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; __PERM__ = Use of renewable primary energy resources used as raw materials; __PERT__ = Total use of renewable primary energy resources; __PENRE__ = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; __PENRM__ = Use of non-renewable primary energy resources used as raw materials; __PENRT__ = Total use of non-renewable primary energy resources; __SM__ = Use of secondary material; __RSF__ = Use of renewable secondary fuels; __NRSF__ = Use of non-renewable secondary fuels; __FW__ = Net use of fresh water

Table 7: Resource use, 1 m³ of glulam, hardwood or cypress pine.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Reuse	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
PERE [MJ]	1,430	53.1	53.1	1.62	1.62	0
PERM [MJ]	11,200	0	0	-11,200	-11,200	-11,200
PERT [MJ]	12,700	53.1	53.1	-11,200	-11,200	-11,200
PENRE [MJ]	6,160	859	859	89.1	89.1	0
PENRM [MJ]	0	0	0	0	0	0
PENRT [MJ]	6,160	859	859	89.1	89.1	0
SM [kg]	0	0	0	0	0	0
RSF [MJ]	0	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0	0
FW [m³]	3.00	0.00562	0.0466	9.77E-04	9.77E-04	0

Waste and Output Flows

Table 8: Waste categories, 1 m³ of glulam, softwood.

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Reuse	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
HWD [kg]	2.11E-06	2.87E-06	2.87E-06	1.36E-07	1.36E-07	0
NHWD [kg]	34.9	623	514	5.66E-04	5.66E-04	0
RWD [kg]	0.0110	0.00608	0.00608	4.94E-06	4.94E-06	0
CRU [kg]	0	0	0	0	0	621
MFR [kg]	1.10	0	0	0	621	0
MER [kg]	0	0	0	621	0	0
EEE [MJ]	0	1.01	101	0	0	0
EET [MJ]	0	0	0	0	0	0

HWD *= Hazardous waste disposed;* ***NHWD*** *= Non-hazardous waste disposed;* ***RWD*** *= Radioactive waste disposed;*
CRU *= Components for reuse;* ***MFR*** *= Materials for recycling;* ***MER*** *= Materials for energy recovery;*
EEE *= Exported electrical energy;* ***EET*** *= Exported thermal energy*

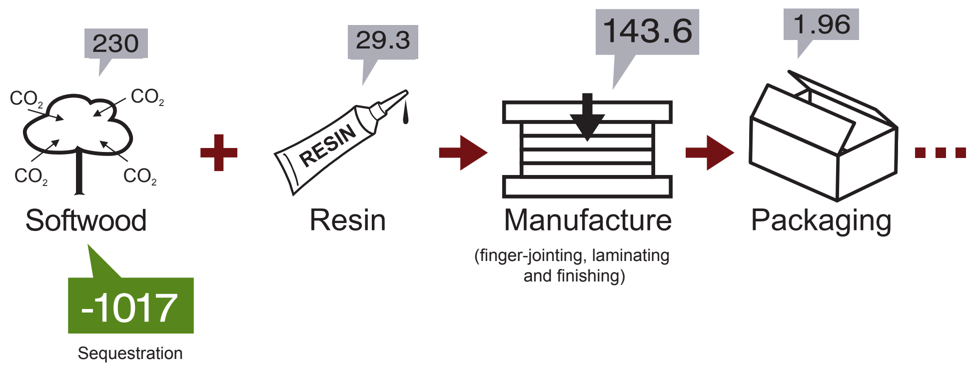
Table 9: Waste categories, 1 m³ of glulam, hardwood or cypress pine.

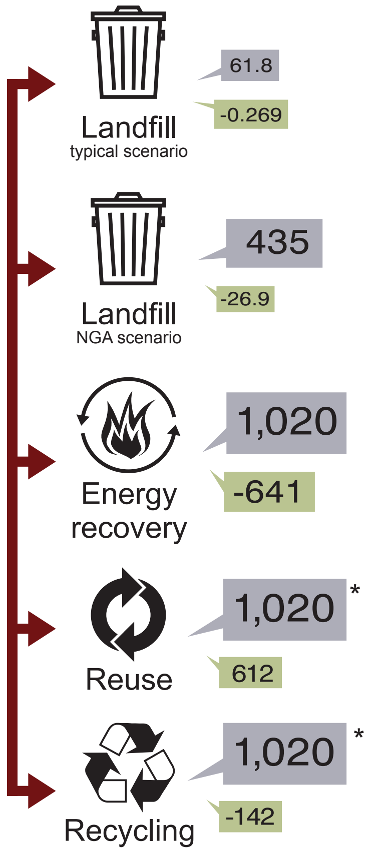
	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Reuse	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**	**C3**
HWD [kg]	1.75E-06	2.99E-06	2.99E-06	1.48E-07	1.48E-07	0
NHWD [kg]	53.5	676	569	6.14E-04	6.14E-04	0
RWD [kg]	0.00801	0.00608	0.00608	5.35E-06	5.35E-06	0
CRU [kg]	0	0	0	0	0	674
MFR [kg]	0.0970	0	0	0	674	0
MER [kg]	0	0	0	674	0	0
EEE [MJ]	0	0	98.3	0	0	0
EET [MJ]	0	0	0	0	0	0

Understanding the Life Cycle of Glulam

Life cycle of Softwood glulam

Life cycle carbon footprint in kg CO_2-equivalent per m³ of softwood glued-laminated timber (12% moisture content), including biogenic and fossil carbon



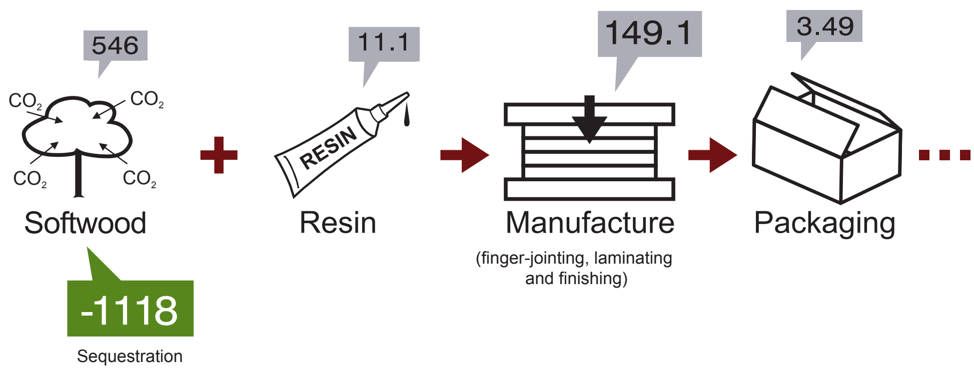


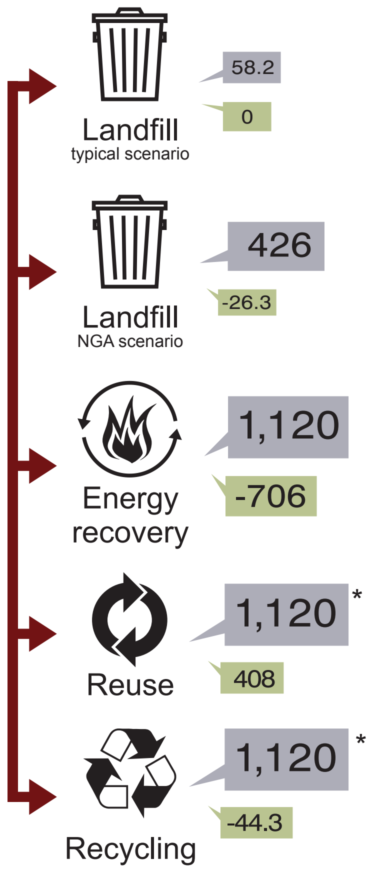
Where... Grey = environmental impact Green = impact avoided in next product system (credit)

* While carbon is not released directly through recycling, it is passed to another product system and is therefore counted as being released

Life cycle of Hardwood glulam

Life cycle carbon footprint in kg CO_2-equivalent per m³ of hardwood glued-laminated timber (10% moisture content), including biogenic and fossil carbon





Where... Grey = environmental impact Green = impact avoided in next product system (credit)

* While carbon is not released directly through recycling, it is passed to another product system and is therefore counted as being released

Variation in Results

The variation between sites used to create the average shown in this EPD are given in Table 10 for the environmental impact indicators in modules A1-A3. Note that the site-level environmental profiles are calculated assuming an input of average Australian kiln-dried dressed wood, not each glulam manufacturer's supply chain. Full supply chain datasets were not available for all manufacturers.

Table 10: Inter-site variability for glulam (modules A1-A3).

	Softwood			Hardwood/Cypress		
Parameter [Unit]	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**
GWP [kg CO_2-eq.]	-12.3%	+19.0%	±12.8%	-110.8%	+17.1%	±49.9%
GWPF [kg CO_2-eq.]	-16.4%	+9.4%	±12.1%	-10.0%	+16.2%	±9.4%
GWPB [kg CO_2-eq.]	-11.2%	+17.9%	±12.0%	-57.5%	+8.1%	±25.7%
ODP [kg CFC11-eq.]	-76.7%	+66.4%	±66.4%	-14.9%	+359.8%	±159.1%
AP [kg SO_2-eq.]	-15.3%	+15.4%	±13.7%	-9.4%	+13.8%	±8.3%
EP [kg PO_4^{3}-eq.]	-10.4%	+11.5%	±9.7%	-4.7%	+14.9%	±7.8%
POCP [kg C_2H_4-eq.]	-6.7%	+4.3%	±4.5%	-3.1%	+4.0%	±2.7%
ADPE [kg Sb-eq.]	-12.1%	+11.3%	±9.5%	-7.2%	+90.5%	±37.0%
ADPF [MJ]	-21.9%	+14.5%	±16.3%	-5.6%	+28.9%	±13.4%

***Min** = (minimum - average) / average; **Max** = (maximum - average) / average;*
***CV** = coefficient of variation = standard deviation / average*

Carbon Dioxide Sequestration

During growth, trees absorb carbon dioxide (CO_2) from the atmosphere through the process of photosynthesis and convert this into carbon-based compounds that constitute various components of a tree, including wood. On average, half the dry weight of all wood is made up of the element carbon (Gifford 2000).

All major Australian production forests and plantations are independently certified to one, or both, of the internationally recognised forest management certification systems: the Australian Standard for Sustainable Forest Management (AS 4708), which is recognised under the Programme for the Endorsement of Forest Certification (PEFC), and/or one of the Forest Stewardship Council's (FSC®) interim forest management standards. It is therefore appropriate to include biogenic CO_2 sequestration in this EPD in line with EN 16485 (Section 6.3.4.2).

Module D: Recycling, Reuse and Recovery Potentials

Table 11: Module D, 1 m³ of glulam, softwood.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Reuse	Recycling
Environmental Impact					
GWP [kg CO_2-eq.]	-0.269	-26.9	-641	-142	612
GWPF [kg CO_2-eq.]	-0.269	-26.9	-643	-135	-380
GWPB [kg CO_2-eq.]	-5.50E-06	-5.50E-04	1.59	-6.25	992
ODP [kg CFC11-eq.]	-7.69E-15	-7.69E-13	-6.48E-12	-1.18E-11	-4.02E-10
AP [kg SO_2-eq.]	-0.00119	-0.119	0.0144	-1.04	-1.80
EP [kg PO_4^{3}-eq.]	-1.00E-04	-0.01000	-0.0202	-0.241	-0.378
POCP [kg C_2H_4-eq.]	-6.19E-05	-0.00619	0.119	-0.429	-0.812
ADPE [kg Sb-eq.]	-2.00E-08	-2.00E-06	-3.90E-05	-2.57E-05	-1.51E-04
ADPF [MJ]	-3.07	-307	-11,300	-1,730	-4,960
Resource Use					
PERE [MJ]	-0.345	-34.5	-1.88	-2,510	-3,600
PERM [MJ]	0	0	0	0	-10,200
PERT [MJ]	-0.345	-34.5	-1.88	-2,510	-13,800
PENRE [MJ]	-3.07	-307	-11,300	-1,740	-4,980
PENRM [MJ]	0	0	0	0	0
PENRT [MJ]	-3.07	-307	-11,300	-1,740	-4,980
SM [kg]	0	0	0	621	621
RSF [MJ]	0	0	10,200	0	0
NRSF [MJ]	0	0	0	0	0
FW [m^3]	-0.00159	-0.159	-0.00711	-0.533	-2.43
Wastes and Outputs					
HWD [kg]	-4.05E-10	-4.05E-08	-8.54E-07	-5.09E-07	-2.11E-06
NHWD [kg]	-7.83E-04	-0.0783	29.9	-17.8	-34.9
RWD [kg]	-3.78E-07	-3.78E-05	-2.77E-04	-6.26E-04	-0.0110
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	-1.10
MER [kg]	0	0	0	0	0
EEE [MJ]	0	0	0	0	0
EET [MJ]	0	0	0	0	0

Table 12: Module D, 1 m³ of structural glulam, hardwood or cypress pine.

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Reuse	Recycling
Environmental Impact					
GWP [kg CO_2-eq.]	0	-26.3	-706	-44.3	408
GWPF [kg CO_2-eq.]	0	-26.3	-708	-36.5	-527
GWPB [kg CO_2-eq.]	0	-5.37E-04	1.75	-7.81	935
ODP [kg CFC11-eq.]	0	-7.51E-13	-7.14E-12	-3.43E-11	-1.57E-10
AP [kg SO_2-eq.]	0	-0.116	0.0137	-0.689	-3.41
EP [kg PO_4^{3-}-eq.]	0	-0.00978	-0.0227	-0.136	-0.687
POCP [kg C_2H_4-eq.]	0	-0.00604	0.131	-0.271	-4.37
ADPE [kg Sb-eq.]	0	-1.95E-06	-4.29E-05	-1.85E-05	-5.00E-05
ADPF [MJ]	0	-300	-12,400	-419	-6,140
Resource Use					
PERE [MJ]	0	-33.7	-2.07	-2,410	-1,430
PERM [MJ]	0	0	0	0	-11,200
PERT [MJ]	0	-33.7	-2.07	-2,410	-12,700
PENRE [MJ]	0	-300	-12,400	-424	-6,160
PENRM [MJ]	0	0	0	0	0
PENRT [MJ]	0	-300	-12,400	-424	-6,160
SM [kg]	0	0	0	674	674
RSF [MJ]	0	0	11,200	0	0
NRSF [MJ]	0	0	0	0	0
FW [m^3]	0	-0.155	-0.00784	-0.588	-3.00
Wastes and Outputs					
HWD [kg]	0	-3.95E-08	-9.41E-07	-7.20E-06	-1.75E-06
NHWD [kg]	0	-0.0765	32.8	-3.95	-53.5
RWD [kg]	0	-3.69E-05	-3.05E-04	-0.00219	-0.00801
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	-0.0970
MER [kg]	0	0	0	0	0
EEE [MJ]	0	0	0	0	0
EET [MJ]	0	0	0	0	0

Durability and Preservative Treatment

As described in the Scope section, the body of the EPD covers untreated glulam. To calculate an environmental profile for treated softwood glulam, please add the values for the appropriate treatment type from either Table 13 or Table 14 to the A1-A3 values in Table 4. For hardwood glulam, please add the values for the appropriate treatment type from Table 15 to the A1-A3 values in Table 5.

AS/NZS 1604.5:2012 Specification for preservative treatment Glued laminated timber products allows for the use of wood that is already treated or post- treatment (envelope treatment) to the appropriate hazard class with allowable preservative.

Table 13: Environmental data for preservative treatment of softwood (non-copper treatments), per m³ of treated glulam.

Parameter [Unit]	Bifenthrin [H2]	Bifenthrin [H2F]	LOSP (permethrin) [H2]	LOSP (permethrin) [H2F]	LOSP (azole + permethrin) [H3]
Environmental Impact					
GWP [kg CO_2-eq.]	11.2	10.9	12.1	11.4	59.0
GWPF [kg CO_2-eq.]	11.2	10.9	12.1	11.4	58.9
GWPB [kg CO_2-eq.]	0.00527	0.00307	0.0114	0.00679	0.0892
ODP [kg CFC11-eq.]	1.77E-12	1.14E-12	3.59E-12	2.25E-12	1.51E-10
AP [kg SO_2-eq.]	0.0478	0.0470	0.0504	0.0486	0.158
EP [kg PO_4^{3-}-eq.]	0.00409	0.00400	0.00439	0.00418	0.0149
POCP [kg C_2H_4-eq.]	0.0386	0.0230	0.0191	0.0123	6.74
ADPE [kg Sb-eq.]	3.14E-05	1.82E-05	1.02E-04	6.09E-05	2.02E-04
ADPF [MJ]	151	141	165	151	2,070
Resource Use					
PERE [MJ]	14.2	22.0	19.9	16.3	17.6
PERM [MJ]	0	0	0	0	0
PERT [MJ]	14.2	22.0	19.9	16.3	17.6
PENRE [MJ]	151	366	286	167	232
PENRM [MJ]	0	0	0	0	0
PENRT [MJ]	151	366	286	167	232
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m³]	0.0701	0.114	0.106	0.0699	0.0902
Wastes and Outputs					
HWD [kg]	2.88E-08	1.86E-07	4.76E-04	5.24E-08	3.12E-04
NHWD [kg]	0.0384	1.46	0.165	0.0528	0.118
RWD [kg]	2.62E-04	0.00335	0.00214	7.16E-04	0.00141
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	0
MER [kg]	4.00	5.00	6.00	7.00	8.00
EEE [MJ]	0	0	0	0	0
EET [MJ]	0	0	0	0	0

Table 14: Environmental data for preservative treatment of softwood (copper treatments), per m³ of treated glulam.

Parameter [Unit]	Copper + DDAX [H3]	Copper azole [H3]	Copper azole [H4]	CCA [H3]	CCA [H4]
Environmental Impact					
GWP [kg CO_2-eq.]	17.8	15.3	19.2	32.5	25.1
GWPF [kg CO_2-eq.]	17.8	15.2	19.2	32.0	24.7
GWPB [kg CO_2-eq.]	0.0478	0.0314	0.0570	0.527	0.350
ODP [kg CFC11-eq.]	8.75E-11	5.74E-11	1.04E-10	8.56E-10	5.68E-10
AP [kg SO_2-eq.]	0.326	0.229	0.379	0.378	0.266
EP [kg PO_4^{3-}-eq.]	0.00678	0.00578	0.00734	0.0120	0.00925
POCP [kg C_2H_4-eq.]	0.0146	0.0104	0.0170	0.0179	0.0127
ADPE [kg Sb-eq.]	2.90E-04	1.90E-04	3.46E-04	0.00361	0.00239
ADPF [MJ]	281	228	310	395	306
Resource Use					
PERE [MJ]	33.8	21.1	13.2	13.2	13.2
PERM [MJ]	0	0	0	0	0
PERT [MJ]	33.8	21.1	13.2	13.2	13.2
PENRE [MJ]	2,090	316	129	129	129
PENRM [MJ]	0	0	0	0	0
PENRT [MJ]	2,090	316	129	129	129
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m^3]	0.223	0.114	0.0610	0.0610	0.0610
Wastes and Outputs					
HWD [kg]	3.47E-07	5.67E-04	1.63E-08	1.63E-08	1.63E-08
NHWD [kg]	0.313	0.190	0.0300	0.0300	0.0300
RWD [kg]	0.00762	0.00255	1.47E-05	1.47E-05	1.47E-05
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	0
MER [kg]	9.00	10.00	11.0	12.0	13.0
EEE [MJ]	0	0	0	0	0
EET [MJ]	0	0	0	0	0

Table 15: Environmental data for preservative treatment of hardwood glulam, per m^3 of treated glulam.

Parameter [Unit]	Boron [H1]	ACQ [H3]	Copper azole [H3]	CCA [H4]	CCA [H5/6]
Environmental Impact					
GWP [kg CO_2-eq.]	10.8	27.5	21.5	14.5	24.4
GWPF [kg CO_2-eq.]	10.8	27.4	21.5	14.4	24.0
GWPB [kg CO_2-eq.]	0.00243	0.121	0.0717	0.0973	0.333
ODP [kg CFC11-eq.]	7.11E-12	6.71E-10	1.31E-10	1.58E-10	5.41E-10
AP [kg SO_2-eq.]	0.0504	0.126	0.465	0.107	0.256
EP [kg PO_4^{3-}-eq.]	0.00442	0.0128	0.00824	0.00537	0.00899
POCP [kg C_2H_4-eq.]	0.00268	0.00849	0.0208	0.00528	0.0122
ADPE [kg Sb-eq.]	2.97E-04	0.0395	4.35E-04	6.65E-04	0.00228
ADPF [MJ]	135	357	357	178	297
Resource Use					
PERE [MJ]	13.3	49.3	23.2	32.4	46.1
PERM [MJ]	0	0	0	0	0
PERT [MJ]	13.3	49.3	23.2	32.4	46.1
PENRE [MJ]	135	381	365	648	1,020
PENRM [MJ]	0	0	0	0	0
PENRT [MJ]	135	381	365	648	1,020
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m^3]	0.0683	0.302	0.128	0.178	0.261
Wastes and Outputs					
HWD [kg]	2.28E-08	4.44E-07	7.14E-04	3.87E-07	6.51E-07
NHWD [kg]	0.0477	8.64	0.232	3.16	5.40
RWD [kg]	6.14E-05	0.00964	0.00320	0.00730	0.0125
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	0
MER [kg]	0	1.000	2.00	3.00	4.00
EEE [MJ]	0	0	0	0	0
EET [MJ]	0	0	0	0	0

Water Consumption

The FW indicator in the EPD results tables reports consumption (i.e. net use) of 'blue water' (which includes river water, lake water and ground water). This indicator deliberately excludes consumption of 'green water' (rain water).

PCR 2012:01 (Section 16.1) states that all water loss from a drainage basin is considered consumption, including any net loss of rain water. According to the PCR, net loss should be interpreted as any additional water loss beyond what would occur in the original, natural system. For plantation softwood forestry, the natural system might be a native forest or a grassland (Quinteiro et al. 2015). Previous work by CSIRO calculated the difference in water flow between plantation forests and a base case land use (pasture) (CSIRO 2009).

Table 16 reports green water consumption calculated by CSIRO using 2005-08 data. These values have not been updated and are now reported here rather than in the main results tables to reflect their uncertainty. At the time of writing, there is no internationally agreed method for calculating green water consumption due to evapotranspiration relative to a hypothetical natural state (Manzardo et al. 2016). As such, different calculation methods may yield significantly different results, introducing a high level of uncertainty.

The reader should also be aware that water consumption does not account for relative water stress in the catchment(s) where the forest is located, meaning that it provides no information about the potential impacts of any water consumption that does occur.

Table 16: Green water consumption estimates for modules A1-A3 from CSIRO (2009).

	Sawn, kiln-dried softwood	Dressed, kiln-dried softwood
Parameter [Unit]	A1-A3	A1-A3
Green water consumption in forest [m^3]	414	1,290

Timber & Forest Certification

Many Australian timber and reconstituted wood products are certified to a forest certification scheme. This certification is an independent auditing process which provides:

- Assurance that the timber is from well-managed forests certified to internationally and nationally accepted forest management standards
- Assurance that the timber is from legally harvested sources
- Chain of custody (CoC) certification extending from the forest to the end user, which is traceable throughout the supply chain.

Two schemes apply to Australian wood production forests. One is administered by the Australian Forestry Standard Ltd (AFS). The AFS scheme is also endorsed by the international Programme for Endorsement of Forest Certification (PEFC). The other scheme is administered by the Forest Stewardship Council (FSC®) Australia.

If a Green Star project elects to use the timber credit as part of their Green Star submission, the Green Building Council of Australia recognises PEFC-endorsed forest certification schemes (such as the Australian Forest Certification Scheme, AFCS) as well as FSC®. Compliance with the chain of custody certification rules of either forest certification scheme for at least 95% by value of timber products used in the project will meet the requirements for this credit point (GBCA 2014).

As of 2017, there are more than 26.7 million hectares of native and plantation forests certified under AFS (AFS 2017) and 1.2 million hectares certified under FSC® interim national standards (FSC 2017).

In addition, two of the Australian glulam manufacturers' premises listed in this EPD are CoC certified, and can therefore supply certified products.

Land Use and Biodiversity

Like other land uses, forestry operations for timber and wood production can have both positive and negative effects on biodiversity. However, as biodiversity varies considerably by region and as data are often limited, assessing potential biodiversity impacts within LCA is challenging.

An Australian study (Turner *et al*. 2014) demonstrated a new method – BioImpact – to discern the biodiversity impacts of different land uses. A trial of this method was conducted using case studies in three different regions and four production systems in New South Wales: native hardwood forestry, plantation softwood forestry, mixed cropping and rangeland grazing. Managed forestry resulted in biodiversity impacts equivalent to or better than those of cropping/grazing systems.

Indoor Environment Quality – Formaldehyde Emissions Minimisation

Glulam products in Australia are manufactured using either polyurethane (PU) resin, which is formaldehyde-free, or phenol resorcinol formaldehyde (PRF) resin.

Formaldehyde is a colourless, strong-smelling gas that occurs naturally in the environment. It is present in the air that we breathe at natural background levels of about 0.03 parts per million (ppm) and up to 0.08 ppm in outdoor urban air (EWPAA 2012). Formaldehyde is used as an ingredient in synthetic resins, industrial chemicals, preservatives, and in the production of paper, textiles, cosmetics, disinfectants, medicines, paints, varnishes and lubricants.

Once cured, phenol resorcinol formaldehyde emits extremely low levels of formaldehyde. It will meet the requirements for classification of emissions class Super E0 as defined in an industry-wide formaldehyde testing and labelling program run by the Engineered Wood Products Association of Australasia. This formaldehyde emission class is detailed in Table 17.

Table 17: Formaldehyde emission classes.

Emission class	Emission limit (mg/litre)	Emission limit (ppm)*	Adhesive associated with emission class
Super E0 / (equivalent to F☆☆☆☆)	Less than or equal to 0.3	Less than or equal to 0.03	Phenol resorcinol formaldehyde

** Based on a test chamber volume of 10 litre, zero airflow during the 24 hour test cycle, molecular weight of formaldehyde 30.03 and the number of microlitres of formaldehyde gas in 1 micromole at 101KPa and 298K.*

Glulam with formaldehyde emissions less than or equal to Super E0 (which applies to all glulam producers listed in this EPD) are compliant with the most stringent Green Star Formaldehyde credit for engineered wood products.

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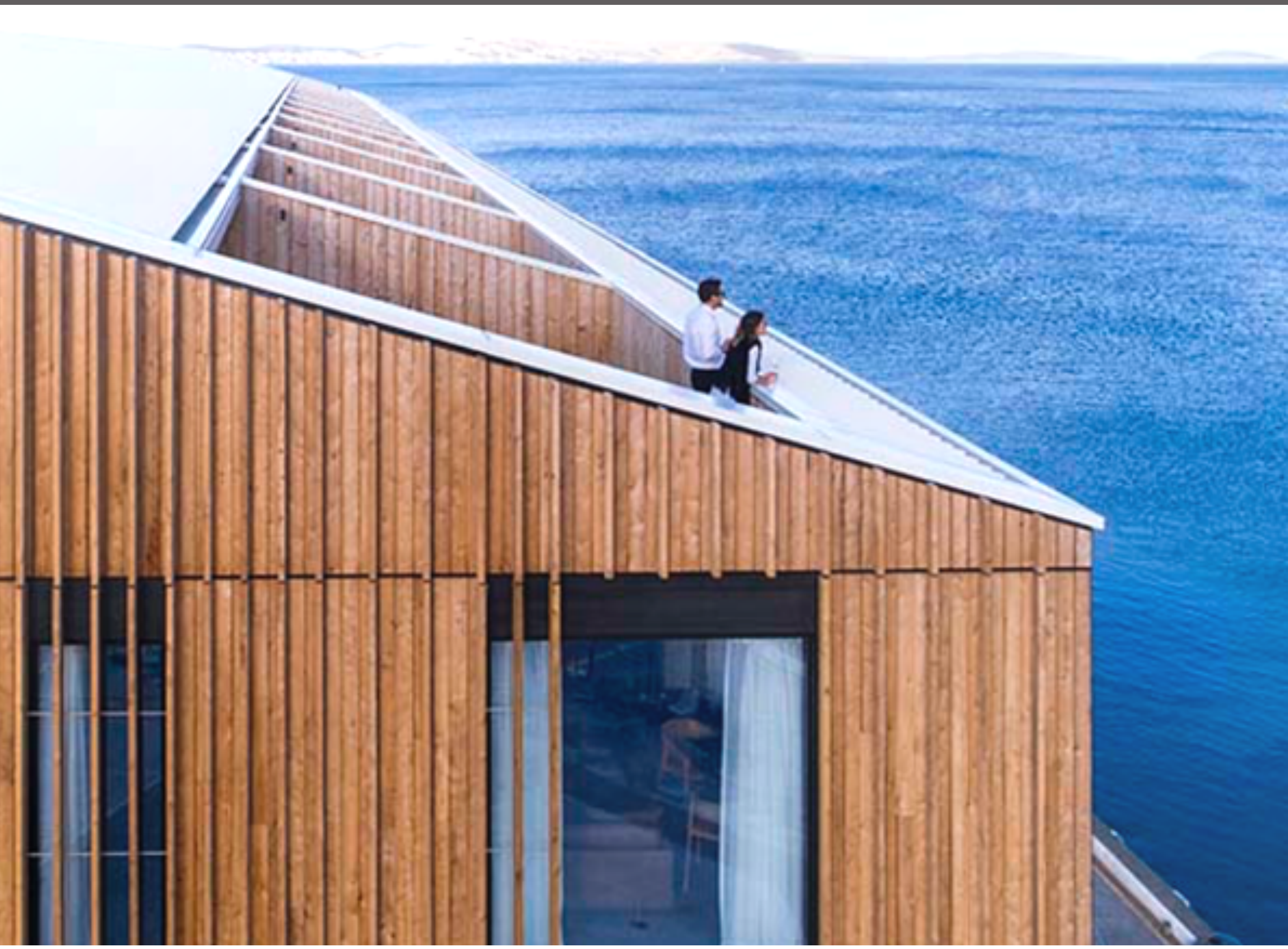
Environmental Product Declaration
White Cypress Timber



Environmental Product Declaration (EPD)
in accordance with ISO 14025 and EN 15804+A1

EPD Registration No. S-P-02327 | Version 1.0
Issued 14 Feb 2022 | Valid until 14 Feb 2027

Geographical Scope: Australia

ECO PLATFORM EPD VERIFIED

AUSTRALASIA EPD®
ENVIRONMENTAL PRODUCT DECLARATION

Environmental Product Declarations

WoodSolutions has developed a suite of EPDs for industry-average, Australian-produced timber products.

These EPDs help to showcase the environmental credentials of Australian wood products. They also provide life cycle data for calculating the impacts of wood products at a building level.

EPDs include:

#01 Softwood Timber

#02 Hardwood Timber

#03 Particleboard

#04 Medium Density Fibreboard (MDF)

#05 Plywood

#06 Glued Laminated Timber (Glulam)

#07 White Cypress Timber

WoodSolutions is an industry initiative designed to provide independent, non-proprietary information about timber and wood products to professionals and companies involved in building design and construction.

WoodSolutions is resourced by Forest and Wood Products Australia (FWPA). It is a collaborative effort between FWPA members and levy payers, supported by industry peak bodies and technical associations.

This work is supported by funding provided to FWPA by the Commonwealth Government.

ISBN: 978-1-925213-15-7

Acknowledgments

This EPD and the accompanying life cycle assessment background report would not have been possible without the assistance of the processors providing data on the operations and the following people: Mick Stephens - CEO of Timber Queensland, Maree McCaskill - General Manager of Timber NSW, Greg Phipps - Director of Eco Cottages, and Sonia Costin - Research Scientist of Eco Cottages. We also acknowledge the assistance of cypress forestry managers from the Queensland Department of Agriculture and Fisheries and Forestry Corporation of NSW.

Researchers:

thinkstep Pty Ltd,

25 Jubilee Street, South Perth WA 6151, Australia

Version history

V1.0 Initial version based on 2019/20 production data from a new industry survey.

Produced: February 2022

EPD Details

An Environmental Product Declaration, or EPD, is a standardised and verified way of quantifying the environmental impacts of a product that is based on a consistent set of rules known as a PCR (Product Category Rules). EPDs within the same product category from different programs may not be comparable. EPDs of construction products may not be comparable if they do not comply with EN 15804. Forest & Wood Products Australia has sole ownership, responsibility, and liability for this EPD.

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CEN standard EN 15804:2012+A1:2013 served as the core PCR

PCR:
PCR 2012:01 Construction products and Construction services, Version 2.33, 2020-09-18

PCR review was conducted by:
The Technical Committee of the International EPD® System.
Chair: Massimo Marino. Contact via info@environdec.com.

Independent verification of the declaration and data, according to ISO 14025:

☐ EPD process certification (Internal)
☑ EPD verification (External)

Third party verifier

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Verifier approved by: EPD Australasia Ltd

Procedure for follow-up of data during EPD validity involves third-party verifier:

☑ Yes
☐ No
☑ Use Softwood EPD for guidance

Introduction

This Environmental Product Declaration (EPD) presents the average performance of sawn timber from Australian White Cypress grown in managed forests and processed in Australia. It provides information on the environmental impacts of raw materials, production, and end-of-life stages of the products life cycle.

This EPD has been prepared in accordance with ISO 14025:2006, EN 15804:2012+A1:2013, EN 16485:2014 PCR 2012:01 (EPD International). It covers Australian White Cypress sawn timber products.

The environmental data presented in this document were primarily derived from a survey of industry members covering the 2019 calendar year conducted by thinkstep-anz on behalf of FWPA. This current survey covers timber produced from approximately 64% of total sawn cypress logs harvested in Australia (ABARES, 2020).

About White Cypress

Australian cypress is a unique native softwood which provides timber with rich colour and characteristics that include natural termite resistance and high durability (AS 5604:2005). The genus is comprised of 15 species with the dominant commercial species being White Cypress (Callitris glaucophylla). It is commonly found throughout Victoria, western New South Wales, and central western Queensland growing on flat and sandy soils. White Cypress, often referred to as cypress pine due to the tree's conical growth habit, grows to a height of up to 25 metres and a stem diameter of 0.6 metres (WoodSolutions 2020).

Stand of White Cypress pines (Callitris glaucophylla) Photo: Michael Ryan

In contrast to a creamy-white band of sapwood, the heartwood ranges in colour from light yellow through orange to light brown, with occasional dark brown streaks. Grain is generally straight with a very fine and even texture. The presence of numerous tight knots is a distinctive feature that produces a strikingly decorative figure on exposed faces.

Natural resins in the wood impart a distinctive odour to White Cypress which contribute to the timber's impressive natural durability. Heartwood is naturally resistant to termites with a life expectancy for above ground exposed applications greater than 40 years (Class 1) and up to 25 years in-ground (Class 2) (AS 5604:2005). In protected above ground applications, including interior applications, life expectancy is indefinite.

In terms of hardness, White Cypress is a moderately hard timber – an appropriate hardness for most applications (ATFA 2010). It can be satisfactorily machined and turned to a smooth finish. Pre-drilling is recommended for hand nailing seasoned timber, although machine nailing with shear-point nails works well. White Cypress readily accepts most standard coatings, stains, and polishes. Special techniques, such as surface roughening, are required for gluing.

In its area of natural occurrence, White Cypress is commonly manufactured into sawn timber (usually unseasoned) and used in framework and other aspects of general building construction. More widely, it is used as flooring, cladding and fencing material. Decorative uses of White Cypress include quality indoor and outdoor furniture, turnery, joinery, carving, parquetry, and linings. Other common applications include oyster stakes and jetty piles in low-salinity environments, as well as beehives (WoodSolutions 2020).

Industry contributors

Production of this EPD has been facilitated by FWPA with the support of cypress processors who pay processor levies to FWPA and four processors contributing data from five sawmills (as shown in Table 1).

Table 1: White Cypress processors contributing to this EPD

Company	Town, State	Financial contributor	Data contributor
Grants Sawmilling Co.	Narrandera, NSW	X	X
Grants Sawmilling Co.	Condobolin, NSW	X	X
Hornick Cypress	Roma, QLD	X	
Hurfords Wholesale	Chinchilla, QLD	X	X
Inglewood Sawmill	Inglewood, QLD	X	
Injune Cypress	Injune, QLD	X	X
Queensland Cypress Supplies	Mungallala, QLD	X	
Vic's Timber & Dressing	Cecil, Plains, QLD	X	X
Walker Cypress Mills	Cecil, Plains, QLD	X	
Yuleba Cypress Sawmills	Miles, QLD	X	

Description of the Australian Sawn Softwood Industry

The Australian sawn cypress manufacturing industry is an important contributor to the regional economies of Queensland and New South Wales where producers are based. In 2016-17 it was estimated that there were 17 cypress sawmills in Australia - 13 in Queensland and 4 in New South Wales - all located near cypress managed forest resource (Downham et. al. 2019). In 2018-19 these sawmills processed an estimated 149,000 m3 of cypress logs (ABARES 2020).

Almost all the cypress pine sawlogs were sourced from public forests (99 per cent) and only 1 per cent was sourced from private forests. (Downham et. al. 2019).

Table 2: Softwood sawmills by Australian state

NSW[a]	Qld	Aust.
4	13	17

a Includes ACT

How this EPD can be used in the Green Star and Infrastructure rating systems

This EPD and the information and transparency it provides means it can be used to obtain credit points under the Green Building Council of Australia (GBCA) Green Star sustainable building rating system. This EPD complies with the requirements for an industry or sector wide EPD given that:

1. It conforms with ISO 14025 and EN 15804+A1.
2. It has been verified by an independent third party.
3. It has at least a cradle-to-gate scope.
4. The participants in the EPD are listed (see Table 1).

It may be used by project teams using the Design & As Built and Interiors rating tools to obtain Green Star points under the following credits:

- Credit 19 Life Cycle Impacts
- Credit 21 Sustainable Products (Australian White Cypress Timber EPD contributes with a Sustainability Factor of 0.5.)

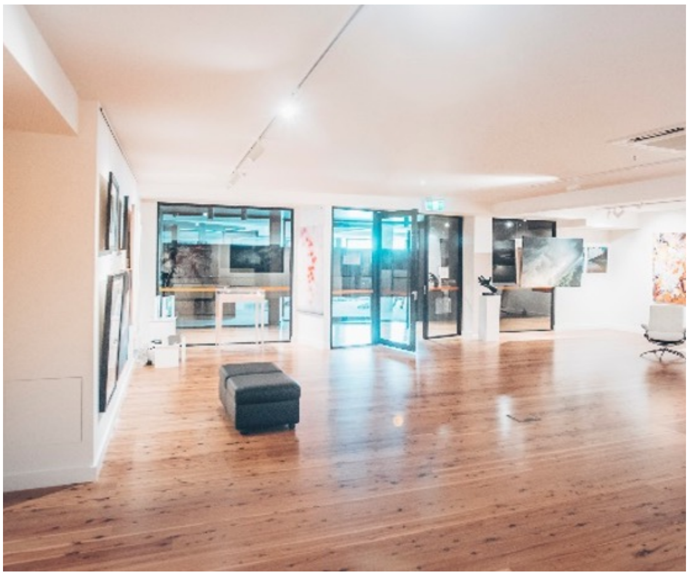
For projects using any of the above Green Star rating tools, up to an additional 3 points are available if Credit 19 is extended to reduce the embodied carbon through the Responsible Carbon Impact innovation challenge.

It may be used by project teams using the new Green Star rating tools released from 2020 to obtain points under the Responsible Products Framework in the following criteria:

- Life-cycle basis
- Environmental impact disclosure
- Carbon emissions disclosure
- Ingredient disclosure
- 3rd Party verification.

Additional point(s) are also available if White Cypress is supplied as PEFC/Responsible Wood certified by a chain of custody certified supplier. Ask your cypress supplier for details.

This EPD is also recognised for credits in the Infrastructure Sustainability (IS) rating scheme of the Infrastructure Sustainability Council of Australia (ISCA).



Scope

Products

This Sector EPD describes the following average products (declared units) manufactured in Australia by the contributors listed in Table 1:

- *1 m^3 of rough-sawn, green (unseasoned) White Cypress*
  30% moisture content (dry basis), density of 830 kg/m^3
- *1 m^3 of dressed, green (unseasoned) White Cypress*
  30% moisture content (dry basis), density of 830 kg/m^3

The declared units above represent an entire product category rather than a specific product from a specific manufacturer. The values represent a production volume weighted average. As such, a specific product purchased on the market may have a lesser or greater environmental impact than the average presented in this EPD. Some products may also undergo further processing (e.g. kiln-drying, seasoning, glue lamination, coating) before being used in a building. These processes have not been included in this EPD.

All products consist of 100% Australian White Cypress grown in managed native forests. No preservative chemicals are applied to increase durability and/or termite or other insect resistance.

Packaging

The producers surveyed for this analysis used a variety of packaging for their cypress timber products. The LCA took an average of all packaging used. In general, cypress timber is covered with a low density polyethylene wrap, with either steel or polypropylene strapping used to keep the product and wrap in place.

End Uses

Rough-sawn, green cypress
Structural framing, fencing, and landscape timbers.

Dressed, green cypress
Flooring, decking, cladding, panelling, furniture, stair treads, structural timber, feature fencing and commercial decking.

Representativeness

Market coverage: The data in this EPD are from detailed surveys of 5 of the 17 cypress sawmills in Australia. These 5 mills collectively processed 95,864 m^3 of harvested White Cypress logs in 2019 (reference year for the study), equating to approximately 64% of the total Australian processing of White Cypress logs (149,028 m^3) (based on the 2018/19 total from ABARES, 2020).

Temporal representativeness: Primary data were collected from participating sites for the 2019 calendar year. Following EN 15804, producer specific data are required to have been updated within the last 5 years to be used in an EPD, meaning that these datasets are valid.

Geographical and technological representativeness: The data are representative of the 5 sites surveyed, which collectively produce approximately 64% of all Australian-produced sawn cypress. More detailed information can be found in the Variation in Results section later in this EPD.

Industry Classifications

Product	Classification	Code	Category
All	UN CPC Ver.2	31100	Wood, sawn or chipped lengthwise, sliced or peeled, of a thickness exceeding 6 mm
Some rough-sawn, green cypress	UN CPC Ver.2	31330	Other wood in the rough (including split poles and pickets)
Rough-sawn green, cypress timber	ANZSIC 2006	1411	Log sawmilling
Dressed green, cypress timber	ANZSIC 2006	1413	Timber resawing and dressing

Content declaration

White Cypress sawn timber contains no added substances that are on the REACH Candidate List of Substances of Very High Concern for Authorisation (ECHA 2021).

White Cypress sawn timber contains no added substances that are on the Living Building Challenge Red List or the Watch List Priority for Red List Inclusion (LBC 2021).

LCA Calculation Rules

System Boundary

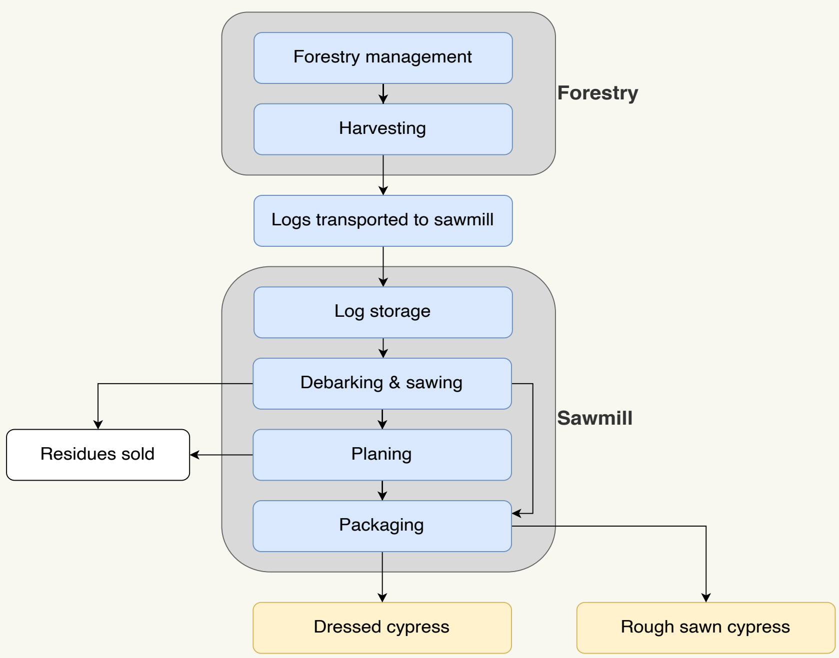
This EPD is of the 'cradle-to-gate' type with options. The options include two modules in module C - the end-of-life stage, which is modelled using scenarios, and module D - benefits and loads beyond the system boundary.

Product stage			Construction stage		Use stage							End-of-life stage				Benefits and loads beyond the system boundary
Raw material supply	Transport of raw materials	Manufacturing	Transport to customer	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport to waste processing	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	X	X	X

Key: X = included in the EPD
MND = module not declared (such a declaration shall not be regarded as an indicator result of zero)

Production (Module A)

The production stage includes the environmental impacts associated with forestry and processing of inputs, transport to, between and within the sawmills, manufacturing of green sawn cypress and planing for dressed cypress.



End-of-Life (Module C)

When a wood product such as cypress pine reaches the end of its useful life it may either be reused, recycled, combusted to produce energy, or landfilled. All scenarios are in use in certain regions (Forsythe Consultants 2007; National Timber Product Stewardship Group 2015) and have been included within this EPD.

Each scenario assumes that 100% of the wood is sent to that scenario. To create an end-of-life mix for a given region or end use, the reader should take a weighted sum of these scenarios. Where no data are available, the 'landfill (typical)' scenario should be used for 100% of the waste as landfill is currently the most common end-of-life route for timber and wood products in Australia.

Reuse

The cypress product is assumed to be removed from a building manually and reused with no further processing (i.e. direct reuse). Transport and wastage are excluded and only one reuse cycle is considered. The second life is assumed to be the same (or very similar) to the first, meaning that a credit is given for production of 1 m^3 of primary sawn cypress in module D. The sequestered CO_2 and the energy content of the wood are assumed to leave the system boundary at C3 so that future product systems can also claim these without double-counting (EN 16485:2014 Section 6.3.4.2). Any further processing, waste or transport would need to be modelled and included separately, e.g. transporting old, large dimension cypress beams offsite for sawing to make furniture.

Recycling

Cypress may be recycled in many ways. This scenario considers recycling of smaller dimension cypress that is shredded into wood chips. Wood waste is chipped (module C3) and assigned credits relative to the avoided production of woodchips from virgin cypress (module D). The sequestered CO_2 and the energy content of the wood are assumed to leave the system boundary at C3 so that future product systems can also claim these without double-counting (EN 16485:2014 Section 6.3.4.2).

Energy recovery

This scenario includes shredding (module C3) and combustion with recovered energy offset against average thermal energy from natural gas (module D) in line with EN 16485:2014 (Section 6.3.4.5). Note that other options are also in use within Australia, including replacement of coal, replacement of electricity, and replacement of both electricity and thermal energy (via co-generation).

Landfill

This EPD includes two scenarios for landfill, each with a different value for the degradable organic carbon fraction (DOC_F) of wood. The two values are based on bioreactor laboratory research. This experimental work involves the testing of a range of waste types in reactors operated to obtain maximum methane yields. As the laboratory work optimises the conditions for anaerobic decay, the results can be considered as estimates of the DOC_F value that would apply over very long time horizons.

- Landfill (typical): DOC_F = 0.1%. This is based on bioreactor laboratory research by Wang et al. (2011) on pinus radiata, one of the dominant softwood species in Australia.
- Landfill (NGA): DOC_F = 10%. This is the value chosen for Australia's National Greenhouse Accounts (NGA) (Australian Government 2020). This is a reduction from the previous value of 23% (Australian Government 2014) that was derived from early bioreactor laboratory research from the 1990s (e.g. Barlaz 1998) that investigated the degradability of wood tree branches ground to a fine powder under anaerobic conditions. This DOC_F value can be considered extremely conservative when compared to values from later research (as used in the typical scenario above) and effectively assumes that at least part of the wood waste is ground into a powder to accelerate degradation.

The impacts associated with the landfill are declared in module C4. All landfill gas that is combusted for energy recovery (module C4) is assumed to occur in a power plant with an electrical conversion efficiency of 36% (Australian Government 2014b, p. 189) and the resulting electricity receives a credit for offsetting average electricity from the Australian grid (module D) in line with EN 16485:2014 (Section 6.3.4.5).

Both landfill scenarios assume the following for carbon emissions:

- Of the gases formed from any degradation of wood in landfill, 50% is methane and 50% is carbon dioxide (Australian Government 2020, Table 46).
- All carbon dioxide is released directly to the atmosphere.
- 43% of the methane is captured, based on weighted average methane captured in Australian landfills (Australian Government 2021, section 7.3.1).
- Of this 43% captured, one-quarter (10.8% of the total) is flared and three-quarters (32.3% of the total) are used for energy recovery (Carre 2011).
- Of the 57% of methane that is not captured, 10% (5.7% of the total) is oxidised (Australian Government 2016, Table 43) and 90% (51.3%) is released to the atmosphere.
- In summary, for every kilogram of carbon converted to landfill gas, 74.4% is released as carbon dioxide and 25.7% is released as methane.

Key Assumptions

Energy: Thermal energy and transport fuels have been modelled as the Australian average (see (Sphera, 2020) for documentation). Electricity for production (modules A1-A3) has been modelled as a state-specific split based upon the volume of production in each state. Electricity at end-of-life (module C) has been modelled using an average Australian electricity mix as the location where the product reaches end-of-life is unknown.

Forestry: All breakdown of forest matter after harvest is modelled as aerobic and therefore carbon neutral as carbon sequestered is released as carbon dioxide. Any burning of forestry material left behind after logging is modelled as being carbon neutral, aside from the trace emissions of various organic gases (Commonwealth of Australia, 2016). All forestry certified to PEFC/Responsible Wood sustainable forest management standards and/or the Code of practice for native forest timber production on Queensland's State forest estate (State of Queensland 2020) is assumed to be sustainably managed and as such there are no carbon emissions associated with land use change. Loss of carbon from the soil is assumed to be zero (i.e., no significant erosion).

Following section 6.3.4.2 of EN 16485 (PCR for wood products used in construction (EN 16485:2014), Australian white cypress forests are considered to be a natural system, with timber production being one of several functions. Natural processes like wildfires are not attributable to the timber production function and so are not considered in the LCA of these timber products. It is assumed that all native white cypress forest will regrow after bushfires.

Cut-off Criteria

Environmental impacts relating to personnel, infrastructure, and production equipment not directly consumed in the process are excluded from the system boundary as per the PCR (EPD International, 2020, Section 7.5.4). All other reported data were incorporated and modelled using the best available life cycle inventory data.

Allocation

Upstream data: For refinery products, allocation is done by mass and net calorific value. Inventories for electricity and thermal energy generation include allocation by economic value for some by-products (e.g., gypsum, boiler ash and fly ash). Allocation by energy is applied for co-generation of heat and power. For materials and chemicals, the allocation rule most suitable for the product is applied (see Sphera, 2020).

Co-products (e.g. sawn wood and sawdust from milling): As the difference in economic value of the co-products is high (>25% as per EN 15804, Section 6.4.3.2), allocation has been done by economic value.

Background Data

Data for all energy inputs, transport processes and raw materials are from GaBi Databases 2020 (Sphera, 2020). Most datasets have a reference year between 2016 and 2019 and all fall within the 10-year limit allowable for generic data under EN 15804 (Section 6.3.7).

Electricity

The electricity supply grid mixes were based on GaBi state and country-specific grid mix datasets for Queensland, New South Wales for the sawmills and Australia for the end of life (Sphera, 2020).
The emission factor for Queensland is 1,056 g CO_2/kWh, New South Wales is 1,020 g CO_2/kWh and Australia is 891 g CO_2/kWh.

EPD Results

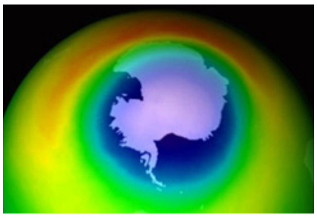
Note: these tables show the impacts associated with production and end-of-life. Any potential credits to future products from recycling or energy recovery are presented in the Other Environmental Information section.

Environmental Impact Indicators

An introduction to each environmental impact indicator is provided below. The best-known effect of each indicator is listed to the right of its name.

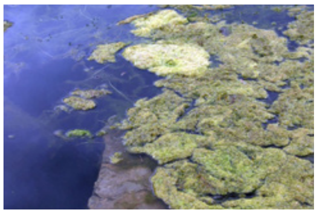
Global Warming Potential (GWP) → Climate Change
A measure of greenhouse gas emissions, such as carbon dioxide and methane. These emissions increase absorption of radiation emitted by the earth, intensifying the natural greenhouse effect. Contributions to GWP can come from either fossil or biogenic sources, e.g. burning fossil fuels or burning wood. GWP is reported as a total as well as being separated into biogenic carbon (GWPB) and fossil carbon (GWPF).

Ozone Depletion Potential (ODP) → Ozone Hole
A measure of air emissions that contribute to the depletion of the stratospheric ozone layer, causing higher levels of ultraviolet B (UVB) to reach the earth's surface with detrimental effects on humans, animals and plants.



Acidification Potential (AP) → Acid Rain
A measure of emissions that cause acidifying effects to the environment. Acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline and the deterioration of building materials.

Eutrophication Potential (EP) → Algal Blooms
A measure of nutrient enrichment that may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. It includes potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P).



Photochemical Ozone Creation Potential (POCP) → Smog
A measure of emissions of precursors that contribute to ground level smog formation (mainly ozone O_3), produced by the reaction of VOCs and carbon monoxide in the presence of nitrogen oxides under the influence of UV light. Ground level ozone may be harmful to human and ecosystem health and may also damage crops.

Abiotic Depletion Potential (ADP)→ Resource Consumption
The consumption of non-renewable resources leads to a decrease in the future availability of the functions supplied by these resources. Depletion of mineral resource elements (ADPE) and non-renewable fossil energy resources (ADPF) are reported separately.

Table 3: Environmental impacts, 1 m³ of rough-sawn, green (unseasoned) White Cypress

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-1,070	61.0	543	1,230	1,230
GWPF [kg CO_2-eq.]	130	58.0	58.2	8.40	8.40
GWPB [kg CO_2-eq.]	-1,200	3.05	484	1,220	1,220
ODP [kg CFC11-eq.]	2.22E-13	1.77E-13	1.77E-13	1.49E-15	1.49E-15
AP [kg SO_2-eq.]	0.825	0.185	0.226	0.0531	0.0531
EP [kg PO_4^{3}-eq.]	0.160	0.0226	0.0326	0.0123	0.0123
POCP [kg C_2H_4-eq.]	0.581	0.0120	0.103	0.00461	0.00461
ADPE [kg Sb-eq.]	3.13E-06	4.55E-06	4.55E-06	1.03E-07	1.03E-07
ADPF [MJ]	1,630	829	829	111	111

Table 4: Environmental impacts, 1 m³ of dressed, green (unseasoned) White Cypress

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-1,010	61.1	543	1,230	1,230
GWPF [kg CO_2-eq.]	184	58.0	58.3	8.40	8.40
GWPB [kg CO_2-eq.]	-1,190	3.05	484	1,220	1,220
ODP [kg CFC11-eq.]	2.35E-13	1.74E-13	1.74E-13	1.49E-15	1.49E-15
AP [kg SO_2-eq.]	1.14	0.186	0.226	0.0531	0.0531
EP [kg PO_4^{3}--eq.]	0.209	0.0227	0.0327	0.0123	0.0123
POCP [kg C_2H_4-eq.]	0.730	0.0120	0.103	0.00461	0.00461
ADPE [kg Sb-eq.]	3.71E-06	4.53E-06	4.53E-06	1.03E-07	1.03E-07
ADPF [MJ]	2,250	830	830	111	111

Resource Use

Table 5: Resource use, 1 m³ of rough-sawn, green (unseasoned) White Cypress

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	44.6	52.3	52.3	0.735	0.735
PERM [MJ]	13,400	0	0	-13,400	-13,400
PERT [MJ]	13,400	52.3	52.3	-13,400	-13,400
PENRE [MJ]	1,600	841	841	111	111
PENRM [MJ]	34.6	0	0	0	0
PENRT [MJ]	1,630	841	841	111	111
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m^3]	0.216	0.00609	0.0754	0.00105	0.00105

PERE *= Use of renewable primary energy excluding renewable primary energy resources used as raw materials;* ***PERM*** *= Use of renewable primary energy resources used as raw materials;* ***PERT*** *= Total use of renewable primary energy resources;* ***PENRE*** *= Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials;* ***PENRM*** *= Use of non-renewable primary energy resources used as raw materials;* ***PENRT*** *= Total use of non-renewable primary energy resources;* ***SM*** *= Use of secondary material;* ***RSF*** *= Use of renewable secondary fuels;* ***NRSF*** *= Use of non-renewable secondary fuels;* ***FW*** *= Net use of fresh water*

Table 6: Resource use, 1 m³ of dressed, green (unseasoned) White Cypress

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
PERE [MJ]	43.3	51.3	51.3	0.735	0.735
PERM [MJ]	13,400	0	0	-13,400	-13,400
PERT [MJ]	13,400	51.3	51.3	-13,400	-13,400
PENRE [MJ]	2,220	842	842	111	111
PENRM [MJ]	34.6	0	0	0	0
PENRT [MJ]	2,255	842	842	111	111
SM [kg]	0	0	0	0	0
RSF [MJ]	0	0	0	0	0
NRSF [MJ]	0	0	0	0	0
FW [m^3]	0.297	0.00400	0.0733	0.00105	0.00105

Waste and Output Flows

Table 7: Waste categories, 1 m³ of rough-sawn, green (unseasoned) White Cypress

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	5.33E-05	2.91E-06	2.91E-06	1.61E-07	1.61E-07
NHWD [kg]	3.06	830	677	0.00259	0.00259
RWD [kg]	0.00191	0.00459	0.00459	1.18E-05	1.18E-05
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	830
MER [kg]	0	0	0	830	0
EEE [MJ]	0	1.68	168	0	0
EET [MJ]	0	0	0	0	0

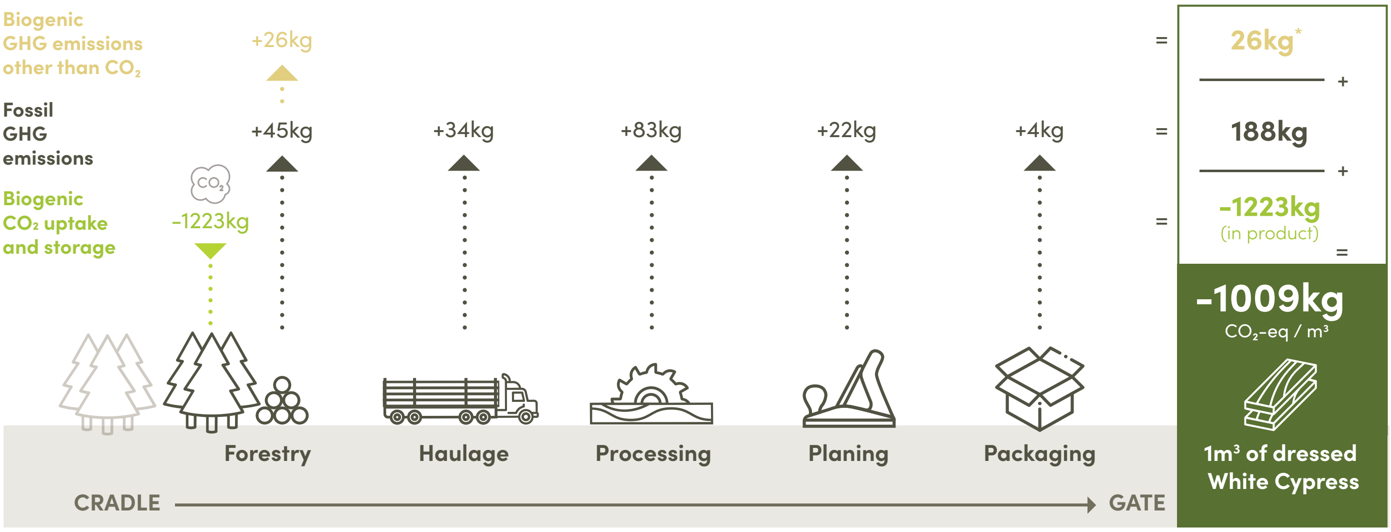
HWD *= Hazardous waste disposed;* ***NHWD*** *= Non-hazardous waste disposed;* ***RWD*** *= Radioactive waste disposed;*
CRU *= Components for reuse;* ***MFR*** *= Materials for recycling;* ***MER*** *= Materials for energy recovery;*
EEE *= Exported electrical energy;* ***EET*** *= Exported thermal energy*

Table 8: Waste categories, 1 m³ of dressed, green (unseasoned) White Cypress

	Production	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Parameter [Unit]	**A1-A3**	**C4**	**C4**	**C3**	**C3**
HWD [kg]	6.65E-05	2.91E-06	2.91E-06	1.61E-07	1.61E-07
NHWD [kg]	3.87	830	677	0.00259	0.00259
RWD [kg]	0.00200	0.00459	0.00459	1.18E-05	1.18E-05
CRU [kg]	0	0	0	0	0
MFR [kg]	0	0	0	0	830
MER [kg]	0	0	0	830	0
EEE [MJ]	0	1.68	168	0	0
EET [MJ]	0	0	0	0	0

Interpretation

Understanding the Carbon Life Cycle of White Cypress Timber



Carbon footprint 1m³ of dressed White Cypress
Cradle to Gate A1 - A3

*CO_2 biogenic emissions from production (e.g. from combustion and degradation of residues) are excluded as they are balanced by uptake during tree growth (i.e., balance to zero)

Variation in Results

The variation between sites used to create the average shown in this EPD are given in Table 9 below for the environmental impact indicators in modules A1-A3.

Table 9: Inter-site variability for White Cypress (modules A1-A3).

	Rough-sawn, green (unseasoned) White Cypress			Dressed, green (unseasoned) White Cypress		
Parameter [Unit]	**Min**	**Max**	**CV**	**Min**	**Max**	**CV**
GWP [kg CO_2-eq.]	-5.5%	+6.5%	±4.0%	-0.9%	+5.8%	±2.8%
GWPF [kg CO_2-eq.]	-19.8%	+22.8%	±14.4%	-1.2%	+24.1%	±10.5%
GWPB [kg CO_2-eq.]	-3.7%	+8.0%	±4.3%	-2.8%	+3.7%	±2.7%
ODP [kg CFC11-eq.]	-89.8%	+142.6%	±83.3%	-59.3%	+180.6%	±103.4%
AP [kg SO_2-eq.]	-19.3%	+22.6%	±13.9%	-3.2%	+23.8%	±11.1%
EP [kg PO_4^{3-}-eq.]	-23.5%	+23.1%	±15.1%	-3.2%	+23.0%	±10.9%
POCP [kg C_2H_4-eq.]	-17.2%	+31.1%	±18.6%	-16.7%	+30.4%	±19.9%
ADPE [kg Sb-eq.]	-44.5%	+78.7%	±45.6%	-17.6%	+88.9%	±47.0%
ADPF [MJ]	-22.6%	+24.7%	±16.3%	-1.7%	+24.9%	±10.3%

***Min** = (minimum - average) / average; **Max** = (maximum - average) / average;*
***CV** = coefficient of variation = standard deviation / average*

Carbon Dioxide Sequestration

During growth, trees absorb carbon dioxide (CO_2) from the atmosphere through the process of photosynthesis and convert this into carbon-based compounds that constitute various components of a tree, including wood. For cypress (Callitris spp.) 52.5% of the dry weight of wood is made up of the element carbon (Gifford 2000).

All state-owned Australian cypress production forests are independently certified to the internationally recognised forest management certification system: the Australian Standard for Sustainable Forest Management (AS 4708) produced by Responsible Wood, which is recognised under the Programme for the Endorsement of Forest Certification (PEFC). It is therefore appropriate to include biogenic CO_2 sequestration in this EPD in line with EN 16485 (Section 6.3.4.2).

Other Environmental Information

Module D: Recycling, Reuse and Recovery Potentials

Table 10: Module D, 1 m^3 of rough-sawn, green (unseasoned) White Cypress

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
Parameter [Unit]	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-0.416	-41.6	-886	-190
GWPF [kg CO_2-eq.]	-0.416	-41.6	-888	-158
GWPB [kg CO_2-eq.]	-2.21E-04	-0.0221	1.67	-31.9
ODP [kg CFC11-eq.]	-2.57E-15	-2.57E-13	-1.87E-14	-3.57E-13
AP [kg SO_2-eq.]	-0.00166	-0.166	-0.154	-0.910
EP [kg PO_4^{3}-eq.]	-1.49E-04	-0.0149	-0.0866	-0.205
POCP [kg C_2H_4-eq.]	-8.93E-05	-0.00893	0.117	-0.392
ADPE [kg Sb-eq.]	-2.83E-08	-2.83E-06	-7.48E-05	-5.04E-06
ADPF [MJ]	-4.67	-467	-15,100	-2,030
Resource Use				
PERE [MJ]	-0.711	-71.1	-5.27	-96.8
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.711	-71.1	-5.27	-96.8
PENRE [MJ]	-4.67	-467	-15,100	-2,030
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-4.67	-467	-15,050	-2,033
SM [kg]	0	0	0	830
RSF [MJ]	0	0	13,400	0
NRSF [MJ]	0	0	0	0
FW [m^3]	-0.00225	-0.225	-0.0143	-0.490
Wastes and Outputs				
HWD [kg]	-7.56E-10	-7.56E-08	-3.50E-06	-4.80E-07
NHWD [kg]	-0.00120	-0.120	33.4	-25.1
RWD [kg]	-7.99E-07	-7.99E-05	-0.00104	-9.74E-04
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Table 11: Module D, 1 m³ of dressed, green (unseasoned) White Cypress

Parameter [Unit]	Landfill (typical)	Landfill (NGA)	Energy recovery	Recycling
Environmental Impact				
Parameter [Unit]	**C4**	**C4**	**C3**	**C3**
GWP [kg CO_2-eq.]	-0.416	-41.6	-886	-190
GWPF [kg CO_2-eq.]	-0.416	-41.6	-888	-158
GWPB [kg CO_2-eq.]	-2.21E-04	-0.0221	1.67	-31.9
ODP [kg CFC11-eq.]	-2.57E-15	-2.57E-13	-1.87E-14	-3.57E-13
AP [kg SO_2-eq.]	-0.00166	-0.166	-0.154	-0.910
EP [kg PO_4^{3}-eq.]	-1.49E-04	-0.0149	-0.0866	-0.205
POCP [kg C_2H_4-eq.]	-8.93E-05	-0.00893	0.117	-0.392
ADPE [kg Sb-eq.]	-2.83E-08	-2.83E-06	-7.48E-05	-5.04E-06
ADPF [MJ]	-4.67	-467	-15,100	-2,030
Resource Use				
PERE [MJ]	-0.711	-71.1	-5.27	-96.8
PERM [MJ]	0	0	0	0
PERT [MJ]	-0.711	-71.1	-5.27	-96.8
PENRE [MJ]	-4.67	-467	-15,100	-2,030
PENRM [MJ]	0	0	0	0
PENRT [MJ]	-4.67	-467	-15,050	-2,033
SM [kg]	0	0	0	830
RSF [MJ]	0	0	13,400	0
NRSF [MJ]	0	0	0	0
FW [m³]	-0.00225	-0.225	-0.0143	-0.490
Wastes and Outputs				
HWD [kg]	-7.56E-10	-7.56E-08	-3.50E-06	-4.80E-07
NHWD [kg]	-0.00120	-0.120	33.4	-25.1
RWD [kg]	-7.99E-07	-7.99E-05	-0.00104	-9.74E-04
CRU [kg]	0	0	0	0
MFR [kg]	0	0	0	0
MER [kg]	0	0	0	0
EEE [MJ]	0	0	0	0
EET [MJ]	0	0	0	0

Natural Durability

As described in the Scope section, this EPD covers untreated sawn cypress products. Natural resins in White Cypress impart a distinctive odour and contribute to the timber's impressive natural durability. According to Australian Standard AS 5604:2005 Timber - natural durability ratings (AS 5604:2005), heartwood is naturally resistant to termites; life expectancy for inner heartwood for above ground applications is greater than 40 years and up to 25 years in-ground; sapwood is not susceptible to lyctus borer.

Sustainable Forest Management and COC Certification

Many Australian production forests harvested for timber are certified to a sustainable forest management certification scheme. This certification is an independent auditing process that provides:

- Assurance that the timber is from well-managed forests certified to internationally and nationally accepted forest management standards.
- Assurance that the timber is from legally harvested sources.
- Chain of custody (CoC) certification extending from the forest to the end user, which is traceable throughout the supply chain.

Publicly managed Callitris forests are the source of 99% of white cypress logs processed into timber products (Downhan et. al 2019). Public cypress forests are certified with the Responsible Wood Certification Scheme against the Sustainable Forest Management (AS 4708). Timber production in Queensland cypress forests must comply with the Code of practice for native forest timber production on Queensland's State forest estate (State of Queensland 2020). The following forest managers are certified:

- Forest Products-DAF (Certificate No. AFS 603520)
- Forestry Corporation of NSW-Hardwood Forests Division (Certificate No. AFS 604224)

If a Green Star project elects to use the Responsible Timber credit as part of their Green Star submission, the Green Building Council of Australia recognises PEFC-endorsed forest certification schemes (such as the Responsible Wood Certification Scheme).

Some Australian cypress suppliers are listed in this EPD are CoC certified and can therefore supply certified products. Visit https://www.responsiblewood.org.au/search-database/ and search for "cypress pine" "White Cypress pine" and "cypress" under species.

Harvesting and biodiversity

White Cypress is an important species in eastern Australia for conservation as well as for the commercial forestry industry (Thompson & Eldridge 2005). Australia has over two million hectares of native cypress forest (ABARES 2018) and the entire White Cypress woodland habitat (from soil surface to canopy) is utilised by mammals, reptiles, birds and invertebrates, including many threatened and rare species (Thompson & Eldridge 2005).

Unlike other softwoods harvested in Australia, White Cypress performs poorly as a plantation species. Commercial cypress is therefore sourced from natural stands. It was recognised early in the 1900s, that dense native cypress woodlands benefit greatly from thinning practices. Dense stands of White Cypress reveal very little evidence for self-thinning (Law et al 2018). Thinning forest regrowth is known to accelerate tree growth and can increase structural complexity. Thinning products, such as sawlogs, can then be recovered for commercial benefit. Regrowth forest commonly offers a more suitable habitat for animals and plants than non-native plantations (Dwyer et al 2009 after Bowen et al., 2007; Fensham & Guymer, 2009).

Cypress forestry management practices have come a long way and current research now highlights the potential benefits of thinning regrowth for biodiversity. In 2018 the NSW Department of Primary Industries performed a comprehensive study on the effects of thinning cypress forests on biodiversity. The outcome revealed that biodiversity responded mostly positive or neutral. The recommendation was made that under proper management, such as mosaic or patchwork thinning including un-thinned areas, and retention of dead trees, a majority of species responds positively (NSW DPI 2018, Gonsalves et al 2018).

Regrowth woodlands of White Cypress are rather stable, provide habitat and biodiversity benefits and aid in carbon sequestration (Thompson & Eldridge 2005). They also improve soil conditions and the mitigation of salinity, therefore, under effectively managed commercially viable stands, multiple benefits can be achieved (Elridge et al 2003). Although the science of thinning for biodiversity is still evolving, it is no less essential to recognise the environmental benefits of cypress, to forward progress within the industry.

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