2

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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

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)

Jamberoo Farm House by Casey Brown Architecture

Photo credit: Patrick Bingham Hall / Pesaro Publishing

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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.

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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

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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:
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PCR review was conducted by:
The Technical Committee of the International EPD® System.
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☐ 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

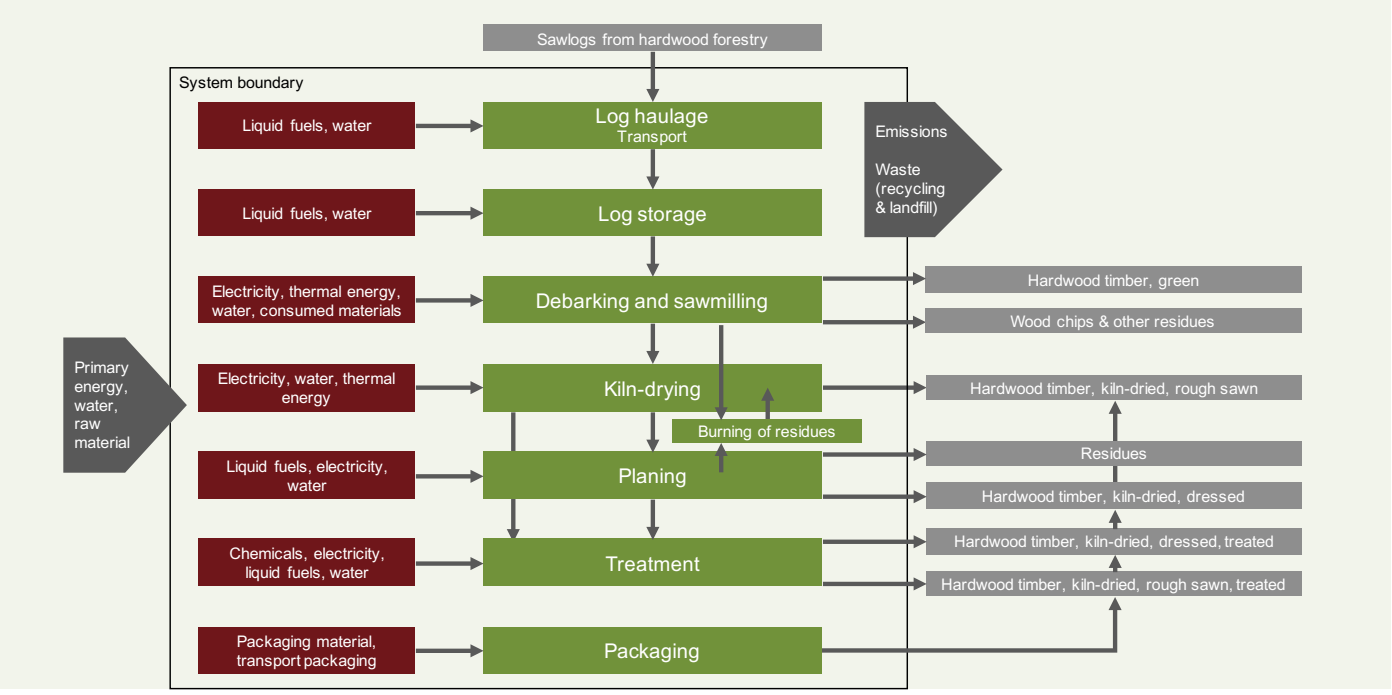
This EPD is of the 'cradle-to-gate' type with options. The options include the end-of-life stage, which is modelled through the use of scenarios.

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

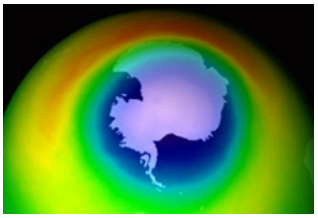
Note: these tables show the impacts associated with production and end-of-life.
Any potential credits to future products from recycling or energy recovery are presented in the Other Environmental Information section.

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 m^3 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 m^3 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 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**
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*

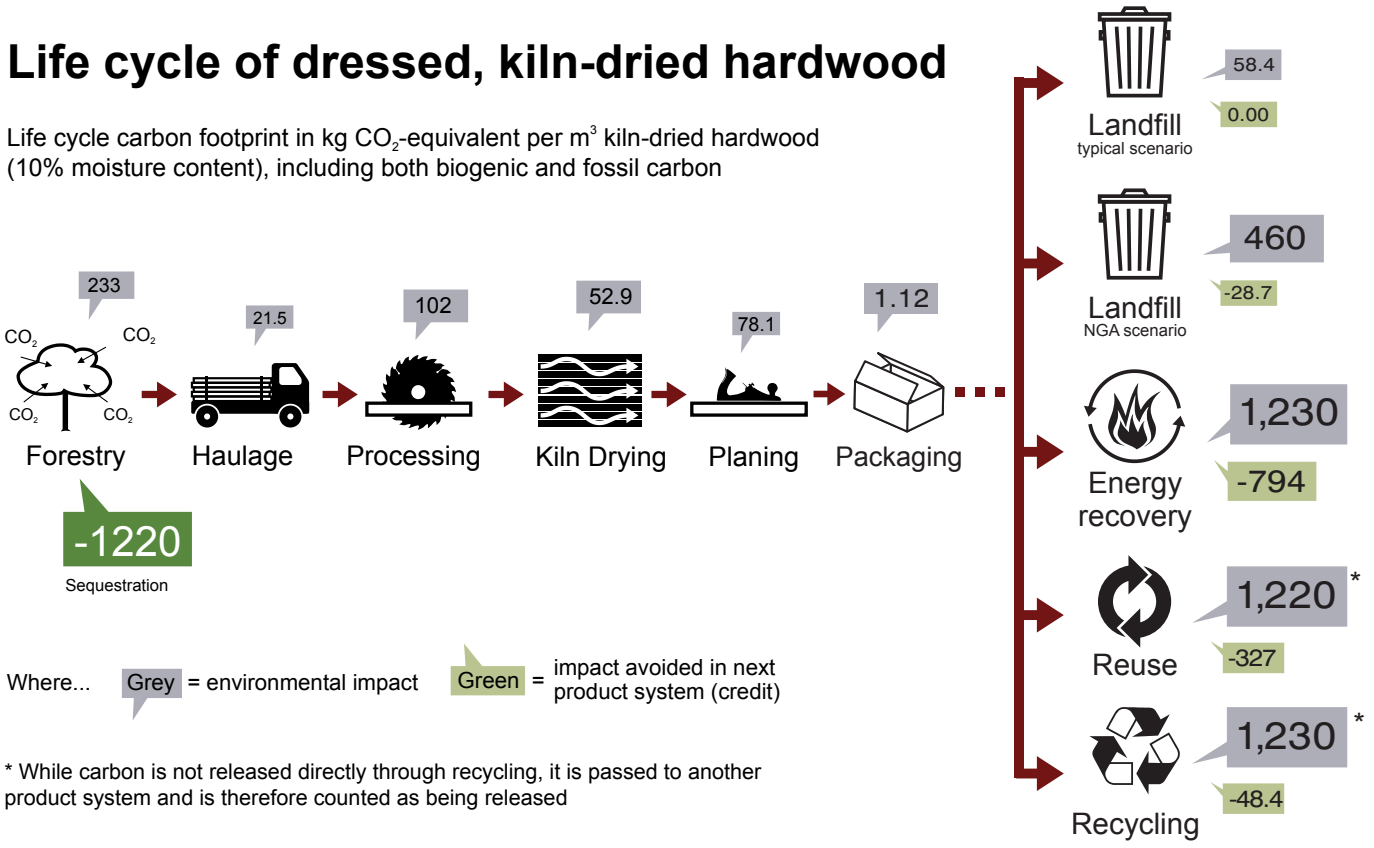
Table 11: Waste categories, 1 m³ of dressed, kiln-dried hardwood.

	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 m³ 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 [m^3]	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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