weathertex

Natural Flat Sheet, Weatherboard Selflok, Weathergroove and Shingles

470 Masonite Rd, Heatherbrae New South Wales
Australia 2324

Version Number: 2.0
Date Updated: 05 November 2024

Global GreenTag
International EPD Program
EPD™
Environmental Product Declaration

Compliant to ISO14025 & EN15804+ A2 2019

EPD Nos.	**WXN012024EP**
	WXN022024EP
	WXN032024EP
Issue Date	**15 Oct 2024**
Valid to	**15 Oct 2029**

ECO PLATFORM

ECO PLATFORM EPD VERIFIED

Mandatory Disclosures

EPD type	Cradle to grave		**Issue Date**	15 Oct 2024
Range Name	Weathertex Natural Flat Sheet and Weatherboard		**Valid Until**	15 Oct 2029
Product Name	Selflok	Weathergroove	Shingles	
EPD Number	WXN012024EP	WXN022024EP	WXN032024EP	
Objectives	To show improved, net-zero, net-positive and regenerative results and timely imperatives to secure viable climate and biodiversity on earth against a background of increasing disasters attributable to anthropogenic climate change.			
Communication	This EPD discloses potential environmental outcomes compliant with ISO14025:2010. Independent external verification[a] of this declaration and data ensures it is fit for business-to-consumer communication. [1]			
Product Category Rules (PCR)	Global GreenTag International Platform EPD compliant with ISO14025 standard [1] impact assessment methodology in reference EN15804 [2] and PCR WNB: 2023 [3].			
Explanations	Further explanatory information is available at info@globalgreentag.com or by contacting certification1@globalgreentag.com.			
Comparability	Different program EPDs may not be comparable. Comparability is further dependent on the product category rules and data source used.			
Reliability	LCIA results are relative expressions that do not predict impacts on category endpoints, exceeding of thresholds, safety margins or risks.			

EPD Program Operator	LCA and EPD Producer	Declaration Owner
Global GreenTag International Pty Ltd L38, 71 Eagle St., Brisbane QLD 4000 Australia Phone: +61 (0)7 33 999 686 http://www.globalgreentag.com	Ecquate Pty Ltd PO Box 123 Thirroul NSW 2515 Australia Phone: +61 (0)7 5545 0998 http://www.ecquate.com	Weathertex Pty Ltd 470 Masonite Rd, Heatherbrae NSW 2324 Australia Phone: +61 (0)2 4980 3100 https://weathertex.com.au
Global GreenTag International green product certification trust brands	Ecquate building ecopositive	weathertex

Demonstration of Verification

☑ **Internal**	Delwyn Jones 15 Oct 2024 — LCA Developed by Delwyn Jones, The Evah Institute 24 09 2024 — EPD Developed by Dr Sharmina Begum, The Evah Institute 17/10/2024 — EPD Reviewed by David Baggs, Global GreenTag Pty Ltd
☑ **External Verifier Statement**	I, the undersigned, verifier, hereby confirm my examination did not find any relevant deviations by the EDP owner, LCA report or PCRs based on EN 15804 2012+A2:2019 and ECO Platform agreed interpretations by CEN TR 16970. Company-specific, upstream and downstream data in the LCA & environmental features report files held at The Evah Institute were plausible and consistent. This verification applied Global GreenTag International adopted ECO Platform checklists and this EPD states where to find programme rules and PCRs. 15 Oct 2024 — Verified by Murray Jones Ecquate Pty Ltd

Program Description

EPD Scope	The scope is cradle to grave A1 to C4 + D as defined by ISO14025 [1] .
System boundary	The system boundary with nature includes material and energy acquisition, processing, manufacture, transport, installation, use plus waste arising to end of life.
Stages included	All known operations in modules A1 to D3 are included. Modules B1 Use, B4 Replace, B5 Refurbish, B6 Water use, B7 energy use or C3 Processing waste had no flows.
Information	Figure 1 depicts A1 to C4 modules inside this cradle to grave system boundary.

Model	**Building Life Cycle Assessment**																	**Beyond system**		
Information	**Actual**			**Scenarios**																
Stages	Product			Construct		Use							End-of-Life					Benefit & load		
						Fabric					Operate									
Modules	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4		D1	D2	D3
Operations Cradle to Grave Fate C_2F & beyond system to Cradle (C_2C)	Resources	Transport	Manufacture	Transport	Construct	Use	Maintain	Repair	Replace	Refurbish	Energy use	Water use	Demolish	Transport	Process Waste	Disposal		Reuse	Recovery	Recycling
Flows	√	√	√	√	√	0	√	√	0	0	0	0	√	√	0	√		√	√	√

Figure 1 Modules A to C Cradle to Grave and Beyond The System Boundary

Data Sources

Primary Data	Data is from primary sources 2018 to 2023 including manufacturer and supplier standards, logistics, technology, market share and management system in accordance with EN ISO 14044:2006, 4.3.2. All are physically allocated not economically allocated.
A1-A3 Stage inclusions	Operations include all known raw material acquisition, refining and processing plus scrap or material reuse from prior systems; electricity generated from all sources with extraction, refining & transport plus secondary fuel energy and recovery processes. Also, transport to factory gate; manufacture of inputs, ancillary material, product, packaging, maintenance, replacement plus flows leaving at end-of-waste boundary and fate of all flows at end of life.
Variability	Significant differences of average LCIA results are declared.
Chemicals of Concern	Contains no substances in the European Chemicals Agency "Authorised or Candidate Lists of Substances of Very High Concern (SVHCs)".

LCA Data Quality

Data quality parameters are tabled below. Data was <10 years, cut-off & quality is ISO14025.[compliant.[1]

Background	**Data Quality**	**Parameters and Uncertainty (U)**			
Correlation	**Metric σg**	U ±0.01	U ±0.05	U ±0.10	U ±0.20
Reliability	**Reporting**	Site Audit	Expert verify	Region	Sector
	Sample	>66% trend	>25% trend	>10% batch	>5% batch
Completion	**Including**	>50%	>25%	>10%	>5%
	Cut-off	0.01%w/w	0.05%w/w	0.1%w/w	0.5%w/w
Temporal	**Data Age**	<3 years	≤5 years	<7.5 years	<10 years
	Duration	>3 years	<3 years	<2 years	1 year
Technology	**Typology**	Actual	Comparable	In Class	Convention
Geography	**Focus**	Process	Line	Plant	Corporate
	Range	Continent	Nation	Plant	Line
	Jurisdiction	Representation is Global, Australasia and Pacific Rim			

System Scope and Boundaries

Figure 2 shows included processes in a cradle to grave system boundary to end of life fates reuse, recycling, or landfill grave.

Stages A1 to 3 model actual operations to acquire, refine, transport, fabricate, coat, use, clean, repair, reuse and dispose of metal, masonry, ceramic, timber, glass, plastic and composites.

Stage A4 to C4 are modelled on typical scenarios to forecast operations including those of:

- Mining, extracting and refining resources to make commodities and packaging;
- Acquiring, cultivating, harvesting, extracting, refining produce and biomass;
- Fuel production to supply power and process energy and freight;
- Chemicals use in processing resources, intermediates and ancillaries;
- Process energy, fuel and freight of resources, intermediates and ancillaries;
- Use, cleaning, recoating, repair, recycling, re-use and landfill, as well as
- Infrastructure process energy transformed and material wear loss e.g. tyres.

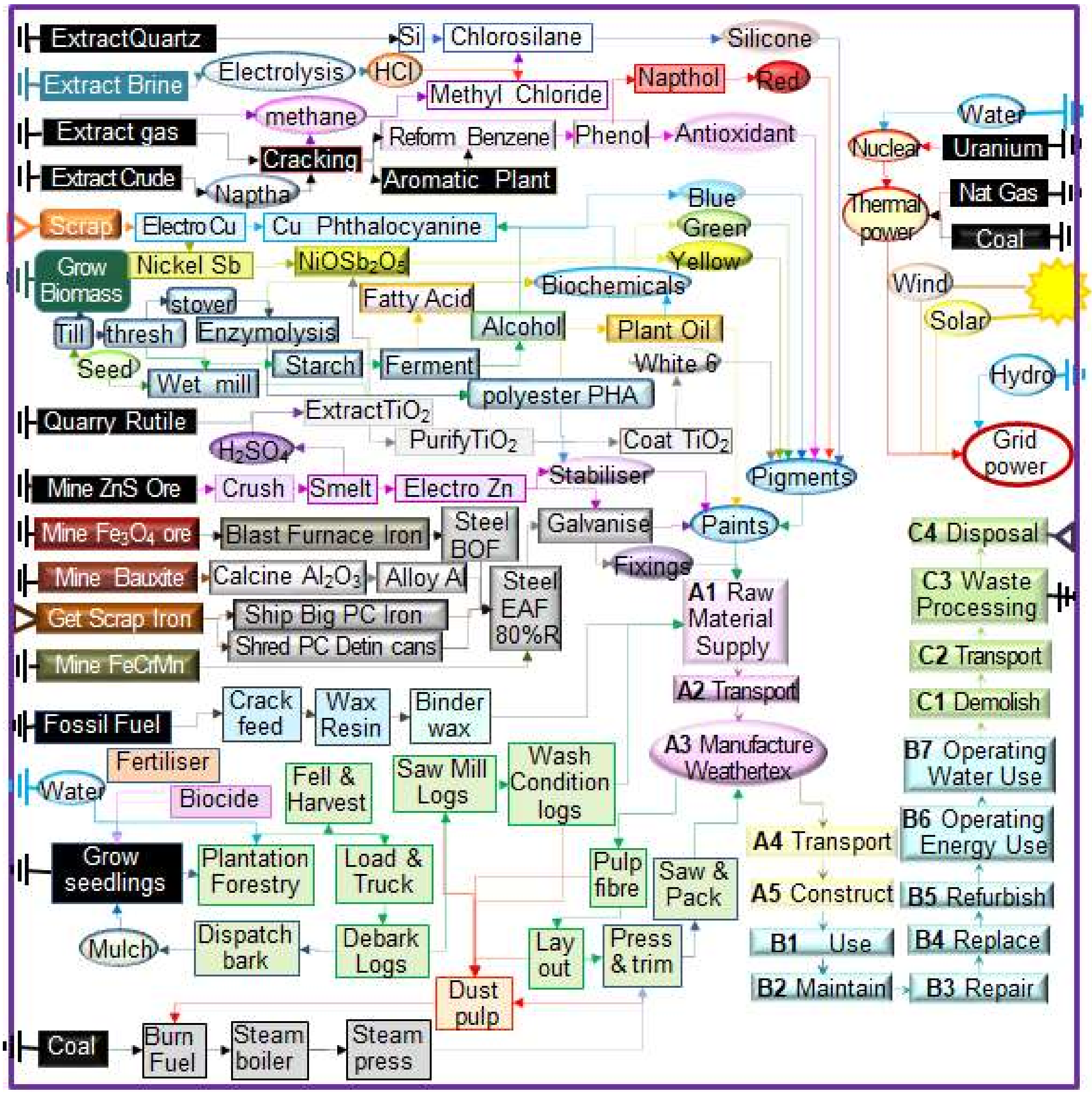

Figure 2. Product Process Flow Chart

Details of Manufacturer

Weathertex natural flat sheet and weatherboard is used for exterior cladding of residential and commercial buildings to protect against potential damage caused by rain, snow, wind or hail. A 100% Australian-owned manufacturer, Weathertex was founded in 1939 in Raymond Terrace, NSW. All timber is from local PEFC certified state or private forests. Weathertex product is a leading industrial standard for climate security. The base materials are 97% hardwood timber and 3% natural wax.

Product Information

This section provides data required to calculate assessment results factoring different mass and periods.

Range Names	Weathertex Natural Flat Sheet and Weatherboard
Brand Name & Code	Selflok, Weathergroove and Shingles
Factory warranty	Fit for purpose use, 10 years.
Manufacturer	Weathertex Pty Ltd
Factory address	470 Masonite Rd, Heatherbrae NSW 2324 Australia
Site representation	Australasia
Time	Made and sold in 2022 for single use
Application	Cladding in bushfire attack levels (BAL 19) up to and including construction
Function	Interior and exterior wall and ceiling weatherboard and architectural cladding
Lifetime	60 years Reference Service Life (RSL) as in ISO 15686. [5,6]
Declared unit	Declared product of 9.88kg/m^2 coverage on exterior and interior buildings
Functional unit	60 years use of declared product/kg cradle to grave and beyond

Whole of life Performance

This section provides qualitative information on whole of life performance.

Material quality	>95% PEFC and Global GreenTag International certified sustainable lumber.
Finishes	Weathertex Flat Sheet and Weatherboard provides a textured surface finish.
Effluent	LCI results and ESCAP raised no red light concerns in emissions to water.1
Waste	Cradle to grave waste to landfill from operations was non-hazardous.
Standard Reference	https://drive.google.com/file/d/1LrhPfYrAX2hhUp383F3Q6fJYbkNWxp47/view
Practices Reference	https://weathertex.com.au/construction-details/
Disposal	No production waste is sent to river, land or ocean outfalls or council landfills.
Wildlife safety	Low VOC, no plastics, glues or formaldehydes.
Ecological Health	No potential in-use impacts on environment or health are known.

Whole of life Health Safety & Environment Performance

This section provides qualitative information on Health Safety & Environment whole of life performance.

Health Safety & Environment	Apart from compliance to occupational and workplace health safety and environmental laws no additional personal protection is considered essential for manufacture, use or reuse.
Health Protection	The product does not contain levels of carcinogenic, toxic or hazardous substances that warrant ecological or human health concern cradle to grave. It passed the Eco specifier Cautionary Assessment Process (ESCAP) and no issues or red-light concerns existed for product human or ecological toxicity.
Environmental Protection	Continuous improvement under the maker's uncertified management system avoids toxics, waste and pollution plus reduce their material and energy use.

1 According with national standards in ANZECC Guideline For Fresh & Marine Water Quality (2000)

Product Components

This section summarises factory components, functions, source nation and % mass share.

Base Material Origin and Detail

This section lists Weathertex key components &packaging by function, type, sources & % mass share.

Function	Component	Source	Amount
Fibre	Eucalyptus Hardwood	Newcastle	>97<98
Water Proofing	Paraffin Melt Wax	Global	>3<4
Packaging	**Component**	**Source**	**Amount**
Spacers	PC Recycled Carboard	Australia	>8 <9
Wrapping	Linear Low density Polyethylene	Global	>3<4
Strapping	Blue steel	Australia	>1 <2
Pallet	Wood	Australia	<0.3
Strapping	Polymer	Global	<0.1
Labelling	Ink	Global	<0.0001

Product Functional & Technical Performance Information

This section provides manufacturer specifications and additional information.

Applicable standards	As tabled below plus AS/NZS1859.4,.1, AS 3959, AS 1530.3.		
Product Acronym	**Selflok**	**Weathergroove**	**Shingles**
Thickness (mm)	9.5	9.5	9.5
Sheet Length*Width (mm)	3660 x 300	3660, 3050 or 2745 x 1196	1196 x 225
Thermal Properties	**Results**	**Acoustic Properties**	**System Dependant**
Thermal Conductivity	0.22 W/m-K	Weathertex can be used as part of wall systems to meet required specific thermal and acoustic ratings.	
Thermal Resistance	0.04 m^2 K/W		
Performance Properties	**Standard**	**Result**	**Requirement**
Density	AS/NZS 4266.1	1000 kg/m^3	> 750 kg/m^3
Dimensions		Pass	±2mm/m
Bending Strength		32 MPa	> 20 MPa
Modulus of Elasticity		4500 MPa	> 2900 MPa
Fire Properties	**Standard**	**Result**	**Requirement BCA Vol 1**
Bushfire Attack Level	AS 3959	≤ BAL 19	1 -G5D32 & 2-H7D4
Ave. Specific Extinction Area	AS/NZS 3837	38.7 m2/kg	1-S7C4
Material Group Number	AS/NZS 5637.1	Group 3	1-S7C4
Early Fire Hazard Indices			
Ignitability	AS 1530.3	12	1–S7C4
Spread of Flame		5	
Heat Evolved		4	
Smoke Developed		2	
Fire Resistance Level	AS1530.4	Systems ≤120/120/120	1-Spec C1.1
Combustibility	BCA Vol 1 C1.1	Type C Compliant[2]	1-S5C24

[2] A class 2,3 or 9c building with a rise in storeys of 2 may be of type C construction it requirements of C1.5 are satisfied.

Scenarios Descriptions

This section defines modelling stages scenarios A4 to D3 beyond actual operations in module A1 to A3.

Module	Type specified	Amount	Type specified	Amount
Construction Modules				
A4 Transport factory to depot then to site	Sea Shipping	13,000	85% Capacity	Full back load
	Interstate Rail	1,300 km	85% Capacity	Full back load
	25t semi-trailer	200 km	85% Capacity	No back load
A5 Install	VOCs indoors	0%	Packaging & Waste	0%
Building Modules				
B1 Use	VOCs	0%	No other flows	0%
B2 Maintain	fit for purpose	100%	fit for purpose	0%
B3 Repair	fit for purpose	95%	Repair damaged	5%
			Repaint 8 yearly	100%
B4 Replace	fit for purpose	100%	No other flows	0%
B5 Refurbish	fit for purpose	100%	fit for purpose	100%
B6 Energy use	off grid	100%	Solar and wind energy	100%
B7 Water use	off grid	100%	Rain and dew	100%
End of Life Modules				
C1 Demolish	fit for purpose	100%	No other flows	0%
C2 Transport	fit for purpose	100%	No other flows	0%
C4 Disposal	fit for purpose	100%	No other flows	0%
Beyond System Boundary Modules				
D1 Reuse	fit for purpose	75%	No other flows	0%
D2 Recover	fit for purpose	22.5%	No other flows	0%
D3 Recycle	fit for purpose	2.5%	No other flows	0%

Environmental Impact Terminology

Environmental impacts contributing to risks of social and ecological issues and collapse are tabled below with common names and remedies given for each indicator.

Global warming forcing Climate Change	Greenhouse gases absorb infra-red radiation. This heat reduces thermal energy differentials, from equator to poles, forcing ocean current and wind circulation to blend and regulate climate. Weakly blended "lumpier" weather has more frequent, extreme heat wave, fire-storm, cyclone, rain-storm, flood and blizzard events. Accumulation of carbon dioxide, natural gas methane, nitrous oxides and volatile organic compounds from burning fossil fuels causes global warming. Forest and wilderness growth absorbing air-borne carbon in biomass can drawdown such accumulation. Urgent renewable energy reliance is vital in time to avoid imminent tipping points and the worsening "***climate emergency***".
Ozone layer depletion	Stratospheric ozone loss weakens the planet's solar shield so more shorter wavelength ultraviolet (UVB) light reaching earth damages plants and increases malignant melanoma and skin cancer in humans and animals. Chlorofluorocarbons, hydrochlorofluorocarbons (HCFC), chlorobromomethane, hydrobromofluorocarbons, carbon tetrachloride, methyl chloroform, methyl bromide and halon gas cause ozone layer loss. To repair the *"**ozone hole**"* reliance on ozone-safe refrigerants, aerosols and solvents is essential to avoid further its depletion and enable accumulation of naturally-formed ozone.
Acidification	Acidification reduces soil and waterway pH, impedes nitrogen fixation vital for plant growth and inhibits natural decomposition. It increases rates and incidence of fish kills, forest loss and deterioration of buildings and materials. Chief synthetic causes of "***acid rain***" are emissions of sulphur and nitrogen oxides, hydrochloric and hydrofluoric acids and ammonia from burning fossil fuels polluting precipitation of rain and snow world-wide.
Eutrophication of terrestrial, freshwater and marine life	Eutrophication from excessively high macronutrient levels added to natural waters promotes excessive plant growth that severely reduces oxygen, water and habitat security for aquatic and terrestrial organisms across related ecosystems. Chief synthetic cause of "***algal blooms***" is nitrogen (N, NOx, NH_4) and phosphorus (P, PO_4^{3-}) in rain run-off over-fertilised land catchments.
Photochemical ozone creation	Tropospheric photochemical ozone, called "***summer smog***" near ground level, is created from natural and synthetic compounds in UV sunlight. Low concentration smog damages vegetation and crops. High concentration smog is hazardous to human health. Chief synthetic causes are nitrogen oxides, carbon monoxide and volatile organic compounds (VOC) pollutants. Avoiding reliance on dirtiest coal fuel and volatile chemicals has reduced smog incidence in many areas globally.
Depletion of minerals, metals & water	Abiotic depletion of finite mineral resources increases time, effort and money required to obtain more resources to the point of extinction of naturally viable reserves. This can limit access to available, valuable and scarce elements vital for human-life. The youth movement "***extinction rebellion***" calls on adults to secure climate, reserves and biodiversity for current and future generations.
Depletion of fossil fuel reserves	Abiotic depletion of resources by consuming finite oil, natural gas, coal and yellowcake fossil fuel reserves leaves current and future generations suffering limited available, accessible, plentiful, essential valuable as well as scarce raw material, medicinal, chemical, feedstock and fuel stock. Approaching "***peak oil***" acknowledged fossil fuel reserves are finite and the need for decision-makers to act to avoid market instability, insecurity and or oil and gas wars.

Impact, Input and Output Result Categories, Units and Methods

This section summarises impact and inventory result units with descriptions and references to methods.

Impact & Input and Output Result Category Codes, Units and Methods

Result	Code	Units	Description of Methods
Climate Change Biogenic	GWP_{BIO}	kg CO_{2eq}	GWP sequestered from air [4]
Climate Change LULUC	GWP_{LULUC}	kg CO_{2eq}	GWP land use & land use change [4]
Climate Change Fossil	GWP_{FF}	kg CO_{2eq}	GWP fossil fuels [4]
Climate Change Total	GWP_{TOTAL}	kg CO_{2eq}	Global Warming Potential [4]
Stratospheric Ozone Depletion	ODP	kg CFC_{11e}	Stratospheric Ozone Loss [5]
Photochemical Ozone Creation	POCP	kg $NVOC_{e}$	Summer Smog [6]
Acidification Potential	AP	mol H^{+}_{eq}	Accumulated Exceedance [7]
Eutrophication Freshwater	EP_{FRESH}	kg P_{eq}	Excess freshwater nutrients [8]
Eutrophication Marine	EP_{MARINE}	kg N_{eq}	Excess marine nutrients [9]
Eutrophication Terrestrial	EP_{LAND}	mol N_{eq}	Excess nutrients to land [8]
Mineral Depletion	ADP_{MIN}	kg Sb_{eq}	Abiotic Depletion minerals [9]
Fossil Depletion	ADP_{FF}	MJ_{ncv}	Abiotic Depletion fossil fuel [10]
Water Scarcity Depletion	WDP	$m^3_{WDP\ eq}$	Water Deprivation Scarcity [11,12]
Input			
Net Fresh Water Use	FW	m^3	Lake, river, well & town water
Secondary Material	SM	kg	Post-consumer recycled (PCR)
Secondary Energy Renewable Fuel	RSF	MJ_{ncv}	PCR biomass burnt
Secondary Energy Non Renewable Fuel	NRSF	MJ_{ncv}	PCR fossil-fuels burnt
Primary Energy Renewable Material	PERM	MJ_{ncv}	Biomass retained material
Primary Energy Renewable Fuel	PERE	MJ_{ncv}	Biomass fuels burnt
Primary Energy Renewable Total	PERT	MJ_{ncv}	Biomass burnt + retained
Primary Energy Non Renewable Material	PENRM	MJ_{ncv}	Fossil feedstock retained
Primary Energy Non Renewable Fuel	PENRE	MJ_{ncv}	fossil-fuel used or burnt
Primary Energy Non Renewable Total	PENRT	MJ_{ncv}	Fossil feedstock & fuel use
Output			
Hazardous Waste Disposed	HWD	kg	Reprocessed to contain risks
Non-hazardous Waste Disposed	NHWD	kg	Municipal landfill facility waste
Radioactive Waste Disposed	RWD	kg	Most ex nuclear power stations
Components For Reuse	CRU	kg	Product scrap for reuse as is
Material For Recycling	MFR	kg	Factory scrap to remanufacture
Material For Energy Recovery	MER	kg	Factory scrap use as fuel
Exported Energy Electrical	EEE	MJ_{ncv}	Uncommon for building products
Exported Energy Thermal	EET	MJ_{ncv}	Uncommon for building products

Results Cradel to Grave within the System Boundary

Table 1 lists A1 Resources, A2 Transport, A3 Manufacture, A4 Delivery, A5 Construct, B2 Maintain, B3 Repair, B4 Replace, B5 Refurb, C1 Demolish, C2 Transport and C4 Disposal results. Modules B1 Use, B4 Replace, B5 Refurbish, B6 Water use, B7 energy use or C3 Processing waste had no flows or result.

Table 1 Impact & Input and Output Results/kg Functional Unit

Burdens	A1-3	A4	A5	B2	B3	C1	C2	C4
GWP_{BIO}	-2.5	-1.9E-04	7.27E-02	-0.1	-0.18	-1.3E-19	-5.4E-07	6.9
GWP_{LULUC}	1.2E-04	1.0E-09	0.37	6.2E-06	-1.1E-02	1.0E-08	7.9E-10	0
GWP_{FF}	2.2	1.9E-02	0.11	0.71	0.17	1.9E-03	6.1E-03	2.0E-05
GWP_{TOTAL}	-0.40	0.02	0.18	0.61	-5.5E-03	1.9E-03	6.1E-03	6.9
ODP	4.5E-09	1.7E-13	1.1E-10	3.1E-09	1.8E-10	7.0E-17	1.1E-13	0
POCP	8.7E-03	1.2E-04	4.0E-04	2.9E-03	6.1E-04	7.6E-06	6.0E-05	6.0E-07
AP	2.9E-03	1.2E-05	1.3E-04	1.2E-03	1.9E-04	3.5E-06	5.0E-06	4.9E-04
EP_{FRESH}	2.9E-06	5.6E-10	1.1E-07	6.4E-07	1.7E-07	3.9E-13	3.1E-10	0
EP_{MARINE}	4.9E-04	2.3E-06	2.2E-05	2.0E-04	3.4E-05	6.4E-07	9.4E-07	8.4E-10
EP_{LAND}	1.6E-02	7.7E-06	7.8E-04	1.4E-03	1.2E-03	4.1E-06	3.2E-06	1.8E-08
ADP_{MIN}	2.9E-05	7.2E-06	2.0E-06	3.1E-04	2.2E-06	6.2E-12	4.0E-06	0
ADP_{FF}	1.9	2.2E-02	8.1E-02	0.52	0.12	9.2E-04	7.5E-03	0
WDP	3.8E-03	2.9E-06	1.5E-04	9.7E-03	2.4E-04	8.5E-08	1.4E-06	0
Input								
FW	2.4E-02	1.8E-05	9.5E-04	6.0E-02	1.5E-03	5.2E-07	8.7E-06	0
SM	1.5	2.3E-06	8.9E-03	0	1.4E-02	1.6E-05	1.7E-06	0
RSF	2.7	6.8E-06	0.20	0	0.31	2.9E-04	9.2E-05	0
NRSF	0.24	3.0E-04	6.0E-03	4.2E-02	9.2E-03	1.3E-09	1.6E-03	0
PERM	22	2.4E-03	1.1	1.1	1.7	2.0E-03	2.0E-04	0
PERE	0.41	2.7E-03	6.8E-03	0.56	1.0E-02	2.0E-03	1.9E-03	0
PERT	25	7.4E-04	1.1	1.7	1.7	3.9E-10	4.8E-04	0
PENRM	5.0	0.11	0.16	1.7	0.25	2.5E-04	3.7E-02	0
PENRE	25	0.19	1.1	7.4	1.8	1.6E-02	6.3E-02	0
PENRT	30	0.30	1.3	9.1	2.0	1.7E-02	0.10	0
Output								
HWD	5.9E-04	3.7E-05	2.6E-05	9.9E-04	3.7E-05	7.2E-08	1.2E-05	0
NHWD	0.19	3.1E-04	5.6E-02	9.9E-02	1.2E-02	4.3E-06	9.6E-05	5.0E-02
RWD	7.7E-18	1.0E-31	2.0E-19	2.5E-17	3.0E-19	5.5E-38	8.0E-32	0
CRU	0.4241	5.0E-06	2.1E-02	0	3.2E-02	5.0E-06	5.0E-06	0
MFR	0.24	5.7E-06	6.5E-03	7.6E-02	9.8E-03	2.2E-05	4.0E-06	0
MER	5.2E-05	2.3E-07	1.3E-06	3.4E-05	2.0E-06	1.3E-13	1.5E-07	0
EEE	0	0	0	0	0	0	0	0
EET	0	0	0	0	0	0	0	0

Results for Module D: Beyond System Boundaries

Table 2 lists D1 reuse, D2 recovery and D3 recycling benefit and load results beyond the system boundary.

Table 2 D1 to D3 Impact & Inventory Results/Functional Unit

Result	D1	D2	D3
Climate Change Biogenic	1.7	2.3E-02	-1.8E-03
Climate Change LULUC	1.8E-02	-1.4E-06	-9.2E-03
Climate Change Fossil	-1.8	-0.16	-2.8E-03
Climate Change Total	-5.2E-03	-0.14	-4.6E-03
Stratospheric Ozone Depletion	-1.8E-09	-7.0E-10	-2.9E-12
Photochemical Ozone Creation	-6.3E-03	-6.8E-04	-1.0E-05
Acidification Potential	-2.0E-03	-2.7E-04	-3.2E-06
Eutrophication Freshwater	-1.7E-06	-1.4E-07	-2.7E-09
Eutrophication Marine	-3.5E-04	-4.6E-05	-5.5E-07
Eutrophication Terrestrial	-1.2E-02	-3.2E-04	-2.0E-05
Mineral Depletion	-2.8E-05	-7.1E-05	-5.0E-08
Fossil Depletion	-1.3	-0.12	-2.0E-03
Water Scarcity Depletion	-2.4E-03	-2.2E-03	-3.8E-06
Input			
Net Fresh Water Use	-1.5E-02	-1.4E-02	-2.4E-05
Secondary Material	-0.14	-5.1E-07	-2.2E-04
Secondary Energy Renewable Fuel	-3.1	-1.5E-06	-4.9E-03
Secondary Energy Non Renewable Fuel	-9.3E-02	-9.5E-03	-1.5E-04
Primary Energy Renewable Material	-18	-0.25	-2.8E-02
Primary Energy Renewable Fuel	-0.11	-0.13	-1.7E-04
Primary Energy Renewable Total	-18	-0.38	-2.8E-02
Primary Energy Non Renewable Material	-2.6	-0.41	-4.1E-03
Primary Energy Non Renewable Fuel	-18	-1.7	-2.9E-02
Primary Energy Non Renewable Total	-21	-2.1	-3.3E-02
Output			
Hazardous Waste Disposed	-4.1E-04	-2.3E-04	-6.4E-07
Non-hazardous Waste Disposed	-1.4E-01	-2.2E-02	-1.4E-03
Radioactive Waste Disposed	-3.1E-18	-5.6E-18	-4.9E-21
Components For Reuse	-3.3E-01	-1.1E-06	-5.3E-04
Material For Recycling	-1.0E-01	-1.7E-02	-1.6E-04
Material For Energy Recovery	-2.1E-05	-7.7E-06	-3.3E-08
Exported Energy Electrical	0	0	0
Exported Energy Thermal	0	0	0

Results Cradel to Grave within the System Boundary

Table 3 lists A1 Resources, A2 Transport, A3 Manufacture, A4 Delivery, A5 Construct, B2 Maintain, B3 Repair, B4 Replace, B5 Refurb, C1 Demolish, C2 Transport and C4 Disposal results. Modules B1 Use, B4 Replace, B5 Refurbish, B6 Water use, B7 energy use or C3 Processing waste had no flows or result.

Table 3 Impact & Input and Output Results/kg Functional Unit

Burdens	A1-3	A4	A5	B2	B3	C1	C2	C4
GWP $_{BIO}$	-2.5	-1.9E-04	-1.9E-04	-0.10	-0.18	-1.3E-19	-5.4E-07	6.9
GWP $_{LULUC}$	1.2E-04	1.0E-09	1.0E-02	6.2E-06	-1.1E-02	1.0E-08	7.9E-10	0
GWP $_{FF}$	2.2	1.9E-02	2.0E-04	0.71	0.17	1.9E-03	6.1E-03	2.0E-05
GWP $_{TOTAL}$	-0.40	1.9E-02	1.0E-02	0.61	-5.5E-03	1.9E-03	6.1E-03	6.9
ODP	4.5E-09	1.7E-13	2.4E-08	3.1E-09	1.8E-10	7.0E-17	1.1E-13	0
POCP	8.7E-03	1.2E-04	9.6E-02	2.9E-03	6.1E-04	7.6E-06	6.0E-05	6.0E-07
AP	2.9E-03	1.2E-05	3.0E-02	1.2E-03	1.9E-04	3.5E-06	5.0E-06	4.9E-04
EP $_{FRESH}$	2.9E-06	5.6E-10	9.4E-05	6.4E-07	1.7E-07	3.9E-13	3.1E-10	0
EP $_{MARINE}$	4.9E-04	2.3E-06	5.3E-03	2.0E-04	3.4E-05	6.4E-07	9.4E-07	8.4E-10
EP $_{LAND}$	1.6E-02	7.7E-06	0.17	1.4E-03	1.2E-03	4.1E-06	3.2E-06	1.8E-08
ADP $_{MIN}$	2.9E-05	7.2E-06	3.5E-04	3.1E-04	2.2E-06	6.2E-12	4.0E-06	0
ADP $_{FF}$	1.9	2.2E-02	19.2	0.52	0.12	9.2E-04	7.5E-03	0
WDP	3.8E-03	2.9E-06	3.2E-02	9.7E-03	2.4E-04	8.5E-08	1.4E-06	0
Input								
FW	2.4E-02	1.8E-05	0.20	6.0E-02	1.5E-03	5.2E-07	8.7E-06	0
SM	1.5	2.3E-06	0.07	0	1.4E-02	1.6E-05	1.7E-06	0
RSF	2.7	6.8E-06	8.7E-04	0	0.31	2.9E-04	9.2E-05	0
NRSF	0.24	7.4E-04	5.9E-03	4.2E-02	9.2E-03	3.9E-10	4.8E-04	0
PERM	22	3.0E-04	2.3E-03	1.1	1.72	1.3E-09	1.6E-03	0
PERE	0.41	2.4E-03	5.2E-03	0.56	1.0E-02	2.0E-03	2.0E-04	0
PERT	25	2.7E-03	7.4E-03	1.7	1.73	2.0E-03	1.9E-03	0
PENRM	5.0	0.11	0.1	1.7	0.25	2.5E-04	3.7E-02	0
PENRE	25	0.19	0.12	7.4	1.76	1.6E-02	6.3E-02	0
PENRT	30	0.30	0.22	9.1	2.00	1.7E-02	0.10	0
Output								
HWD	5.9E-04	3.7E-05	8.5E-03	9.9E-04	3.7E-05	7.2E-08	1.2E-05	0
NHWD	0.19	3.1E-04	0	9.9E-02	1.2E-02	4.3E-06	9.6E-05	5.0E-02
RWD	7.7E-18	1.0E-31	4.1E-17	2.5E-17	3.0E-19	5.5E-38	8.0E-32	0
CRU	0.4241	5.0E-06	4.4E+00	0	3.2E-02	5.0E-06	5.0E-06	0
MFR	0.24	5.7E-06	1.37	7.6E-02	9.8E-03	2.2E-05	4.0E-06	0
MER	5.2E-05	2.3E-07	2.8E-04	3.4E-05	2.0E-06	1.3E-13	1.5E-07	0
EEE	0	0	0	0	0	0	0	0
EET	0	0	0	0	0	0	0	0

Results for Module D: Beyond System Boundaries

Table 4 lists D1 reuse, D2 recovery and D3 recycling benefit and load results beyond the system boundary.

Table 4 D1 to D3 Impact & Inventory Results/Functional Unit

Result	D1	D2	D3
Climate Change Biogenic	1.9	0.54	2.9E-02
Climate Change LULUC	0.66	4.5E-02	3.0E-04
Climate Change Fossil	-1.5	-0.59	-2.9E-02
Climate Change Total	0.33	-4.6E-02	1.5E-04
Stratospheric Ozone Depletion	-1.6E-09	-8.9E-10	-3.0E-11
Photochemical Ozone Creation	-5.5E-03	-2.2E-03	-1.0E-04
Acidification Potential	-1.8E-03	-7.1E-04	-3.3E-05
Eutrophication Freshwater	-1.5E-06	-5.7E-07	-2.8E-08
Eutrophication Marine	-3.1E-04	-1.2E-04	-5.7E-06
Eutrophication Terrestrial	-1.1E-02	-3.8E-03	-2.1E-04
Mineral Depletion	-2.3E-05	-4.2E-05	-3.8E-07
Fossil Depletion	-1.1	-0.43	-2.1E-02
Water Scarcity Depletion	-2.2E-03	-1.8E-03	-4.0E-05
Input			
Net Fresh Water Use	-1.3E-02	-1.1E-02	-2.5E-04
Secondary Material	-0.12	-4.1E-02	-2.3E-03
Secondary Energy Renewable Fuel	-2.8	-0.91	-5.2E-02
Secondary Energy Non Renewable Fuel	-8.3E-02	-3.2E-02	-1.6E-03
Primary Energy Renewable Material	-16	-5.3	-0.29
Primary Energy Renewable Fuel	-9.4E-02	-9.4E-02	-1.7E-03
Primary Energy Renewable Total	-16	-5.4	-0.29
Primary Energy Non Renewable Material	-2.2	-0.93	-4.2E-02
Primary Energy Non Renewable Fuel	-16	-6.1	-0.30
Primary Energy Non Renewable Total	-18	-7.0	-0.34
Output			
Hazardous Waste Disposed	-3.8E-04	-2.4E-04	-6.3E-06
Non-hazardous Waste Disposed	-4.0E-02	-4.6E-02	-2.3E-03
Radioactive Waste Disposed	-2.8E-18	-3.7E-18	-5.1E-20
Components For Reuse	-0.30	-9.8E-02	-5.6E-03
Material For Recycling	-9.1E-02	-3.9E-02	-1.7E-03
Material For Energy Recovery	-2.0E-05	-1.0E-05	-3.4E-07
Exported Energy Electrical	0	0	0
Exported Energy Thermal	0	0	0

Results Cradel to Grave within the System Boundary

Table 5 lists A1 Resources, A2 Transport, A3 Manufacture, A4 Delivery, A5 Construct, B2 Maintain, B3 Repair, B4 Replace, B5 Refurb, C1 Demolish, C2 Transport and C4 Disposal results. Modules B1 Use, B4 Replace, B5 Refurbish, B6 Water use, B7 energy use or C3 Processing waste had no flows or result.

Table 5 Impact & Input and Output Results/kg Functional Unit

Burdens	A1-3	A4	A5	B2	B3	C1	C2	C4
GWP_{BIO}	-2.5	-1.9E-04	-1.9E-04	-0.10	-0.18	-1.3E-19	-5.4E-07	6.9
GWP_{LULUC}	1.2E-04	1.0E-09	1.0E-02	6.2E-06	-1.1E-02	1.0E-08	7.9E-10	0
GWP_{FF}	2.2	1.9E-02	2.0E-04	0.71	0.17	1.9E-03	6.1E-03	2.0E-05
GWP_{TOTAL}	-0.40	1.9E-02	1.0E-02	0.61	-5.5E-03	1.9E-03	6.1E-03	6.9
ODP	4.5E-09	1.7E-13	2.4E-08	3.1E-09	1.8E-10	7.0E-17	1.1E-13	0
POCP	8.7E-03	1.2E-04	9.6E-02	2.9E-03	6.1E-04	7.6E-06	6.0E-05	6.0E-07
AP	2.9E-03	1.2E-05	3.0E-02	1.2E-03	1.9E-04	3.5E-06	5.0E-06	4.9E-04
EP_{FRESH}	2.9E-06	5.6E-10	9.4E-05	6.4E-07	1.7E-07	3.9E-13	3.1E-10	0
EP_{MARINE}	4.9E-04	2.3E-06	5.3E-03	2.0E-04	3.4E-05	6.4E-07	9.4E-07	8.4E-10
EP_{LAND}	1.6E-02	7.7E-06	0.17	1.4E-03	1.2E-03	4.1E-06	3.2E-06	1.8E-08
ADP_{MIN}	2.9E-05	7.2E-06	3.5E-04	3.1E-04	2.2E-06	6.2E-12	4.0E-06	0
ADP_{FF}	1.9	2.2E-02	19.2	0.52	0.12	9.2E-04	7.5E-03	0
WDP	3.8E-03	2.9E-06	3.2E-02	9.7E-03	2.4E-04	8.5E-08	1.4E-06	0
Input								
FW	2.4E-02	1.8E-05	0.20	6.0E-02	1.5E-03	5.2E-07	8.7E-06	0
SM	1.5	2.3E-06	0.07	0	1.4E-02	1.6E-05	1.7E-06	0
RSF	2.7	6.8E-06	8.7E-04	0	0.31	2.9E-04	9.2E-05	0
NRSF	0.24	7.4E-04	5.9E-03	4.2E-02	9.2E-03	3.9E-10	4.8E-04	0
PERM	22	3.0E-04	2.3E-03	1.1	1.72	1.3E-09	1.6E-03	0
PERE	0.41	2.4E-03	5.2E-03	0.56	1.0E-02	2.0E-03	2.0E-04	0
PERT	25	2.7E-03	7.4E-03	1.7	1.73	2.0E-03	1.9E-03	0
PENRM	5.0	0.11	0.1	1.7	0.25	2.5E-04	3.7E-02	0
PENRE	25	0.19	0.12	7.4	1.76	1.6E-02	6.3E-02	0
PENRT	30	0.30	0.22	9.1	2.00	1.7E-02	0.10	0
Output								
HWD	5.9E-04	3.7E-05	8.5E-03	9.9E-04	3.7E-05	7.2E-08	1.2E-05	0
NHWD	0.19	3.1E-04	0	9.9E-02	1.2E-02	4.3E-06	9.6E-05	5.0E-02
RWD	7.7E-18	1.0E-31	4.1E-17	2.5E-17	3.0E-19	5.5E-38	8.0E-32	0
CRU	0.4241	5.0E-06	4.4E+00	0	3.2E-02	5.0E-06	5.0E-06	0
MFR	0.24	5.7E-06	1.37	7.6E-02	9.8E-03	2.2E-05	4.0E-06	0
MER	5.2E-05	2.3E-07	2.8E-04	3.4E-05	2.0E-06	1.3E-13	1.5E-07	0
EEE	0	0	0	0	0	0	0	0
EET	0	0	0	0	0	0	0	0

Results for Module D: Beyond System Boundaries

Table 6 lists D1 reuse, D2 recovery and D3 recycling benefit and load results beyond the system boundary.

Table 6 D1 to D3 Impact & Inventory Results/Functional Unit

Result	D1	D2	D3
Climate Change Biogenic	1.7	2.3E-02	-1.8E-03
Climate Change LULUC	1.8E-02	-1.4E-06	-9.2E-03
Climate Change Fossil	-1.8	-0.16	-2.8E-03
Climate Change Total	-5.2E-03	-0.14	-4.6E-03
Stratospheric Ozone Depletion	-1.8E-09	-7.0E-10	-2.9E-12
Photochemical Ozone Creation	-6.3E-03	-6.8E-04	-1.0E-05
Acidification Potential	-2.0E-03	-2.7E-04	-3.2E-06
Eutrophication Freshwater	-1.7E-06	-1.4E-07	-2.7E-09
Eutrophication Marine	-3.5E-04	-4.6E-05	-5.5E-07
Eutrophication Terrestrial	-1.2E-02	-3.2E-04	-2.0E-05
Mineral Depletion	-2.8E-05	-7.1E-05	-5.0E-08
Fossil Depletion	-1.3	-0.12	-2.0E-03
Water Scarcity Depletion	-2.4E-03	-2.2E-03	-3.8E-06
Input			
Net Fresh Water Use	-1.5E-02	-1.4E-02	-2.4E-05
Secondary Material	-0.14	-5.1E-07	-2.2E-04
Secondary Energy Renewable Fuel	-3.1	-1.5E-06	-4.9E-03
Secondary Energy Non Renewable Fuel	-9.3E-02	-9.5E-03	-1.5E-04
Primary Energy Renewable Material	-18	-0.25	-2.8E-02
Primary Energy Renewable Fuel	-0.11	-0.13	-1.7E-04
Primary Energy Renewable Total	-18	-0.38	-2.8E-02
Primary Energy Non Renewable Material	-2.6	-0.41	-4.1E-03
Primary Energy Non Renewable Fuel	-18	-1.7	-2.9E-02
Primary Energy Non Renewable Total	-21	-2.1	-3.3E-02
Output			
Hazardous Waste Disposed	-4.1E-04	-2.3E-04	-6.4E-07
Non-hazardous Waste Disposed	-1.4E-01	-2.2E-02	-1.4E-03
Radioactive Waste Disposed	-3.1E-18	-5.6E-18	-4.9E-21
Components For Reuse	-3.3E-01	-1.1E-06	-5.3E-04
Material For Recycling	-1.0E-01	-1.7E-02	-1.6E-04
Material For Energy Recovery	-2.1E-05	-7.7E-06	-3.3E-08
Exported Energy Electrical	0	0	0
Exported Energy Thermal	0	0	0

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Life Cycle Assessment Method

LCA Author	The Evah Institute is described at www.evah.com.au.
Study Period	Factory data was collected from 2021 to 2023
LCA Method	Compliant with ISO 14040 and ISO 14044 Standards
LCIA method	ReCiPe 2016 Life Cycle Impact Assessment (LCIA)
Scope	Cradle to fate including all supply chain phases and stages depicted in Figure a.
Phases	The LCA covered all known flows in all known stages cradle to end of life fate.
Assumptions	Use is to typical Australian wildlife conservation professional practice.
Scenarios	Use, cleaning, maintenance plus disposal and re-use were scenario-based using Facility Management Association denoted and published typical operations.
Processes	All known processes are included from resource acquisition, water, fuel & energy use, power generation & distribution, freight, refining, intermediates, manufacture, scrap re-use, packing and dispatch, installation, use, maintenance and landfill. All significant waste and emission flows from all supply chain operations used to make, pack and install the product are included.

Evah industry databases cover all known domestic and global scope 1 and 2 operations. They exclude scope 3 burdens from capital facilities, equipment churn, noise and dehydration as well as incidental activities and employee commuting. Electricity supply models in active databases are updated annually. As each project is modelled and new data is available the databases are updated. They are then audited by external Type 1 ecolabel certifiers. The databases exist in top zones of commercial global modelling and calculating engines. Quality control methods are applied to ensure:

- Coverage of place in time with all information for each dataset noted, checked and updated;
- Consistency to Evah guidelines for all process technology, transport and energy demand;
- Completeness of modeling based on in-house reports, literature and industry reviews;
- Plausibility in 2 way checks of LCI input and output flows of data checked for validity, plus
- Mathematical correctness of all calculations in mass and energy balance cross checks.

Data Sources Representativeness and Quality

Primary data used for modelling the state of art of each operation includes all known process for:

- Technology sequences;
- Energy and water use;
- Landfill and effluent, plus
- Reliance on raw and recycled material;
- High and reduced process emissions;
- Freight and distribution systems.

Primary data is sourced from client annual reports and publications on corporate locations, logistics, technology use, market share, management systems, standards and commitment to improved environmental performance. Information on operations is also sourced from client:

- Supply chain mills, their technical manuals, corporate annual reports and sector experts, and
- Manufacturing specifications websites and factory site development license applications.

Background data is sourced from the International Energy Agency, IBISWorld, USGS Minerals, Franklin Associates, Plastics Europe, CML2, Simapro 9.5, EcoInvent 3.9 and NREL USLCI databases plus:

- Library, document, NPI and web searches, review papers, building manuals and
- Global industry association and Government reports on best available technology (BAT).

For benchmarking, comparison and integrity checks inventory data is developed to represent BAT, business as usual and worst practice options with operations covering industry sector supply and infrastructure in Australia and overseas. Such technology, performance and license conditions were modelled and evaluated across mining, farming, forestry, freight, infrastructure and manufacturing and building industry sectors since 1995.As most sources do not provide estimates of accuracy, a pedigree matrix of uncertainty estimates to 95% confidence levels of Geometric Standard Deviation^2 (σ_g) is used to define quality as on page 3. No data set with >±30% uncertainty is used.

Supply Chain Modelling Assumptions

Australian building sector rules and Evah assumptions applied are defined in this section

Scope Boundaries Assumptions and Metadata

Quality/Domain	National including Import and Export
Process Model	It is typical industry practice with currently most common or best (BAT) technology.
Resource flows	LCI uses regional data for resource mapping, fuels, energy, electricity and logistics.
Temporal	Project data collated over the previous 4 years represents averages over the last
Geography	Jurisdiction is of the declared client, site, regional, national, Pacific Rim then Europe.
Representation	It represents the declared client, their suppliers and energy providers to each cradle.
Consistency	All known operations are modelled according to operations with closest proximity.
Technology	The industry supply chain modelled is typical recent Pacific Rim technology and
Functional Unit	A 20 or 60 year period of typical service life, use, cleaning and disposal/kg or m^2
System Control	
Primary Sources	Client and supplier mills, publications, websites, specifications and manuals are
Other Sources	Recent IEA, GGT, Simapro, IBIS, EcoInvent sources used and cited in the LCA
Data mix	Power grid and renewable shares are updated according to the latest IEA reports.
Operational	Company data is used for process performance, product share, waste and
Logistics	Local data is used for power, fuel mix, water supply, logistics share & capacity.
New Data Entry	New data is entered by current researchers at Malaika LCT, Evah and GGTI.
Data Generator	All via current manufacturers, Evah, GGTI, IBIS and others is cited and in LCA
Data Publisher	Publishers include the Evah Institute, GGTI and designated clients only.
Contributors	All professional and personal contributors are cited in Evah & GGTI records.
Data Flow & Mix	
System Boundary	All known resources and emissions are modelled from Earth cradles to end of life
System flows	All known flows are modelled from & to air, land, water & community sources & sinks.
Capital inclusions	Natural stocksΔ, industry stockpilesΔ, capital wear Δ, system losses and usage.
Arid Practice	Dry technology adopted; Water use is factored by 0.1 as for e.g. mining.
Transportation	Distance >20% than EU; >20% fuel efficient larger vehicles, load & distance.
Industrial	Company or industry sector data for manufacturing and minerals involved.
Mining	All raw material extraction is based on Australian or Pacific Rim technology.
Imported fuel	The fuel mix is from nearest sources such as UAE, SE Asia, Canada or New Zealand.
Finishes	Processing inputs with finishing burdens are factored in otherwise that is denoted.
Validation	
Accuracy	10^{th} generation study is ± 5 to 15% uncertain due to some background data.
Completeness	All significant operations are tracked and documented from the cradle to grave.
Precision	Tracking of >90% flows apply a 90:10 rule sequentially to 99.9% and beyond.
Allocation	All is allocated to co products on reaction stoichiometry by energetic or mass fraction.
Burdens	All known resource use from & emissions to community air land, water are included.
Plausibility	Results are checked and benchmarked against BAT, BAU & worst practice.
Sensitivity	Calculated U is reported & compared to Bath U RICE & EcoInvent libraries.
Validity Checks	Checks are versus Plastics Europe, Bath U RICE & or Industry LCA Literature.

Further and explanatory information is found at

http://www.globalgreentag.com/

or contact:

certification1@globalgreentag.com

EPD:BA™

Environmental Product Declaration:Benefit Addendum

Nature Positive+ EPD :BA Declaration
Compliance beyond EN 15804+A2, ISO 14025 ISO 21930

Global GreenTag International

Content .... page Number

Nature Positive Assessment

The United Nations (UN) Nature Positive (N+) Program provides global impetus for EPDs to consider gain versus loss in climate and biodiversity security [1, 2, 3, 4]. But the reach of LCIA methods such as ReCiPe and Product Environmental Footprint (PEF) model damage and depletion from maxima to zero [5, 6]. As do most others leading methods TRACI, CML and EcoIndicator 99 (EI(() [7, 8, 9, 10].

Most relevant ISO14025 and EN15804 standards, IPCC reference metrics, EPD Platforms and Ecolabel Certifiers also apply such negative [11, 12, 13, 14, 15]. Conventional LCIA models environmental damages to e.g. climate and loss of human health, ecosystem quality and resource supply [16, 17, 18, 19, 20, 21] Figure A1, The Evah Butterfly Matrix depicts such negative measures and metrics on the left-hand side.

The reach of N+, however extends scientific sightlines beyond zero damage to quantify benefits, gains and regeneration [1, 2, 3, 22, 23, 24, 25]. Other information in N+ EPDs sight beyond damage to define additional information on net-positive benefit outcomes including many gains Figure A1 depicts on the right-hand side [26, 27, 28, 29]. Figure A1 depicts the ReCiPe LCIA modelling damage, depletion and loss versus the Evah Life Cycle Benefit (LCBA) method modelling benefit, repletion and gain [30, 31, 32, 33, 34].

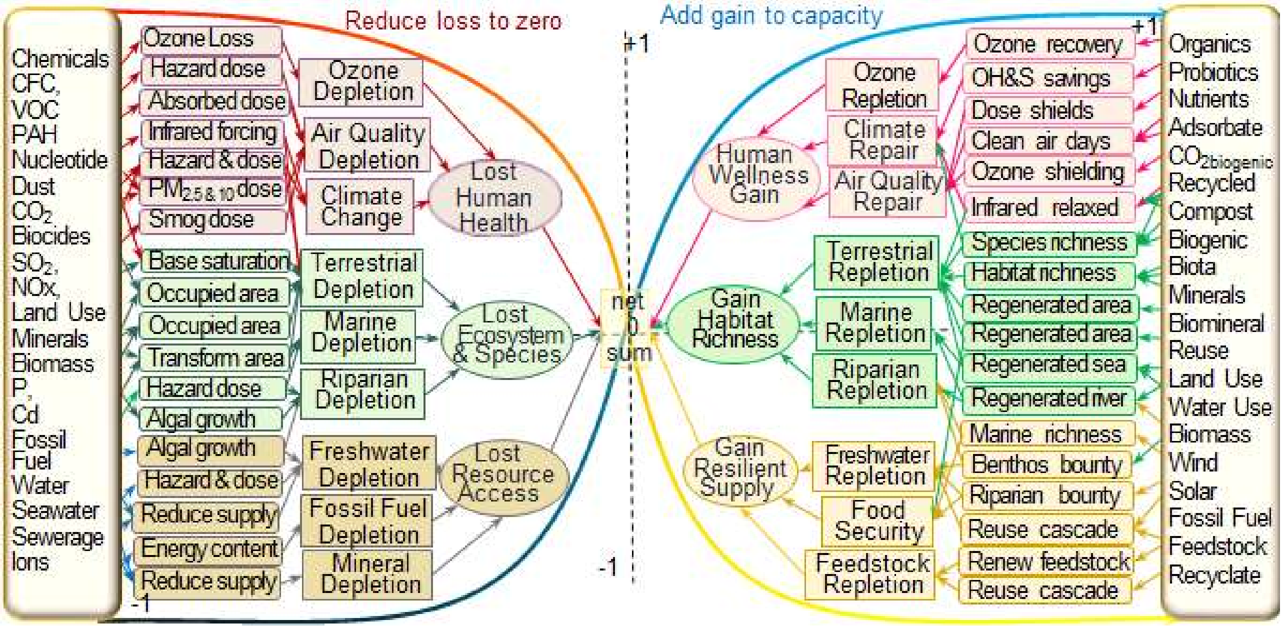

Figure A1 The Evah Butterfly Matrix: ReCiPe Damages and Loss LCIA Versus Benefits and Gain

Indicators of Climate security are embedded in each of the following 3 LCBA tiers: Human wellness, Habitat richness and Supply viability. Integrated UN, ReCiPe, TRACI, CML, EI 99, PEF, IPCC and Circularity methods, measures and metrics are used herein to assess net-loss and net-gain. Such extended assessment is applicable to empower communication and reduce barriers for regenerative and nature-positive initiatives. LCA of benefits offers community, government and business a new environmental science tool with examples of methods to measure gains in accelerating climate security and restoration.

Using LCBA in conjunction with conventional LCIA modelling of damages allows LCA modelling of damages to and beyond zero climate, health, ecosystems and supply losses to beneficial gains in e.g. climate, wellness, biodiversity and supply security .Reaching to quantify and show positive gains well beyond the negative and zero loss outcomes, LCBA enables a truer market assessment. The capacity to report positive metrics can also reduce prevalent greenwashing and reliance on bad news that has disempowered scientifically valid communications and efforts to engage community action.

Some materials and practices inherently promote wellness and like medicine others inherently cure illness. Weathertex supply chain and nesting reports confirm a range of inherently positive outcomes /kg. Positive and net-positive gains and benefits can offset damages and loss. Benefits from less and avoided impacts and gains arising from properties inherent within a component or utility can also be additive. For example biomass generating more clean oxygen while drawing down carbon dioxide from air enacts braking on greenhouse gas forcing of anthropogenic climate change. Together they increase wellness.

Environmental Benefit Terminology

Key environmental benefits contributing to ecological regeneration of climate and biodiversity security are Table Ad below with common names and responses for each indicator.

Climate Security	Reliance on renewable energy is vital to restore thermal energy differentials, from equator to poles. Differential forcing of ocean current and wind circulation blends and regulates climate to reduce extreme weather events. Forest, wilderness and algal growth can drawdown such gasses. Carbon banked in standing forests, detritus, roots and soils brakes climate change. Greenhouse gas *d*rawdown and sequestration in product biomass is vital for "***Climate security***".
Water Security	***"Water security*** arises from conservation and recycling as well as reliance on renewable and reclaimed biomass to avoid climate-change-induced drought. Hectares of intensive forest and plantings stabilise rain catchment and ground water Table A levels. Ground mulches retain soil hydration and reduce water stress.
Ozone Repletion	Repairing the planet's stratospheric ozone solar shield protects plants, humans and animals allowing them to be ***sun-safe***" for longer in the outdoors. Ground level oxygenation via growing plants and algae is a vital way to enable accumulation at higher levels of naturally-formed Ozone***.*** Restoring the ozone layer also depends on use of ozone-safe refrigerants, aerosols and solvents
Buffered air, land and waters	Acid rain-free air-sheds are safer for natural terrestrial, aquatic and urban communities. Buffered air-pH supports healthy soil and waterways, nitrogen fixation vital for plant growth and natural decomposition. Safe pH supports health of fisheries, forests, buildings and materials. The chief way to enhance "***natural-rain***" is reliance on renewable fuels and power supply.
Oxygenated terrestrial and aquatic life	In natural waterways balanced nutrient and oxygen availability for aquatic and terrestrial organisms promotes healthy growth as well as water and habitat security across related ecosystems. A vital way to enhance healthy waterways is tight control of slow-release fertilisers avoiding synthetic nutrients in run-off over land catchments.
Sweet-air	Smog-free air in summer near ground level when most people live and breathe outside is generated by plants and avoiding or filtering pollutants. **Sweet-air** enables healthy vegetation, crops and humans to thrive. Chief ways to enhance sweet-air are reliance on low-emission renewable energy and non-volatile chemicals.
Resource Repletion	The extinction rebellion youth movement calls on governance to secure climate, material reserves and biodiversity for current and future generations. Chief ways to ensure resource repletion include investing in sustainably managed **"circularity",** recycling, renewables and reclaimed biomass. This retains accessible, plentiful, essential valuable raw material, medicinal, chemical, feedstock and fuel stock.
Biodiversity Security	Extensive bushland, biodynamic and organic agriculture plus standing forests offer natural land use ranges and corridors for wildlife, herds and flora **"biodiversity"**: • habitat bird, bee, pollinator, avian, worm biome, shelter, forage and grazing • leaf & litter forage enhance soil condition, mulch, nutrition and retention, • soil microbiota, detritus-feeders and biotic refuges reduce temperature stress • sequestered CO_{2e} in natural habitat, biomass & soil braking climate change.
Ecological Wellness	Human ecological health benefits flow from reliance on renewable and reclaimed biomass instead of fossil fuel. Chief ways to enhance **"wellness"** include avoiding particulates and pollution, smog, volatile organics and carcinogens. Climate and ozone security and safer air-sheds ensue for natural, terrestrial, aquatic and urban communities.

Life Cycle Benefit Assessment Reference Framework

This section summarises the LCBA framework of indicators measures and metrics. Local and global human wellness, habitat regeneration and supply resilience are framed across United Nations Sustainable development goals (UN SDG)s [2]. LCBA reaches beyond zero loss to show gains in climate, wellness, biodiversity and supply security [32, 33]. Most apply comparable LCIA measures and metrics for example as in common use for avoided impacts [7 to 11]. All are also shown versus % circularity outcomes.

LCA framework of LCBA indicators

Benefit Layer	Exposure & Jurisdiction	Unit pa	Local	Global	UN	Circularity
Healthy Able Life Years		**HALY/capita**		**metric**	**SDG**	**% Capacity**
Local Shelter	Household shelter	m^2 GFA	Housed	UN $_{eq}$	1	Housing
Fresh Food	Affordably nourished	kJ UN $_{eq}$	Nourished	UN $_{eq}$	2	Nutrition
Fresh Air	Oxygen indoors	kg O_2	Oxygenate	O_2 $_{C1750}$	3	Oxygenation
Clean Air	$PM_{2.5}$ dust-free	µg PM2.5	Clean Air	PM $_{C1750}$	3	Decongestion
Sweet Air	VOC free indoors	µg VOC	Safe Air	VOC $_{C1750}$	3	Inhalation
Sun Safety	Ozone layer repair	kg O_2 $_{outdoors}$	Sun Safe	O_3 $_{C1750}$	3	Ozonating
Time in Nature	100 days recreation pppa	R&R Ha	Relaxed	Ha $_{C1750}$	3	Free-time
Medical Access	Paramedic Care	hours $_{aid}$	Paramedic	hours $_{to\ aid}$	4	Medic-access
Work Dignity	>30hrs paid work/week	$\$_{eq}$/hour	Employed	km UN $_{eq}$	5	Secure-work
Fresh Water	Potable rain hydrated	m^3	Catchment	rain $_{C1750}$	6	Potability
Supply Energy & Resource Viability		**SERV/capita**				
Viable Water	Refill local reservoirs	m^3 $_{freshwater}$	Watered	Rain $_{C1750}$	6	Freshwater
Viable Air	Photosynthetic Cities	kg O_{2e100}	Breathable	O_2 $_{C1750}$	7	Oxygenation
Viable C-bank	Resink Carbon in product	kg CO_{2e100}	Embody C	CO_{2e100}	7	Bank-carbon
Viable Energy	Reliance on renewable	kg $_{renewed}$	Renewal	oil $_{eq}$	7	Renewability
Viable Food	Reliance on local food	kJ $_{km}$	Autonomy	UN $_{eq}$	8	Food autonomy
Viable Supply	Refuel local reserves	kg $_{feedstock}$	Fuelstock	oil $_{eq}$	9	Autonomy
Viable Mineral	Recycle scarce material	MJ $_{elemental}$	Security	oil $_{eq}$	10	Mineral security
Viable Feedstock	Recycle material & scrap	MJ $_{recycle}$	Feedstock	oil $_{eq}$	10	Recyclability
Viable Disaster	Reserved sustenance	t $_{back-up}$	Sustenance	UN $_{eq}$	11	Recoverability
Viable Shelter	Refuges in disasters	bed $_{pc}$	Refugia	GFA	11	Safe havens
Positive Ecosystem ReFormation		**PERF/Ha**				
Natural Access	Nature parks & tracks	m^2 R&R	Innature	Reach $_{C1750}$	12	Natural Access
Urban Bounty	Pre-urban carrying capacity	t flora/GFA	Urbundant	Bounty $_{C1750}$	12	Greenspace
Soil Carbon	Carbon banking	kg CO_{2e20}	C Soilbank	Soil C $_{C1750}$	13	Soil-Carbon
Climate Brakes	Carbon drawdown	t CO_{2e20}	C Biomass	Worms $_{C1750}$	13	Climate safety
Plants & Algae	Carbon drawdown	t CO_{2e100}	Drawdown	Algae $_{C1750}$	13	Climate security
Aquatic Stock	Species rich range	t Frog-rich	Species	Frogs $_{C1750}$	14	Aquatic bounty
Marine Stock	Species richness & range	t Fish-rich	Species	Whales $_{C1750}$	14	Marine bounty
Wildlife Habitat	Corridor & refuge range	Ha Biomes	Apex $_{species}$	Range $_{C1750}$	15	Linked Ranges
Terrestrial Stock	Rich flora & fauna range	t Wildlife	Species	Bears $_{C1750}$	15	Wildlife rich
Avian Stock	Species rich refugia	t Bird-rich	Richness	Birds $_{C1750}$	15	Abundance
Pollinator stock	Species richness & range	t Pollinated	Species	Bees $_{C1750}$	16	Biodiversity
Nature Reserve	Scarce reserves restocked	t Abundant	Reserves	Stock $_{C1750}$	17	Reserves

Background and Primary LCA Data Included and Excluded in this EPD

Photosynthetic drawdown was modelled on known, long-term, local best practice forest management [35]. This EPD declares the lowest embodied GWP wood estimate factoring no significant land use change since 1925 [36]. Weathertex board and panel products are made from Eucalyptus (E.) tree species forest mix being mostly 75% Blackbutt with 8% Blue Leaf Stringybark and minor shares of other eucalyptus.

Background Data Type and Sensitivity

Table A 1 lists Weathertex and Northern New South Wales (NSW) Eucalyptus species carbohydrate and lignin share by % dry mass[1]. Eucalypt carbohydrates range from 35 to 63% and lignins 22 to 31%.

Table A 1 NSW North Coast Weathertex Forest Share Heartwood Carbs Weathertex (% dry mass)

Species	% Mix	Botanical Name	Lignin	Cellulose	Hemicellulose	total
Blackbutt	75	E pilularis	24.17	31.83	10.61	42.44
Blue Stringybark	8	E agglomerata	27.70	47.60	15.30	62.9
White Stringybark	4	E globoidea	29.50	44.00	16.00	60
Flooded Gum	2	E grandis	25.86	31.45	10.48	41.93
Ironbark	2	E crebra	32.50	43.50	14.50	58
Tallowwood	2	E microcorys	22.76	26.39	8.80	35.19
Sydney Blue Gum	2	E saligna	27.70	47.60	15.30	62.9
Red Mahogany	2	E resinifera	30.00	45.00	16.00	61
Grey Gum	1	Es propinqua	29.00	44.50	16.00	60.5
Brush Box	1	Tristania conferta	28.00	43.50	17.00	60.5
Spotted Gum	1	Corymbia maculata	31.00	44.00	15.00	59
White Mahogany	1	E acmenioides	29.00	45.00	16.00	61
weighted mean			25.47	35.09	11.76	46.85

Eucalyptus Wood Carbohydrate and Ligin Chemical Composition

Dry wood is primarily composed of 65–75% carbohydrates and 18–35% lignin mass. Carbohydrates mainly of 40–50% cellulose and 15–30% hemicellulose are complex polymers that provide structural integrity and small amounts of non-structural sugar and starch polymers.

Table A1 also lists the Weathertex Eucalyptus forest mix and weighted means of 35.09% cellulose, 25.47% lignin and 11.76% hemicellulose.

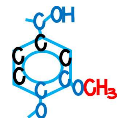

Fig. A2 Guaiacyl

Dry Eucalyptus wood also contains 1.25% protein composed of 18 amino acids. Cell-Lignins are phenolic polymers of Guaiacyl and Syringyl primary phenolic monolignol monomers depicted in Figure A2 and Figure A3. Groups are coloured methyl **CH_3**, carboxyl **CO** blue **C=C** black Nitrogen **N** green and sulphur **S** yellow.

Wall structural proteins that form in xylem cell walls during lignification remain long after cells die. Vascular plants use the methyl donor S-adenosyl-l-methionine (SAM)[2], to make Guaiacyl and Syringyl that link to form lignin polymers in vascular plants [37].

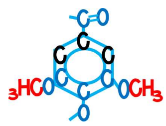

Fig. A3 Syringyl

As depicted on its central aromatic ring Guaiacyl (G) carries one methoxy **CH_3O** group but Syringyl (S) carries two. S units are dominant constituents of hardwood lignin, more than G units, which makes hardwood more reactive and easier to pulp than softwoods. Weathertex hardwood has 76%G and 24%S.SAM is synthesized through catalysis of the S-adenosylmethionine synthase (SAMS) enzyme) from the essential amino acid methionine $C_5H_{11}NO_2S$ in Figure A4[3].

Fig. A4 Methionine

All organisms have methionine in their proteins, and it is indispensable for all carbohydrate and lignin biosynthesis and regulation, but it is not a structural component of all the latter.

1 F. Ximenes, R. Coburn, M. McLean, J. Samuel, N. Cameron, B. Law, C. Threllfall, K. Wright & S. Macintosh North Coast Residues: A …part of the 2023 Nth Coast Forestry Project (2023) NSW DPI, www.dpi.nsw.gov.au/forestry/science/forest-carbon/north-coast-residues-project.
2 Y. Li, W. Xiong, F. He, T. Qi, Z Sun, Y. Liu, S. Bai, H. Wang, Z. Wu & C. Fu (2022) Down-regulation of PvSAMS impairs S-adenosyl-lmethionine and lignin biosynthesis etc., J of Exp Bot, Vol. 73, No. 12 pp. 4157–4169 https://doi.org/10.1093/jxb/erac147
3 Y. Li, W. Xiong, F. He, T. Qi, Z Sun, Y. Liu, S. Bai, H. Wang, Z. Wu & C. Fu (2022) Down-regulation of PvSAMS impairs S-adenosyl-lmethionine and lignin biosynthesis etc., J of Exp Bot, Vol. 73, No. 12 pp. 4157–4169 https://doi.org/10.1093/jxb/erac147

Figure A5 content varies 25 to 55% cellulose, 28 to 35% lignin and 7 to 30% hemicellulose with species. It depicts key microstructures of cellulose, hemicellulose, lignin and extractive compounds. Extractives are outside the scope of this LCA because of limited data availability.

Figure A6 charts various dry wood Cellulose, Hemicellulose and Lignin mass % shares in Northern NSW Eucalyptus species. Weathertex forest mix weighted mean 35.1% cellulose11.8% hemicellulose and lignin 25.5%. Square markers, shown on the end axes are in the lower third median value. So the Weathertex mean is in the lower third of the range of such content and not the highest ones for the various species.

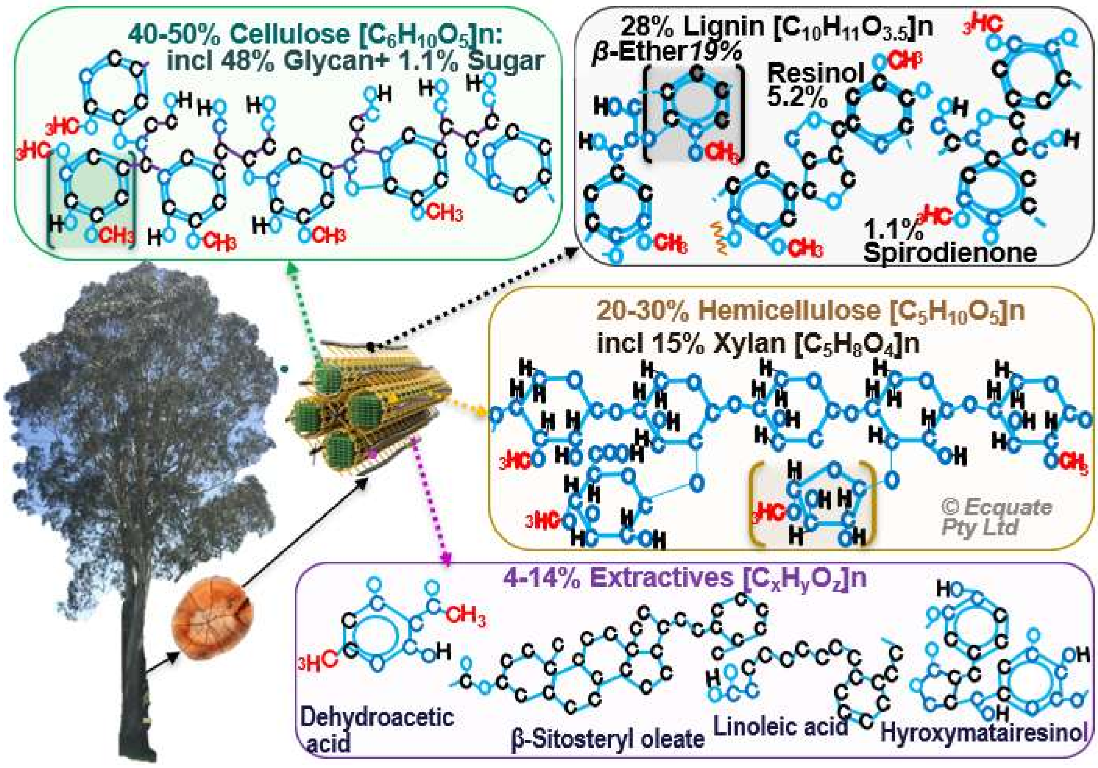

Figure A5 Eucalyptus Wood Major Carbohydrate and Lignin Compounds

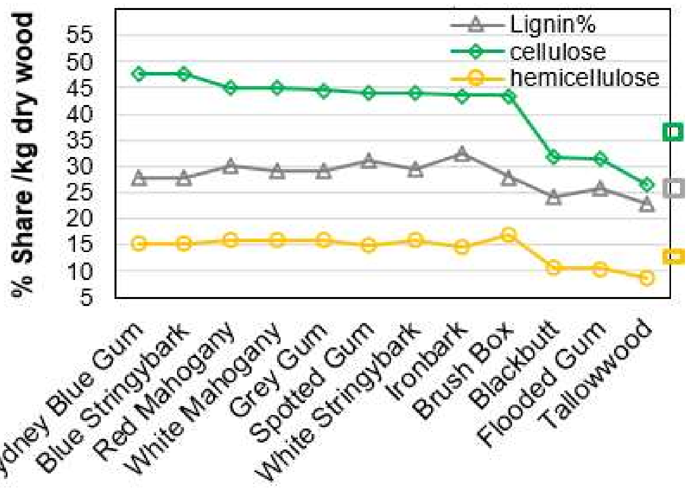

Figure A6 Carbohydrate and Lignin Compounds in Eucalyptus Wood Versus Weathertex

Eucalyptus Wood Protein Chemical Composition

Figure A6 depicts 18 amino acids microstructures of Eucalyptus protein. Each has the same basic components of attached α-carbon, hydrogen, α-carboxyl, α-amine and multivariate R-groups.

All the acids contain methyl, methylene, amine and carboxyl groups but only methionine and cystine contain sulphur[4].

The Figure A6 colours methyl **CH_3** methylene **CH_2** and hydrocarbon **C-C-H** groups red, carboxyl **C=O** blue, amines **NH** and ammonia **NH_3** green, sulphur **S** yellow and **R** unknowns black.

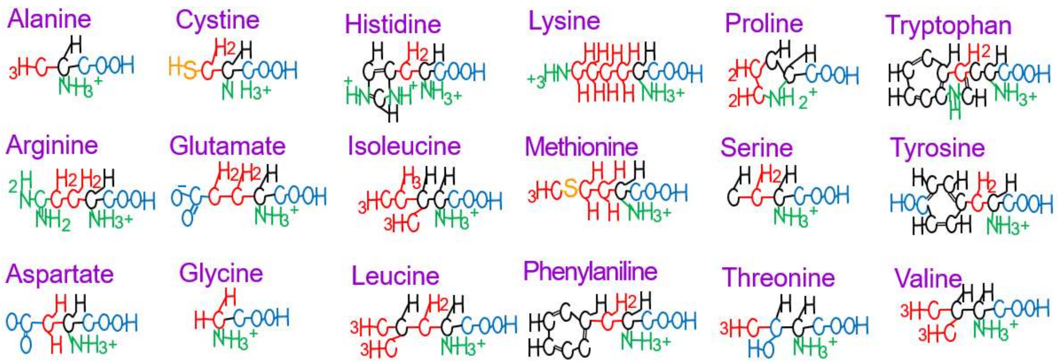

Figure A7 Wood Protein Essential Amino Acid Microstructures

Figure A7 charts the protein amino acid types in cherry and walnut hardwoods and loblolly pine softwood chemical formula as well as their molar share/ kg dry protein listed in Table A2.

This LCA was modelled on 1.25% protein in an average of cherry, walnut, loblolly plus eucalyptus globulous heart and sapwood.

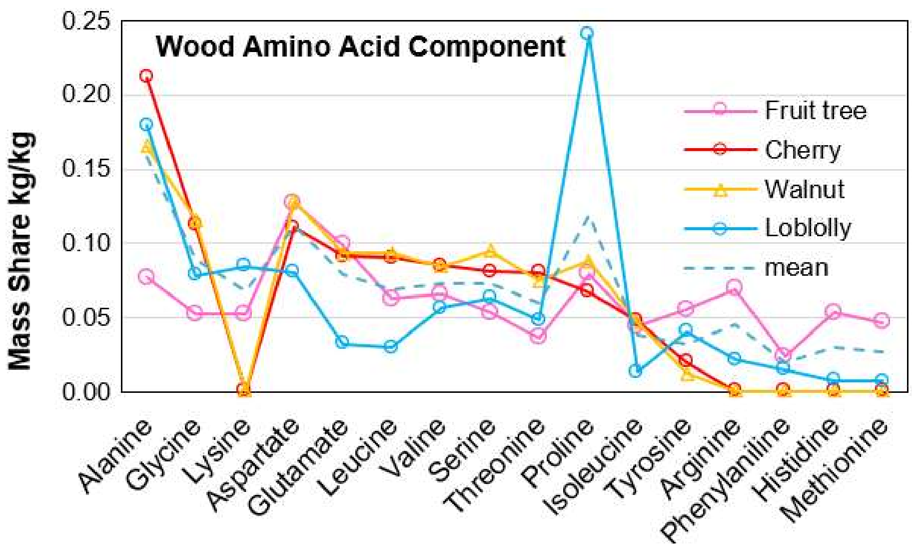

Figure A7 Chemical Microstructures of Wood Protein Amino Acids

Embodied CO_{2e} in Eucalyptus Carbohydrate & Lignin & Protein

Table A2 lists protein amino acid types in cherry and walnut hardwoods and loblolly pine softwood chemical formula as well as their molar share/ kg dry protein. Table A3 and Table A4 list the final average 100 year far term horizon GWP of 0.77kg CO_{2e} /kg dry wood modelled on 1.25% protein. Table A6 list the final average 20 near term GWP of 2.18kg CO_{2e} /kg dry wood.

Table A2 Protein Chemical Microstructure CO2, CH and CH3 molar share/kg dry wood protein

Amino Acids	Formula	CO_2	CH	CH_3	Cherry	Walnut	Loblolly	Mean	CH_3	CO_2
Alanine	$C_3H_7NO_2$	1	1	1	0.212	0.166	0.064	0.071	0.1426	0.2852
Glycine	$C_2H_5NO_2$	1	0	1	0.112	0.116	0.079	0.086	0.0860	0.0860
Lysine	$C_6H_{14}N_2O_2$	1	1	3	0.000	0.000	0.085	0.071	0.2141	0.1427
Aspartate	$C_4H_7NO_4$	3	0	1	0.111	0.129	0.081	0.090	0.0896	0.2687
Glutamate	$C_3H_9N0_4$	2	0	2	0.091	0.093	0.032	0.061	0.1215	0.1215
Leucine	$C_6H_{14}N_2O_2$	1	2	3	0.091	0.093	0.030	0.060	0.1794	0.1794
Valine	$C_5H_{11}NO_2$	1	2	2	0.085	0.085	0.057	0.063	0.1268	0.1903
Serine	$C_3H_7NO_3$	2	0	1	0.081	0.095	0.063	0.067	0.0671	0.1343
Threonine	$C_4H_9NO_3$	2	0	1	0.081	0.075	0.048	0.057	0.0571	0.1142
Proline	$C_5H_9NO_2$	1	1	2	0.067	0.089	0.355	0.207	0.4145	0.4145
Isoleucine	$C_6H_{13}NO_2$	1	1	4	0.048	0.047	0.013	0.030	0.1210	0.0605
Tyrosine	$C_9H_{11}NO_3$	4	6	1	0.020	0.012	0.041	0.020	0.0205	0.2046
Arginine	$C_6H_{14}N_4O_2$	2	2	2	0.000	0.000	0.022	0.018	0.0368	0.0736
Phenylaniline	$C_9H_{11}NO_2$	2	6	1	0.000	0.000	0.015	0.013	0.0128	0.1021
Histidine	$C_6H_9N_3O_2$	1	2	1	0.000	0.000	0.008	0.007	0.0066	0.0197
Methionine	$C_5H_{11}NO_2S$	1	1	3	0.000	0.000	0.008	0.006	0.0189	0.0126
Sub Totals/kg protein		**34**	**29**	**31**	**1.000**	**1.000**	**1.000**	**1.000**	**1.7151**	**2.4097**
Sub Totals/1.25% protein share of CO_2 and CH_3									**0.02144**	**0.03012**

Table A3 GWP_{100} Protein/3 Woods

Formula	IPCC factor	kg	GWP_{100}
CH_3	27.9	0.03012	0.84
CO_2	1.00	0.02144	0.02
subtotal			0.86

Table A4 GWP_{100} Protein/ 5 wood mean

1.25% Protein dry	**GWP_{100}**
e. sapwood	0.64
e. heartwood	0.79
3 woods mean	0.86
Average	0.77

Table A5 GWP $_{20\ year}$ Protein/3 Woods

Formula	IPCC factor	kg	GWP_{20}
CH_3	81.0	0.03012	2.44
CO_2	1.00	0.02144	0.02
subtotal			2.46

Table A6 GWP_{20} Protein/ 5 wood mean

1.25% Protein	**$GWP2_0$**
e. sapwood	1.82
e. heartwood	2.26
3 woods mean	2.46
Average	2.18

Embodied CO_{2e} in Eucalyptus Carbohydrate & Lignin

This LCA models 70% Carbohydrates plus Lignin (Carb+Lig) primarily on individual eucalyptus species log analysis across Chichester State Forest.

The experimental site is 80 km north of the Weathertex Mill which is 120 km north of Sydney. The 100Ha section established in 1974-75 comprises bushland in small catchments at 450-940m elevation[5]. Then the LCA uses the Weathertex site species mix weighted averages from Table A1.

Table A7 lists molar shares of Carbohydrates and Lignin in dry Eucalyptus wood. Table As 8 lists the final weighted mean far term 3.3kg $CO_{2e\ 100}$ /kg dry wood modelled on 70% Carbohydrate and Lignin protein.

Table A 9 list the final near term GWP of 9.68kg $CO_{2e\ 20}$ /kg dry wood protein. Table A 10 lists the total 1.25% protein and 70% carbohydrate and lignin shares of final weighted mean 4.10kg $CO_{2e\ 100}$ far term versus 11.86kg $CO_{2e\ 20}$ near term embodied in each kg of dry Eucalyptus wood.

Table A7 Carb+Lig Weighted Mean/kg Eucalypt

Polymers	Formula	kg/kg	CO_2	CH_4
Cellulose	$C_6H_{10}O_5$	0.35090	0.292	0.058
Lignin	$C_{10}H_{11}O_{3.5}$	0.25470	0.216	0.038
hemicellulose	$C_5H_{10}O_5$	0.11760	0.094	0.024
Max Carbs & Lignin		0.72320	0.603	0.120
Total 70% Carbs & Lignin			0.422	0.084

Table A 8 Carb+Lig $CO_{2e\ 100year}$/kg Eucalypt

Formula	IPCC factor	kg	GWP_{100}
CH_3	27.9	0.084	2.344
CO_2	1.00	0.422	0.989
subtotal			3.33

Table A 9 Carb+Lig $CO_{2e\ 20year}$/kg Eucalypt

Formula	IPCC factor	kg	GWP_{20}
CH_3	81	0.084	6.804
CO_2	1.00	0.422	2.871
subtotal			9.68

Table A 10 Carb+Lig & Protein $CO_{2e\ 100year}$ Vs $_{20year}$/kg Eucalyptus

Formula	$CO_{2e\ 100yr}$	$CO_{2e\ 20yr}$
Carbohydrates & Lignin	3.33	9.68
Protein	0.77	2.18
subtotal	4.10	11.86

5 Cornish P. M. (1993) The effects of logging & forest regeneration on water yields in a moist eucalypt forest in NSW Aust. J Hydrology 150, 301-22.

Embodied CO_{2e} in Dry Wood

Figures A9 and A10 chart our LCA and literature timber GWP results6 7 89 10 11 60year cradle to grave. Historical external studies cited excludes most significant sequestration via biosynthesis embodied in protein, carbohydrate and lignin methyl groups. In practice LCA often ignores input embodied in biomass products.

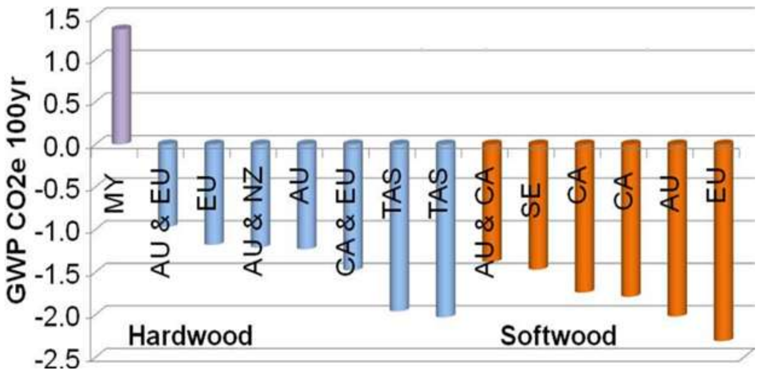

Fig.A9 GWP Range/kg Kiln Dried Lumber Framing

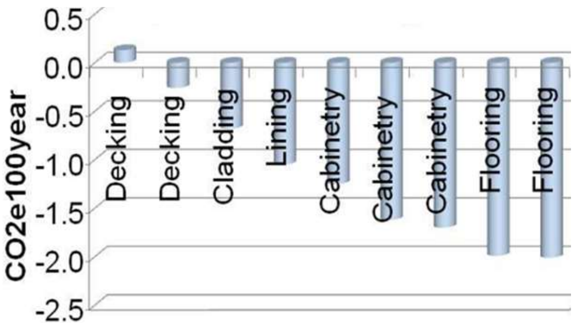

Fig. A10 GWP Range/kg Wood Built Product

Table A 11 shows typical Australian forestry GWP results. All are <2.5 kg $CO_{2e\ 100}$ and exclude the embodied carbon from protein carbohydrate and lignin far term shares 4.10kg $CO_{2e\ 100}$/ kg dry Eucalyptus wood.

Table A 11 NSW Forest GWP Literature Vs Evah

kg/kg wood	CO_{2e100}	kg/kg wood	CO_{2e100}
Kiln dried hardwood board	-1.9[12]	Air dried logs	-1.1
Kiln dried hardwood board	-1.4	Air dried logs	-0.80

Table A 12 lists Weathertex raw board GWP results cradle to grave including all processing stages to 100-year horizons of biogenic, land use change, fossil fuel use and the total GHG [13].

Table A 12 Weathertex NSW Eucalypt Raw Board for embodied $CO_{2e\ 100yr}$

Weathertex site Forest Model Assumed	Biogenic	LULUC	Fossil	Total
Total Protein Carbohydrate & Lignin Weighted Mean	-56	0.38	22.5	-33.5

6 CORRIM 2009 Maximizing Forest Contributions to Carbon Mitigation, CORRIM FS5, Global Forest Resources Assessment, FAO FP 147
7 Ajani, J.I, Keith, H, et al. 2013 Comprehensive carbon stock and flow accounting: national framework 89 61-72.
8 Butler, E., Stockmann, K., et al 2014. Estimates of carbon stored in harvested wood products from USFS, SWR, 1909-2012
9 Bradshaw, C.J.A. 2012. Little left to lose deforestation and forest degradation in Australia since Eu colonization, J Plant Ecol 5:1:109-120
10 Vögtlander, J.G., van der Velden, N.M. et al. 2014. Carbon sequestration in LCA, , Int. Jrl LCA 19:13-23
11 Vlieg M, Jones D, Ashar S, 2017 Forest Product LCA: Carbon Form, Fire, Fuel and Fate, SETAC Brussels.
12 https://fwpa.com.au/wp-content/uploads/2023/09/Forests-Plantations-Wood-Products-and-Australias-Carbon-Balance
13 Characterisation factors from 2021 Intergovernmental Panel on Climate Change (IPCC), AR 6 Climate Change, https://www.ipcc.ch/

Gaps in the background knowledge

Biogenic GWP results are most sensitive to inclusion of embodied N_2O in the protein, carbohydrate and lignin modelling. It is vital to reveal which embodied carbon results best fits a particular tree age, part, forest, species or region. And site-specific data is vital to show if inclusion of embodied N_2O fits wood production in forests across NSW, Australia, New Zealand, PR China and South Africa & USA.

Because of lack of such data, however, no result in this study includes embodied N_2O.

EN15804 Compliance Wood Product LCA

Historical external studies cited excludes most significant sequestration via S-adenosyl-l-methionine (SAM) biosynthesis embodied in protein, carbohydrate and lignin methyl groups.

LCA practice often ignores embodied input on short-term single-use food, medicine and packaging products.

But excluding significant embodied GWP fails to comply with the EN15804 standard for building product EPDs.

No durable wood, biofibre, polymer, ceramic, metal, or mineral merits its embodied content being ignored. With cumulative effects and circularity, best practice is to include all key embodied content.

Their quantification can reveal short term risks and enduring opportunities arising for:

a) Mitigating human, environmental and climate health and resource depletion via.

- Lignin-rich waste energy recovery for renewable gas and liquid fuel use and supply security.
- landfill emissions retrieval to reform methane for fuel, economic, supply and climate security.
- material feedstock reuse, recovery and upcycling for economic returns on investment.
- feedstock energy recovery and reuse for fuel value and reduced fire loads and insecurity.

b) Resource recovery via sewer mining sources of

- secondary biomethane sources to fuel industry and greener-urban techologies.
- energy to pump distilled water for urban reuse to avoid more sea level rise.
- hydrogen sources to fuel industry and urban climate-safe techology.
- energy to pump distilled water to industry and agriculture for economic security.
- scarce materials and tramp elements for making electronic components.

c) Resource recovery via biodigestors of biomass for making

- feedstock and energy recovery to avoid contaminating waterways, air, land and cities.
- biosolids via composting to avoid human disease, marine pollution and food chains.
- polymers, fertilisers and soil-enriching biosolids.
- products that avoid contamination marine food chains from prescription drugs.
- products that avoid human and animal hormones polluting marine food chains.

Recent Bird and Bat Biodiversity Studies in Area and Period for this LCA

The NSW Department of Primary Industries study in 2023 of its North Coast Forestry assessed eucalyptus forests, chemistry and biodiversity in an experimental section of Chichester State Forest [14]. This 100Ha wet sclerophyll forest area comprises small catchments elevated at 450-940m established in 1974-75 about 80 km north of Weathertex Mills as Figure A11 depicts 120 km north of Sydney[15].

Regrowth was from 1983 harvest that left two catchments undisturbed[16]. Harvest involved clearfelling patches except within 20 m either side of creek lines. In 2010 to encourage growth of remaining trees 27 years since harvest one regrowth catchment was thinned to 200 stems/ha[17]. Thinning covering 21ha was 22% of Kokata catchment.

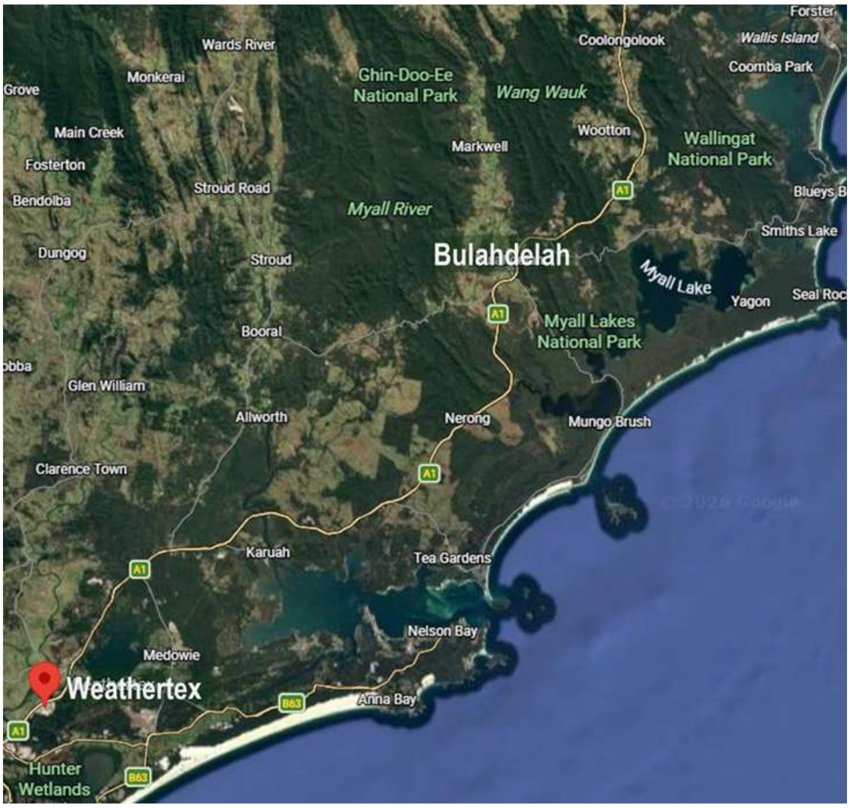

Figure A11 Forest Areas & Survey Regional Map

Over 10-years bats and birds in adjacent unthinned regrowth and old growth areas were surveyed pre and post thinning. Surveys found 71 bird species and 5028 individual birds.

Thinning regrowth benefitted bird populations in these harvested wet sclerophyll forests. Some common forest birds benefitted from the thinning while some less common species did not in that decade. Five rare species such as Logrunner, Mistletoe-bird, Satin and Regent Bowerbirds and Large-billed Scrub-wren were not detected on thinned sites after treatment.

Nine species had sufficient data power to detect change but some benefited and others were disadvantaged depending on habitat, with a response to thinning found to be positive for Lewin's Honeyeater, Eastern Whipbird, White-browed Scrub-wren, Grey Fantail, Eastern Spinebill; neutral for the Brown Gerygone, Golden Whistler and Brown Thornbill; and negative for one Silvereye species.

Sampling of bats was repeated pre thinning in 2006 and 2007 and twice post-thinning in 2011 and 2016. The bat studies recorded a subdued positive, response of activity to thinning. Bat species richness was also greater in thinned than unthinned regrowth. Species composition in thinned areas more closely resembled unharvested forest.

Thinning of dense regrowth can restore foraging habitat for bats in managed landscapes where dense regrowth dominates, especially edge-space guilds[18]. Thinning should avoid felling hollow trees and dead stems as Bats use them as roosts. Bat activity in harvested wet sclerophyll forests can take 33 years to return to that recorded in unharvested stands[19].

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14 *North Coast Residues A project undertaken as part of the 2023 North Coast Forestry Project*
15 *Cornish P. M. (1993) The effects of logging & forest regeneration on water yields in a moist eucalypt forest in NSW. J of Hyd 150, 301-22.*
16 *Ximenes, F.; Gardner, W.D.; Marchant, J.F. Carbon Flow Following the Harvest of Blackbutt Trees and Their Conversion into Sawn Products; Research Paper No. 41; NSW Department of Primary Industries: Sydney, Australia, 2005*
17 *Webb A. A., Kathuria A. & Turner L. (2012) Longer-term changes in streamflow following logging and mixed species eucalypt forest regeneration: The Karuah experiment. Journal of Hydrology 464, 412-22.*
18 *Lindenmayer D., Claridge A., Gilmore A., Michael D. & Lindenmayer B. D. (2002) The ecological roles of logs in Australian forests & potential impacts of harvesting intensification on log-using biota. Pac. Cons. Biol. 8, 121- 40*
19 *de Oliveira M. C., Smith G. C. & Hogan L. D. (1999) Current limitations in the use of bat detectors to assess the impacts of logging - a pilot study*

Contemptorary Natural and Social Disasters

In the data period, however, that this EPD covers, many worst-ever-recorded and widespread natural and social disasters also disrupted supply chains locally nationally and globally.

After widespread natural and social disasters from 2017 to 2023, few benefits were expected for the geographical area near Newcastle in NSW where almost all Weathertex lumber was sourced.

A report from the NSW Department of Primary Industries described impacts of historic social and natural disasters on natural land, bush, urban, air, aquatic and marine environments 2017 to 2020[20].

After the most severe drought in 250 years, in November 2019 NSW's worst bushfire season in 250 years began when more land was burnt than all prior 25 years. 'Black Summer' fires caused extensive severe emergencies[21].

Then by late summer and autumn widespread rains caused extensive flooding in NSW coastal drainages with many towns having their highest daily rainfall on record.

For the rest of 2020 much of NSW received well above average rainfall[22]. Such fire, rain and flood runoff meant record pollution impacts of most freshwater, estuarine and coastal waterways [19 & 23].

In 2020 with COVID-19, international and state borders were closed which severely restricted people's movement within Australia [19 & 24].

By mid-2020 local recreational activity increased mainly because when people could not travel to work or far from home went out to exercise locally where permitted.

After widespread worst-ever recorded natural and social disasters from 2017 to 2023 locally, nationally and globally disrupted security, no benefits were expected from:

- urban stock of flora in parks, walls and greenspace for urban life,
- aquatic stock of frogs in rivers, lakes and dams, aquatic life and
- marine and fish stock in nearby estuaries, bays and oceans for marine life.

Through 2019/20, with near normal recreational fishing activity rates the NSW finfish and invertebrate catch compositions and key species relative importance were stable[19]. Catch levels for many species varied with lower catches for most species. Compared to 2017/18 some common species catches were:

- worst -50% Golden Perch, -52% Murray Cod, -54% Grey Morwong, -66% Australian Bass and -68% Rainbow Trout.
- lower -35% Dusky Flathead,-43% Sand Flathead and -43% Mulloway.
- higher with additional 5% Snapper 13% Sand Whiting, 14% Bream and 27% Silver Trevally.

Despite the following compelling positive results this EPD also illustrates regeneration to combat devastating natural disasters in recent years attributable to anthropogenic climate change[25].Positive benefit, gain and circularity results for a particular outcome type at levels can range from

- improvement ≤100% damage not offsetting loss.
- net-zero 100% gain or loss offsetting damage.
- net-gain ≥100% benefit exceeding damage and loss.
- regenerative ≥200% benefit and gain beyond and loss.

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in south-east Queensland. Australian Zoologist 31, 110-7. North Coast Residues

[20] *NSW DPI Fisheries: Survey of recreational fishing, 2019/20 Key Results Technical Report March 2022 NSW Recreational Fisheries Monitoring Program Survey Report No-161 Bureau of Meteorology. (2020). Special Climate Statement 70 update – drought conditions in Australia and impact on water resources in the Murray-Darling Basin.. https://www.researchgate.net/publication/360773384*

[21] *Smith, H., Cawson, J., Sheridan, G., & Lane, P. (2011). Desktop review, impact of bushfires on water quality. Australian Government Department of Sustainability, Environment, Water, Population and Communities; University of Melbourne.*

[22] *Kemter, M., Fischer, M., Luna, L. V., Schönfeldt, E., Vogel, J., Banerjee, A., Korup, O., & Thonicke, K. (2021). Cascading hazards in the aftermath of Australia's 2019/2020 Black Summer wildfires. Earth's Future(9), 1-7. https://doi.org/10.1029/2020EF001884R*

[23] *Huveneers, C., Jaine, F. R. A., Barnett, A., Butcher, P. A., Clarke, T. M., Currey-Randall, L. M., Dwyer, R. G., Ferreira, L. C., Gleiss, A. C., Hoenner, X., Slerodiaconou, D., Lédée, E. J. I., Meekan, M. G., Pederson, H., Rizzari, J. R., van Ruth, P. D., Semmens, J. M., Taylor, M. D., Udyawer, V., Walsh, P., Heupel, M. R., & Harcourt, R. (2021). The power of national acoustic tracking networks to assess the impacts of human activity on marine Survey of recreational fishing in NSW, 2019/20 – Key Results*

[24] *Storen, R., & Corrigan, N. (2020). COVID-19: a chronology of state and territory government announcements (up until 30 June 2020), Research paper series, 2020-21, 22nd October 2020. Department of Parliamentary Services, Parliament of Australia*

[25] *A Global Goal for Nature, Nature Positive by 2030, About Nature+Positive 2021 https://www.naturepositive.org/*

Life Cycle Benefit Assessment

Some materials and practices inherently promote wellness and like medicine others inherently destroy illness.

Positive and net-positive gains and benefits can offset damages and loss. Benefits from less and avoided impacts and gains arising from properties inherent within a component or utility can also be additive.

The ultimate source of metabolic energy for all biological systems, photosynthesis in plant and algal biomass generates oxygen while drawing down carbon dioxide and water from air that enacts:

- supply of feedstock and food to grow living communities of biomes, wildlife, livestock and people
- energy delivery for ecosystem growth of viable genetic, habitat and species biodiversity ranges
- braking of greenhouse gas force accelerating anthropogenic climate change as well as
- oxygen release that is a buffer against anthropogenic depletion of stratospheric ozone layer.

Together these all increase wellness. Positive benefit, gain and circularity for each outcome level being:

- improved where it avoids >10 to 99% loss.
- net-zero gain when it avoids 100% loss.
- net-benefit when it regains ≥100% loss.
- regenerative where it regains ≥200% loss.

The functional unit is per square metre of raw board or panel cladding used over 20 years and reuse beyond cradle to grave.

Results in the next sections illustrate if, how and why nature positive wellness, ecosystem and supply benefits arise from reliance on renewable energy and circularity of all types of fossil and biomass feedstock resources.

It describes cradle to cradle outcome results under sub-headings

- No significant change in losses
- Improved gain but not negating loss
- Net zero withotu any gain or loss.
- Nature Positive net-benefit overcompensating for loss.
- Regeneration overcompensating for plus replacing loss.

The following sections describe zero as well as net gains in wellness, ecosystem and supply from including flows of photosynthetic, microbial and chemosynthetic drawdown from air water, methyl, oxygen, hydrogen, sulphur and nitrogen groups embodied in lignin, carbohydrates and proteins.

No Significant Change in Inventory Cradle to Cradle

This section describes zero or near net zero health, ecosystem and supply change from including photosynthetic drawdown from air to wood lignin, carbohydrates and proteins Table A13a lists radioactive waste results, components for reuse, secondary fossil fuel use wood energy use unchanged by including water, methyl, oxygen, hydrogen, sulphur and nitrogen flows from air to wood.

Table A13a Unchanged Inventory Outcomes /m² Functional Unit

Measure	Unit	Inventory Measure	Unit
Radioactive Waste	Radiation (k Bq Uranium$_{235}$)	Components For Reuse	kg parts at end life
Wood energy use	MJ net calorific value (ncv)	Secondary Fossil Fuel	MJncv PCR use

Considering variance in data quality over 99 years timeframes for 3 forest rotations net >0 to <10% change is not statistically significant. Table A13b lists insignificant change in water, fuel and feedstock flows.

Table A13b Near Net Zero Resource Inventory Outcomes /m² Functional Unit

Measure	Resource Flow	∆%	Unit
Less water use from	well	-2E-10	m³ well water used
	river & canal	-3E-08	m³ river water used
	sea	-5E-06	m³ seawater used
	Recirculating	-8E-04	m³ recycled water used
	Total	-1.2	m³ water used
	Net freshwater	-1.5	m³ fresh water used
	Public supply	-2.4	m³ potable water used
Less waste from	General Waste	-2.3	kg waste to landfill
Less feedstock material use of	Secondary input	-0.02	kg Post Consumer material (PCR) reused
	Matter For	-0.08	kg PCR material for reuse
	Primary Fossil	-0.21	MJncv (net calorific value) Virgin
	Primary renewable	-0.21	MJ biomass
Less fossil fuel use of	Coal	-0.42	MJncv is Megajoule net calorific value
	Gas	-4.3%	MJncv Virgin fossil gas fuel & feedstock
	Lignite	-5.2%	MJncv Brown Coal Fuel Use
Less use of renewable energy	Geothermal	-0.25	MJncv
	Biomass	-1.9	MJncv
	Wave/tidal	-4.1	MJncv
	Solar	-4.3	MJncv
	Primary	-6.3	MJncv virgin fuel & biomass
	Total Primary	-9.0	MJncv virgin renewable fuel & biomass

Table A13c lists insignificant change to ecosystem quality damages in stratospheric ozone, freshwater eutrophication and natural land use; human health ecotoxicity results and resource depletion water scarcity. Fossil fuel CO_{2e} emission to air forcing Climate Change was 8% less in 20 years and 9% less in 100 years

Table A13c Near Net Zero Damage Outcomes Cradle to Cradle /m² Functional Unit

Damage Measure		∆%	Unit
Freshwater	Eutrophication	-0.25	kg Phosphorus P_{eq}
Land	Natural land use	-0.34	Ha per annum
Human Health	Ecotoxicity EI99	-4.8	Death & DisAbility Lost Years (DALY)
Freshwater	Scarcity	-1.6	m³ access to scarce freshwater supply
Fossil fuelled Climate Change	GWP 20-years	-7.9	kg $CO_{2e\ 20\ yr}$ Greenhouse forcing potential
	GWP 100-years	-9.4	kg $CO_{2e\ 100\ yr}$ Greenhouse forcing potential
Stratosphere Air	Ozone Depletion	-0.1	kg CFC-11e ChloroFlouroCarbon11$_{EQ}$

Improved Inventory and Benefits Cradle to Cradle

This section describes >10% <99% improved wellness, ecosystem and supply security from including photosynthetic, biosynthetic and chemosynthetic drawdown from air of water, methyl, oxygen, hydrogen, sulphur and nitrogen to wood lignin, carbohydrates and proteins. Table A13d lists 45% less hazardous waste disposal, less wasted fuel & fossil feedstock, less wasted wave, tidal, hydro and solar power, renewable energy & feedstock and consequently less recovered & reusable energy.

Table A13d Improved >0<100% Inventory Outcomes /m^2 Functional Unit

Less use	MJncv	∆%	Less use of	MJncv	∆%
fossil fuel	Virgin fuel & feedstock	-11	fossil material	& biomass for reuse	-15
	Recovered &	-11		Total virgin	-29
power	Hydro	-13	renewable energy	PCR biofuel	-15
	Nuclear	-15		Hydrogen	-22
fossil fuel & fstock	Total virgin	-14	biomass & fossil reuse	For energy recovery	-15
	Oil	-46		Embodied in product	-54
	Sulphur MJ $_{surplus}$	-45	waste	Hazardous kg	-45

Table A13e shows 22% less restricted future resource accessibility, 34% less damage overall with 42% less to health and 26% less to ecosystems so more species and habitat extent and richness.

Table A13e Improved >0<100% Overall Loss and Damage /m^2 Functional Unit

Overall Damage measures	Method	∆%	Unit
Total Resource Accessibility	EI99	-22	20/100point /European citizen year in 1999
Ecosystem Quality	EI99	-26	50/100 points/European citizen year in 1999
EcoIndicator 99 (EI99	EI99	-34	100 points/European citizen year in 1999
Human Health	EI99	-42	30/100 points/European citizen year in 1999

Table A13f shows less death and disability years of human health from:

- 12% cleaner air avoiding non-cancer toxicity from respirable dust and chemicals
- 23% safer air avoiding cancer toxicity from respirable synthetic organic chemicals
- 25% cleaner air avoiding non-cancer toxicity from respirable synthetic inorganic chemicals
- 31% sweeter air avoiding toxicity of respirable volatile organic chemicals
- 41% cleaner air avoiding respirable dust-caused inflamatory lung and heart disease
- 44% clearer air avoiding respirable summer smog-forming photochemicals.
- 85% sweeter air avoiding toxicity from respirable organic chemicals

It also lists less potential disappeared fraction of ecosystems from

- 24% less eutrophication depleting oxygen so more for marine plant, animal and micobial life.
- 25% less ecotoxicity so more system viability for ecosystem species, habitat and integrity.
- 44% less acid rain without which the air, land and water is safer for forest flora & fauna.

Table A13f Improved >0<100% Loss and Damage /m^2 Functional Unit

Human Health Loss Measure	Method	∆%	Unit
Non-cancer toxicity	TRACI[26]	-12	Comparative Toxic Units for humans (CTUh)
Respirable organic carcinogens	TRACI	-23	CTUh Cancer toxicity ex
Ecotoxins	EI99	-25	50 EI99 points/European citizen year in 1999
Photochemical Smog	ReCiPe	-31	kg Non methane Volatile Organics (NMVOC)
Particulates 2.5$_{ppm}$	EI99	-41	DALY death and disability lost life years
Summer Smog	TRACI	-44	kg C_2H_2 Photochemical Ozone Formation
Respirable Organics	EI99	-85	DALY mg organic chemical toxicity
Ecosystem Loss Measure	**Method**	**∆%**	**Unit**
Eutrophication Marine	ReCiPe	-24	kg Nitrogen N eq
Ecotoxins	EI99	-25	PDFm^{2}yr Potential Disappeared Fraction
Acidification Potential	ReCiPe	-44	mol $H^+{}_{eq}$. Accumulated Exceedance

[26] *Tool for Reduction and Assessment of Chemicals and Other Environmental Impacts. US EPA .https://www.epa.gov/chemical-research/tool-reduction-and-assessment-chemicals-and-other-environmental-impacts-traci*

Nature Positive Net-benefit Outcomes Cradle to Cradle

This section describes net-benefit that compensates for 100% loss beyond net zero gain. Table A 13g shows 100% net wellness from counting photosynthetic, microbial and chemosynthetic drawdown from air of water, methyl, oxygen, hydrogen, sulphur and nitrogen groups flow to form lignin, carbohydrates and proteins. EcoIndicator 99 wellness security net-gains including from avoided human death and disability from 100% less climate change induced loss of human health life years.

Table A 13g Net-benefit ≥100% Outcomes/m^2 Functional Unit

Benefit Measure	∆%	Unit
Wellness Security		
Human Health Climate Change	100	DALY due to climate change to 100-year horizons
Climate Security		
Far Term Climate Braking	100	kg $CO_{2\ eq\ 100\ yrs}$ climate force brake to 100-year horizons

Regenerative Outcomes Cradle to Cradle

This section describes gains replacing >twice the loss to regenerate pre-industrial ecosystem and climate benchmarks and modern technology to secure wellness and supply. Results show drawdown via photo/chemo/&biosynthesis 35 to 63% into carbohydrates 22 to 31% into lignin 1.25% into protein in wood.

Table A13h lists Raw Weathertex wood product regenerative ecosystem security from: :

- 677% wellness benefits from oxygen net-gain for the stratsophere and all breathing life.
- 371 times more far term climate braking force in the next 100 years
- 47.7 thousand times more biogenic climate braking force in the next 20 years
- 13.3 thousand times more drawdown into forest biota, leaf, seed, fibre and microbial biomass via photosynthesis by leaf, algae, roots and to durable product biomass over the 100 year long term.

Table A13h Regeneration /m^{2}Functional Unit

Measures	∆%	Unit
Wellness Regeneration		
Oxygenated Global Airshed	-677	kg $O_{2\ eq\ 100\ yrs}$
Climate Regeneration		
Near Term Climate Braking	371	kg $CO_{2\ eq\ 100\ yrs}$
Ecosystem Regeneration		
Biodiversity Biogenic Drawdown	47,688	kg $CO_{2\ eq\ 20\ yrs}$
Supply Regeneration		
Total Biomass	13,311	kg in wood feedstock and bark fuel

In this declaration the product supply chain and reports confirm some unchanged, improved and inherently positive outcomes/m2 product cradle to reuse and grave fate. Tables list results from various Life Cycle Impact Assessment (LCIA) methods including the TRACI developed by the UAS EPA and ReCiPe used across Europe and for most Building Industry EPDs.

All have strengths and weaknesses. The latter two are not normalised to any average set of impacts per capita. Normalisation to average sets of impacts per capita is a LCIA method to convert raw eco-metric values into dimensionless scores. It scales impacts relative to a specific reference community total annual eco-impact divided by its population size.

This comparative capacity of the early EI99 method's perceived strength. It's values could be rolled up to reflect one European citizen yearly impact in 1999 normalised across 3 loss outcomes often but not always of 30% Human health, 50% Ecosystem quality & 20% Resource access.

Interpretation LCBA Results

Unlike linear primary fossil feedstock and fuelled operations, inherent benefits arise from reliance on renewable, recycled, reused and or recyclable circularity in supply. So this section, summarises charts and interprets significant LCBA results ranging from improvement, net-gain to regenerative outcomes functional unit cradle to cradle. As it overwhelmed all such results the 5,671% stronger biogenic climate brakes in the near 20 year term was not charted here. Due to the new quantification method y for drawdown of biogenic carbon this was the most significant benefit but in simple charts its size overwhelms all other values.

Human wellness benefits arose from:

- 12% cleaner air free of dust and chemicals
- 23% safer air free of organic chemicals,
- 25% cleaner air free of inorganic chemicals
- 31% sweeter air free volatile chemicals,
- 34% safer human health overall
- 41% cleaner air free of inflamatory paticulates,
- 42% longer hale and able life
- 44% clearer air free of photochemicals,
- 85% healthier air free of carcinogens
- 677% more oxygen rich air for breathing, and
- as oxygen rises to refill more stratsophere ozone

Climate Security benefits were modelled from

- 100% hale well climes overall,
- 231% more biogenic embodied carbon
- 677% more sun safe oxygenation

Resource Access benefit were found to be

- 22% better mineral, fossil and scarce supply
- 97% more potable
- fresh water rain hydrated
- 100% more climate braking to 100-years, and
- that value of more viable biomass to 100-years
- 371%more climate brake force to 100 years

Positive Ecosystem benefits were shown to arise as

- 18% freedom from overall damages
- 24% marine oxygenation for sea life.
- 25% safer species, habitat with less toxicity
- 26% richer species and habitat
- 44% safer forest flora & fauna free of acid rain
- 45% free of contamination ex hazardous waste
- 97% more hydration via potable rainwater

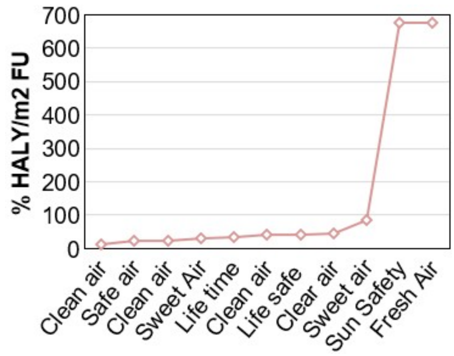

Figure A12a HALY Benefits

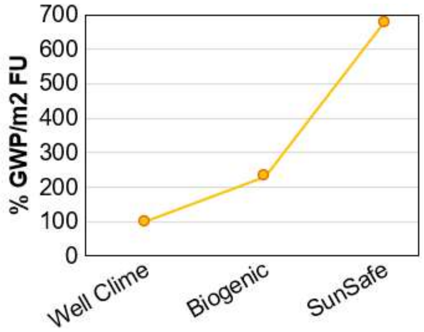

Figure A12b Climate Benefits

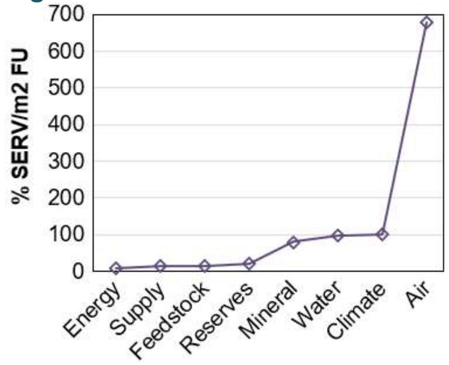

Figure A12c SERVE Benefits

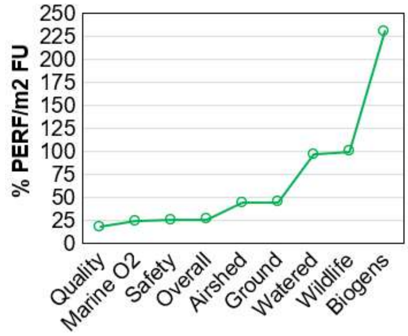

Figure A12d PERF Benefits

Product Environment Footprint/ Global Citizen Annually

The next section reports on the LCIA results using the PEF method/ global citizen annually. The PEF consumption shares were normalised to loss outcomes

- 30% Human health damages,
- 40% Ecosystem quality damages &
- 30% Resource access damages.

The PEF breakdown shown in Table A14a eas fairly typical of European LCIA normalisation methods since 1995. In 2021 for EU-27 citizens food consumption was 48%, housing and mobility ~35% and household goods and appliances17% PEF.

Table A14a Global Annual Product Environment Footprint/ Citizen per annum

Tier	Outcome Category	PEF Unit	Icon	Impact	% Score	
Eco system Quality Loss	Climate Change	kg $CO_{2\ eq\ 100\ yrs}$		1.07E+14	20	
	Ecotoxicity Freshwater	CTUe		8.15E+13	4	
	Acidification	mol H^{+} eq.		3.83E+11	4	
	Stratospheric Ozone Deletion	kg CFC^{-}_{11} eq.		1.61E+08	4	
	Eutrophication Terrestrial	mol N eq.		1.22E+12	3	
	Eutrophication Marine	kg N eq.		1.95E+11	3	
	Eutrophication Freshwater	kg P eq.		5.06E+09	3	
						41
Resource Access Loss	Freshwater Use	m^3 water eq.		7.91E+13	8	
	Land Use	points		9.90E+15	4	
	Biodiversity Drawdown	kg $CO_{2\ eq\ 20\ yrs}$		9.90E+15	4	
	Resource Use Renewable Feedstock	MJ		1.13E+14	2	
	Resource Circularity Matter & Energy	MJ share		2.25E+14	4	
	Resource Use Fossil Energy Reuse	MJ		1.13E+14	2	
	Resource Use Minerals and Metals	kg Sb eq.		3.99E+08	6	
						30
Human Health Loss	Particulate Matter	PPM10		2.14E+06	5	
	Human Ecotoxicity	HALY		2.14E+06	5	
	Ionizing Radiation	kBq U_{235} eq.		1.02E+12	5	
	Volatile Organic Chemicals	kg NMVOC eq.		2.80E+11	2	
	Photochemical Ozone	kg C_2H_2		2.80E+11	2	
	Human Cancer toxicity	CTUh		2.66E+05	5	
	Human Non-Cancer toxicity	CTUh		3.27E+06	5	
						29
Sum	Gross sum	multidimension		normalised		100%

In 2021 Evah and GGTI normalised benefit results to a single PEF score of weighted gain outcome share maximums of 30% Wellness security benefit, 40% Ecosystem security benefit & 30% Resource security benefit.

Weathertex Products PEF for Raw Timber Panels

The Weathertex wood product global PEF benefit /m2 functional unit over 20 years is in Table A 14b. The Ecosystem quality 18% gain is is from outcomes including :

- 3.8% braking greenhouse force embodied in the wood and
- 14% balance in pH without emissions causing acidification

Resource security contributions include better accessibility:

- 6.0% biogenic drawdown reflecting retained biodiversity
- 3.4% natural marginal land use and 3.0% circularity of feedstock in matter & energy
- 0.48% feedstock renewal, 0.06% reused energy and 0.8% reused mineral and metals

Human health 9% gain is from outcomes yielding more hale and able life years

- 5.1% avoided non-cancer toxicity, 2.4% avoided cancer toxicity and 0.73% better wellness
- 0.45% avoided photochemical smog from fewer synthetic volatile organic chemicals
- 0.39% avoided ecotoxicity from polluting polyaromatic hydrocarbons and metal ions.

Table A14b Raw Weathertex Environmental Footprint

Tier	Benefit Category	LCBA Unit	Icon	%	%Score	
40% Ecosystem Repair	Climate Braking Far Term	kg $CO_{2eq\ 100\ yr}$		21	20	
	Potable Freshwater	m^3		2.4	4	
	pH Balance	mol H+ eq.		2.5	4	
	Stratospheric Ozone Reparation	kg CFC-11 eq.		2.4	4	
	Terrestrial Oxygen-Nutrient	mol N eq.		2.4	3	
	Marine Oxygen-Nutrient	kg N eq.		2.4	3	
	Freshwater Oxygen-Nutrient	kg P eq.		2.4	3	
				35.3		41
30% Resource Access	Freshwater Cascades	m3 water eq.		2.4	8	
	Natural Land Use and Change	points		2.8	4	
	Biogenic Drawdown & Biodiversity	kg CO2 $_{eq\ 20yrs}$		21	4	
	Feedstock Renewal	MJ		14	4	
	Matter & Energy Circularity	MJ share		2.4	2	
	Energy Reuse	MJ		2.4	2	
	Mineral and Metal Reuse	kg Sb eq.		2.4	6	
				21.2		30
30% Human Wellness	Particulate-free respiration	PPM10		2.4	10	
	Ecotoxicity-free	HALY		2.4	5	
	Ionizing Radiation-free	kBq U235 eq.		2.4	2	
	Volatile Organic Chemical-free	kg NMVOC eq.		2.4	5	
	Photochemical Smog-free	kg C_2H_2		2.4	2	
	Cancer Toxicity-free	CTUh		2.4	3	
	Non-cancer toxicity-free	CTUh		2.4	2	
				16.8		29
Sum of multidimension al Measures Normalised to 100 points				73.5		100

Interpretation of PEF Results

Altogether these Weathertex product benefits offset 73.5% PEF per capita/ pa. Wellness offset 16.8% from avoided human death & disability mostly ecotoxicity from respirable photochemical smog, 2.5µm particulates, cancer toxicity and non-cancer toxicity. Ecosystem Reparation offset 35.5% PEF from natural land use change acid and rain avoided, plus climate braking and biodiversity regain. Supply Viability offset 21.2% PEF from more circularity in energy, mineral, metal, renewables and feedstock and waste.

Summary Nature Positive LCBA, UNSDG and Circularity Results

The LCBA, land use and % circularity results are Table Ad below across the Nature Positive framework that covers UN SDGs. Land use area results beyond the system boundary have asterisks. Overall 2 have zero change, 28 insignificant gain, 23 >10<100%, improved 2 ≥100% net-benefit and 3 >200% regenerative. Some 4 exceed a full circularity result.

Table A 15 Summary of LCBA results /m^2 Functional Unit

Benefit Layer	Exposure & Jurisdiction	Unit	Circularity	
Healthy Able Life Years (HALY)		**HALY/kg**	**% Capacity**	
Clean air	metal and chemical free		12	Clean Air Days
Safe air	organic chemicals free	CTUh	23	Safe Air Days
Clean air	inorganic chemical free	CTUh	25	Clean Air Days
Sweet Air	VOC free outdoors	µg VOC	31	Carcinogenesis
Life time	hale and able years	HALY	34	Able Longevity
Clean air	$PM_{2.5}$ dust free	µg $PM_{10+2.5}$	41	Decongestion
Life safe	hale and able years	HALY	42	Able Longevity
Clear air	photochemical free	kg C_2H_2	44	Scenic Summer
Sweet air	Carcinogen free	CTUh	85	Less Cancer
Sun Safety	Ozone layer repair	kg $O_{2\ outdoors}$	677	Ozonating
Fresh Air	Oxygen indoors	kg O_2	677	Oxygenation
Supply Energy & Resource Viability (SERV)		**SERV/kg**	**% Capacity**	
Viable Energy	Reliance on renewable	MJ_{ncv}	9	Renewability
Viable Supply	Refuel local reserves	MJ_{ncv}	15	Autonomy
Viable Feedstock	Recycle material & scrap	MJ_{ncv}	15	Recyclability
Viable Reserves	Scare Reserves Supply	MJ_{ncv}	22	Commodities
Viable Water	Refill local reservoirs	m^3 freshwater	97	Watered
Viable Mineral	Recycle scarce material	MJ_{ncv}	80	Minerals
Viable Climate	Weather Moderation	kg O_{2e100}	100	Weatherability
Viable Air	Photosynthetic Cities	kg O_{2e100}	677	Oxygenation
Viable C-bank	Resink Carbon in product	kg CO_{2e100}	5,670	Carbon Banking
Positive Ecosystem ReFormation (PERF)		**PERF/kg**	**% Capacity**	
Quality	overall free damage	MJ biomes	18	Habitat Gain
Marine Oxygen	Marine life	O_2 Marine	24	Marine richness
Safe Habitat	ecotoxicity free integrity	Species count	25	Habitat Richness
overall damages	Species &habitat richness	Habitat extent	26	Species Richness
Safe Air Shed	Forest flora & fauna	H+ Rainwater	44	Buffered Rain
Safe ground	Hazardous waste	µg toxicity	45	Food-safe-soil
Watered	Rainfall	ml rainfall pa	97	Freshwater
Wildlife Habitat	Corridor & refuge range	MJ biomes	100	Linked Ranges*
Plants & Algae	Carbon drawdown	kg CO_{2e100}	231	Rubisco security
Climate Brakes	Carbon drawdown	kg CO2e20	5,670	Climate safety

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