Novel Wood LCA and EPDs

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Conclusions

As forest product impacts and benefits vary with form, fire, fuel, life and fate their EPDs require in-depth knowledge and long term modelling of source nations. Overall these FSC products offer high supply, climate and ecosystem security and human health benefits as well as circularity scores. Tropical wood products rarely offer significant supply, climate or ecosystem security or human health benefits. Benefit analysis offers communication of positive outcomes to communities and much needed quantitative circularity scores for circular economy.

Background

Leading influencers' carbon accounting systems include sequestration [1- 7]. Looming climate change tipping points and critical time factors demand consistent carbon drawdown and storage accounting to report climate braking and mitigation outcomes.

Objectives

The work transforms Life Cycle Inventory (LCI), Life Cycle Impact Assessment (LCIA) from 3rd party certified ISO 14025 and EN15804 compliant Environmental Product Declarations (EPDs) into Life Cycle Benefit Assessment (LCBA) and circularity scores.

Introduction

As summarised in Table 1 the work modeled 70 Forest Stewardship Council Certified (FSC) value chains as well as 5 tropical ones [1].

Table 1 FSC and Old Growth Forest Log Source and Type

Place	Pine	Fir	Ash	Beech	Oak	Gum	Hard	Fruit	Other
AU Australia	9				1	1	1		3
BZ Brazil									2
CA Canada		1							4
CN China						1	1	12	1
EU Europe	3	5	5	5	1	1		1	1
FJ Fiji								2	3
JP Japan		1							
MY Malaysia									1
IA Indonesia									1
NZ New Zealand	1	1							1
US United States of America	1	1			1			1	1
TAS Tasmania					1				1
ZA South Africa							1		1

Scope and Methodology

The scope includes all significant resource acquisition, water, fuel and energy use, power generation and distribution, freight, refining, intermediates, manufacture, scrap, packing and landfill flows to disposal and end-of-waste state.

In Australia, end of life incineration is rare. Typical scrap recovery is 90% and landfill 10%. Australian and US landfill methane emission is much lower than the IPCC base case [2].

The LCA was compiled in Boustead, SimaPro 8, OpenLCA and LCADesign™ software.

LCIA applied CML methods and characterisation factors [10]. Global warming (GWP) IPCC 2013 AR5 emission factors apply [11].

LCBA Evah2020 methodology [11] was used to quantify positive outcomes of:

- Supply energy and resource viability (SERV) renewal and recovery;
- Climate change braking and carbon security (CLIMES);
- Positive ecosystem replenishment fractions (PERF) of species and habitat, plus
- Hale human health adjusted life and ability years (HALY).

Material and Modelling

Supply chain modeling over 3 rotations in 100 years accounted for the:

- Form of prior high value growth deforestation to compensate for land use change;
- Fire losses and re-growth history to factor soil, detritus, log and product carbon flows;
- Fuel type and scrap use in debarking, saw-milling plus product manufacture, and
- Functional service life and end of life fate including reuse and renovation (5-75%).

Results and Discussion

Tables 2, 3 and 4 compare global warming (GWP) potential for different ranges of durable building and fitout wood flooring, framing, cladding, paneling and paper /kg cradle to grave. Results do vary differently per cubic metre volume or on an area basis.

Attribution of carbon sequestration varied mostly with land use change, forest form and biodiversity as well as fire loss [2, 3, 4, 8, 9, 10].

Tropical old growth rainforest and fire loss cancelled carbon uptake. Other logs had full to minor CO_{2e} uptake, varying with fire loss plus fuel use to debark, mill and process.

Table 2 Kiln Dry Lumber GWP Range /kg

Table 3 Fitout GWP Range/kg

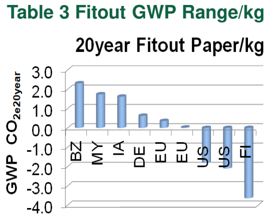
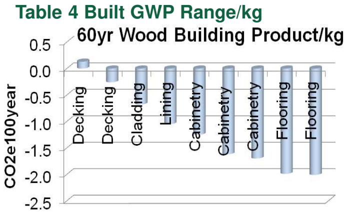


Table 4 Built GWP Range/kg



Tables 5 and 6 list cradle to grave LCI, LCIA and LCBA results for Australian FCS particleboard sub-floor 13kg/m² 60 years use. The fire loss was low but significant.

Results in Table 5 show the flooring offering positive supply, climate and ecosystem security and human health benefits and circularity scores for the circular economy.

Table 5 Particleboard LCI and LCIA Results/m² 60yr

Inventory	Result	Unit
Embodied Water	46.4	litre
Finite Material	12.9	kg
Renewable Matter	50.8	kg
Feedstock	437	MJ
Fossil Fuel	183	MJ
Biomass Fuel	66.8	MJ
Renewable Energy	0.92	MJ

Impact Potential	Result	Unit
Ozone Depletion	3E-08	kg $R11_e$
Greenhouse Gas	-26	kg $CO_{2e\ 100}$
Ecosystem Damage	7E-05	PDF*m²pa
Human Health Damage	3E-04	DALY
Acidification	0.31	kg SO_{2e}
Fossil Fuel Depletion	11.5	$MJ_{surplus}$
Mineral Resource	0.05	$MJ_{surplus}$

Table 6 Particleboard LBCA and Circularity Results/m² 60yr

Benefit	Benefit Layer	Result	Unit	Circularity Score or Outcome
SERV	Material Reuse	69	MJ_{reuse}	34% resource recovery
	Fuel Recovery	69	$MJ_{surplus}$	34% fuel recovery
	Water Recovery	21	$litre_{reuse}$	17 % water recovery
	Material Renewal	378	$MJ_{biogenic}$	82% feedstock renewal
	Energy Renewal	75	$MJ_{surplus}$	37% energy renewal
	Fuel Renewal	73	$MJ_{surplus}$	36% fuel renewal
	Water Renewal	10	$litre_{rain}$	9% catchment on site
CLIMES	Climate Brake	47	kg CO_{2e20}	181% Carbon drawdown
	Biomass Bank	27	kg CO_{2e100}	104% Carbon in product
	Soil Carbon Bank	53	kg CO_{2e100}	204% Carbon in soil fibre
PERF	Climate Security	38	kg CO_{2e100}	146% ecosystem secure
	Forestry Security	452	MJ_{retain}	73% biota and seed biome
	Biodiversity Security	0.26	m²pa	wildlife forage and habitat
	Soil Health Security	0.08	m²pa	microbe and worm refugia
HALY	Human Wellness	10E-05	HALY	years health and ability gain
	Dust Avoidance	0.21	kg PM_{10}	respiratory health gain
	Organic Safe Air	189	g_{NM} VOC	respiratory health gain

Tables 7 and 8 show cradle to grave LCI, LCIA and LCBA results per capita toilet paper use of 160kg/20 years. FSC fibre was 85% Chinese, 5% NZ, 4% Russian, 2% US, 2% Australian and 1% Canadian. Fibre fate was to soil .

Results in Table 8 show this paper scoring highly on supply, climate and ecosystem security and human health benefits as well as circularity.

Table 7 Toilet Paper LCI and LCIA Results /capita 20yr

Inventory	Result	Unit
Embodied Water	3357	litre
Finite Material	337	kg
Renewable Matter	826	kg
Feedstock	6925	MJ
Fossil Fuel	4308	MJ
Nuclear Energy	196	MJ
Biomass Fuel	6163	MJ

Impact Potential	Result	Unit
Ozone Depletion	4.0E-08	kg $R11_e$
Greenhouse Gas	-268	kg $CO_{2e\ 100}$
Ecosystem Damage	0.004	PDF*m²pa
Human Health Damage	0.032	DALY
Acidification	17.0	kg SO_{2e}
Fossil Fuel Depletion	286	$MJ_{surplus}$
Mineral Resource	0.19	$MJ_{surplus}$

Table 8 Toilet Paper LCBA and Circularity Results / capita 20 yr

Benefit	Benefit Layers	Result	Unit	Circularity Score or Outcome
SERV	Energy Recovery	6163	$MJ_{surplus}$	89% recovery of energy
	Material Renewal	5476	$MJ_{surplus}$	87% renewable feedstock
	Energy Renewal	6296	$MJ_{surplus}$	58% renewable energy
CLIMES	Climate Brake	221	kg CO_{2e20}	Carbon embodied in product
	Climate Banking	589	kg CO_{2e20}	Carbon drawdown by biomass
	Biomass Banking	268	kgCO_{2e100}	Carbon sequestered in product
PERF	Climate Security	590	kg CO_{2e100}	Retains ecosystem potential
	Biodiversity Security	483	m²*yr	Forest flora and seed for forage
	Water Catchment	16	$Litre_{rain}$	0.5% local rainwater surplus
	Forestry Security	6163	MJ	89% seed, biota and soil biome
HALY	Human Wellness	0.01	HALY	25% longer life and ability years
	Dust Avoidance	0.74	kg PM_{10}	respiratory health gain
	Repair Ozone Layer	5E-08	kg $R11_e$	57% more ozone reparation
	Organic Safe Air	6E-08	g_{NM} VOC	6.2% respiratory health gain

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