ENVIRONMENTAL PRODUCT DECLARATION

as per /ISO 14025/ and /EN 15804/

Owner of the Declaration	**Studiengemeinschaft Holzleimbau e.V.**
Programme holder	Institut Bauen und Umwelt e.V. (IBU)
Publisher	Institut Bauen und Umwelt e.V. (IBU)
Declaration number	EPD-SHL-20180027-IBG1-EN
Issue date	13.08.2018
Valid to	12.02.2024

Glued laminated timber (Glulam)

Studiengemeinschaft Holzleimbau e.V.

Institut Bauen und Umwelt e.V.

www.ibu-epd.com / https://epd-online.com

1. General Information

Studiengemeinschaft Holzleimbau e.V.	Glued laminated timber (Glulam)
Programme holder IBU - Institut Bauen und Umwelt e.V. Panoramastr. 1 10178 Berlin Germany	**Owner of the Declaration** Studiengemeinschaft Holzleimbau e.V. Heinz-Fangman-Straße 2 42287 Wuppertal
Declaration number EPD-SHL-20180027-IBG1-EN	**Declared product / Declared unit** 1 m³ glued laminated timber
This Declaration is based on the Product Category Rules: Solid wood products, 07.2014 (PCR tested and approved by the SVR)	**Scope:** The content of this Declaration is based on information provided by approx. 50 % of association members, whereby the technology presented here is representative for all members. The results of the Life Cycle Assessment are therefore representative for all glued laminated timber components manufactured in Germany by Studiengemeinschaft Holzleimbau e.V. The owner of the declaration shall be liable for the underlying information and evidence; the IBU shall not be liable with respect to manufacturer information, life cycle assessment data and evidences.
Issue date 13.08.2018	**Verification** The CEN Norm /EN 15804/ serves as the core PCR Independent verification of the declaration according to /ISO 14025/ ☐ internally ☒ externally
Valid to 12.02.2024	
Prof. Dr.-Ing. Horst J. Bossenmayer (President of Institut Bauen und Umwelt e.V.)	Matthias Klingler (Independent verifier appointed by SVR)
Dipl. Ing. Hans Peters (Managing Director IBU)	

2. Product

2.1 Product description / Product definition

Glued laminated timber (Glulam) is an industrially-manufactured product for load-bearing structures. Glued laminated timber comprises at least two kiln-dried coniferous wood planks or laminations which are glued together parallel to grain. Thanks to the initial material being strength-graded and homogenisation via its layered structure, it has improved properties and has higher load-bearing capacities than conventional structural timber. On account of its manufacturing process, glued laminated timber is a very dimensionally-stable building material which is subject to minimum cracking. Glued laminated timber can be manufactured as straight or curved beams. Apart from monitoring required for technical approval, manufacturing can also be subject to supplementary private monitoring in accordance with the provisions of the glued laminated timber monitoring symbol.
Glued laminated timber is manufactured from spruce, fir, pine, larch or Douglas fir. Other coniferous species are permissible but not typical.
The typical strength classes are in accordance with the /Glued Laminated Timber Data Sheet/ published by Studiengemeinschaft Holzleimbau e.V. GL24c, GL28c and GL30c. The products can be manufactured in supreme quality, visual quality or industrial quality in accordance with the Glued Laminated Timber Data Sheet.

Directive (EU) No. 305/2011 /CPR/ applies for placing the product on the market in the EU/EFTA (with the exception of Switzerland). The product requires a Declaration of Performance taking consideration of the /EN 14080:2013-09 Timber structures – Glued laminated timber and glued solid timber – Requirements/, and CE marking.
Use of the product is subject to the respective national specifications at the place of use; in Germany, for example, the /state building codes/ and the technical specifications based on these guidelines, especially the national application standard /DIN 20000-3/.

2.2 Application

Glued laminated timber is used as structural components for buildings and bridges.
Use of wood preservatives in accordance with /DIN 68800-3:2012-02 Wood preservation – Part 1/ is not typical and only permissible if other protective means as per /DIN 68800-2:2012-02 Wood preservation – Part 3/ are not sufficient on their own. Where wood preservatives are used in exceptional cases, they must be regulated in the form of a national technical approval or an approval in accordance with the /Biocides Directive/.

2.3 Technical Data

The product's performance values can be found in the

Declaration of Performance based on /EN 14080:2013-09, Timber structures/.

Technical construction data

The following depicts the technical construction data for glued laminated timber made from coniferous wood or poplar in accordance with /DIN EN 14080/.

Name	Value	Unit
Wood species in accordance with /EN1912/ and letter codes, where available, corresponding with /EN 13556/	Various species of wood[1)]	-
Wood moisture as per /DIN EN 13183-1/[2)]	≤ 15	%
Use of wood preservative (the test description as per /DIN 68800-3/ must be indicated)[3)]	Iv, P and W	-
Characteristic compression strength parallel to the grain in accordance with /DIN EN 14080/[4)]	21.5 to 24.5	N/mm²
Characteristic compression strength perpendicular to the grain in accordance with /DIN EN 14080/[4)]	2.5	N/mm²
Characteristic tension strength parallel to the grain in accordance with /DIN EN 14080/[4)]	17.0 - 19.5	N/mm²
Characteristic tension strength perpendicular to the grain in accordance with /DIN EN 14080/[4)]	0.5	N/mm²
Characteristic modulus of elasticity parallel to the grain in accordance with /DIN EN 14080/[4)]	11,000 to 13,000	N/mm²
Characteristic shear strength in accordance with /DIN EN 14080/[4)]	3.5	N/mm²
Mean shear modulus in accordance with /DIN EN 14080/[4)]	650	N/mm²
Deviation in sizes according to /DIN EN 14080/[5)]	Width: ±2 mm; Heights ≤ 400 mm: 4 mm / -2 mm; Heights > 400 mm: +1 % / -0.5 %; Lengths (≤ 2 m): ±2 mm; Lengths (2 m < / ≤ 20 m): ±0.1 %; Lengths (> 20 m): ±20 mm	mm or %
Mean density of various strength classes in accordance with /DIN EN 14080/[4)]	420 - 480	kg / m³
Surface quality in accordance with the /Glued Laminated Timber Data Sheet/	Industrial quality, visual quality, supreme quality	-
Suitability for use classes in accordance with /DIN 68800-1/[6)]	All wood types: GK 0; Southern pine heartwood: also GK 1; Scots pine heartwood: also GK 1 and 2; heartwood of Douglas fir, larch, yellow cedar: also GK 1, 2 and 3.1	-
Thermal conductivity in accordance with /DIN EN 12664/[7)]	Perpendicular to the grain: 0.13	W/(mK)
Specific thermal capacity in accordance with /DIN EN 12664/	1600	kJ/kgK
Water vapour diffusion resistance factor in accordance with /DIN EN ISO 12572/[8)]	Dry at a mean density of 500 kg/m³: 50	-

[1)] Norway spruce (Picea abies, PCAB), fir (Abies alba, ABAL), Scots pine redwood (Pinus sylvestris, PNSY), Douglas fir (Pseudotsuga menziesii, PSMN), western hemlock (Tsuga heterophylla, TSHT), Corsican pine and Austrian pine (Pinus nigra, PNNL), European larch (Larix decidua, LADC), Siberian larch (Larix sibirica, LASI), Dahurian larch (Larix gmelinii (Rupr.) Kuzen.), maritime pine (Pinus pinaster, PNPN), poplar (applicable clones: Populus x euramericana cv "Robusta", "Dorskamp", "I214" and "I4551", POAL), Radiata pine (Pinus radiata, PNRD), Sitka spruce (Picea sitchensis, PCST), Southern yellow pine (Pinus palustris, PNPL), Western red cedar (Thuja plicata, THPL), Yellow cedar (Chamaecyparis nootkatensis, CHNT). Norway spruce and the fir may be treated as a single wood species.

[2)] /DIN EN 14800/ permits other equivalent measurement methods.

[3)] Treatment with a wood preservative in accordance with /DIN 68800-1/ is only permissible if the structural measures have been exploited and is therefore not typical.

[4)] In accordance with /DIN EN 14080/, more elasto-mechanical properties and bending properties in particular can be declared.
An indication of strength classes is typical. Strength classes GL24c, GL28c and GL30c are typical.
The ranges indicated here refer to mean or characteristic values of the respective strength classes.
Deviating values can be declared.
The declared density values can deviate from these average values owing to varying densities of the wood species used.

[5)] /DIN EN 14080/ refers to other tolerances, e.g. concerning angularity or curved members.

[6)] As /DIN 68800-1/ demands that structural measures are exploited before using a preventive chemical wood preservative, only allocations for untreated glued laminated wood are provided here.

[7)] Design values of thermal conductivity shall be calculated from the declared values in accordance with /DIN 4108-4/.

[8)] The air layer thickness equivalent to the water vapour diffusion is calculated by adding the layer thickness and the water vapour diffusion resistance factor.

2.4 Delivery status

The products are manufactured in the following preferred dimensions:
Min. height: 100 mm
Max. height: > 2400 mm
Min. width: 60 mm
Max. width: > 240 mm
Max. lengths: > 50 m

2.5 Base materials / Ancillary materials

Glued laminated timber comprises at least two kiln-dried coniferous wood planks or laminations which are glued together parallel to grain. Melamine-urea-formaldehyde adhesives (MUF) or polyurethane adhesives (PUR) as well as smaller volumes of phenol-resorcin-formaldehyde adhesives (PRF) and emulsion-polymer-isocyanate (EPI) adhesives are used for basic duroplastic glueing. Formaldehyde emissions are declared in accordance with /DIN EN 14080/. Substances on the /ECHA List of Candidates/ for including substances of very high concern in Annex XIV of the /REACH Directive/ (last revised: 15.01.2018) are not included.
The average percentages of ingredients per m³ glued laminated timber for the Environmental Product Declaration:
- Coniferous wood, primarily spruce: approx. 87.35 %
- Water: approx. 10.48 %
- PUR adhesives: approx. 0.03 %
- MUF adhesives: approx. 2.04 %
- PRF adhesives: approx. 0.1 %

The product has an average gross density of 483.21 kg/m³.

2.6 Manufacture

The manufacture of glued laminated timber involves kiln-drying conventional sawn timber to approx. 12 % moisture content, rough-planed and visually or automatically strength-graded. Depending on the requisite strength class, any board sections of lower strength are lopped out and the remaining board sections bonded via finger joints to form laminations of infinite length. The subsequent rough-planing process involves planing the laminations to thicknesses of up to 45 mm for pressing at least 3-layer blanks after applying adhesive to the wide face in a straight or curved press bed. After hardening, the blanks are planed, bevelled, bound and packed. If necessary, they can be treated with weatherproof or, in exceptional cases, wood preservative.

2.7 Environment and health during manufacturing

Waste air incurred is cleaned in accordance with statutory specifications. There are no risks for water or soil. The process waste water incurred is fed into the local waste water system. Noise-intensive machinery is encapsulated appropriately.

2.8 Product processing/Installation

Glued laminated timber can be processed using conventional tools suitable for processing solid wood. The health and safety guidelines must also be observed during processing/assembly.

2.9 Packaging

Polyethylene, solid wood, paper and cardboard are used as well as small percentages of other plastics.

2.10 Condition of use

Composition for the period of use complies with the base material composition in accordance with section 2.5. Base materials / Ancillary materials.
Approx. 211.5 kg of carbon are bound in the product during use. This complies with approx. 773.84 kg carbon dioxide at full oxidation.

2.11 Environment and health during use

Environmental protection: According to current knowledge, there are no risks for water, air and soil when the products are used as designated.
Health protection: According to current knowledge, no health risks are to be anticipated.
With regard to formaldehyde, glued laminated timber is low-emission thanks to its adhesive content, structure and particular use.
Glued laminated timber glued with PUR or EPI adhesives displays formaldehyde emission values in the range of natural wood (approx. 0.004 ml/m³). MDI emissions cannot be measured within the detection limit of 0.05 µg/m³ for glued laminated timber glued with MDI or PUR adhesives. On account of the high reactivity displayed by MDI with water (humidity and wood moisture), it can be assumed that glued laminated timber thus glued displays MDI emissions close to zero shortly after manufacturing.
Glued laminated timber glued with MUF adhesives emanates formaldehyde subsequently. Measured using the limit value of 0.1 ml/m³ specified by the Ordinance on Chemicals, the values after testing (DIN EN 717-1: 2005) can be classified as low. Average emissions amount to approx. 0.04 ml/m³. In individual cases, they can account for up to approx. 0.06 ml/m³.

2.12 Reference service life

Glued laminated timber has been used for more than 100 years.
When used as designated, infinite durability can be anticipated.
When used as designated, the service life of glued laminated timber is therefore the same as the service life of the respective building.

2.13 Extraordinary effects

Fire

Fire class D in accordance with DIN EN 13501-1; the toxicity of fire gases complies that of natural wood.

Name	Value
Building material class	D
Burning droplets	d0
Smoke gas development	s2

Water

No ingredients are leached which could be hazardous to water.

Mechanical destruction

The fracture surface of glued laminated timber displays an appearance typical for solid wood.

2.14 Re-use phase

In the event of selective de-construction, glued

laminated timber can easily be reused after the use phase has ended.
If glued laminated timber cannot be reused, it is directed towards thermal recycling for generating process heat and electricity on account of its high calorific value of approx. 16 MJ / kg (with moisture of u = 12 %).
During energetic recycling, the requirements outlined in the /Federal Immission Control Act (BlmSchG)/ must be maintained: Untreated glued laminated timber is allocated to waste code 17 02 01 /AVV/ in accordance with Annex III of the /Waste Wood Act (AltholzV)/ dated 15.02.2002 (depending on the type of wood preservative, treated glued laminated timber is allocated to waste code 17 02 04).

2.15 Disposal

Waste wood may not be landfilled in accordance with §9 of the /Waste Wood Act (AltholzV)/.
The packaging materials used can be directed to thermal waste processing, for which the following waste codes are allocated in accordance with /AVV/: 150101 (paper and cardboard packaging), 150102 (plastic packaging), 150103 (wood packaging).

2.16 Further information

More detailed information is available at www.brettschichtholz.de.

3. LCA: Calculation rules

3.1 Declared Unit

The declared unit in the LCA is the provision of 1 m³ glued laminated timber with a mass of 483.21 kg/m³, 12 % wood moisture, 10.482 % water content and 2.166 % adhesive content. All details on adhesives used were calculated on the basis of specific data. Averaging was weighted by production volume.

Details on declared unit

Name	Value	Unit
Declared unit	1	m³
Gross density	48321	kg/m³
Conversion factor to 1 kg	2069	-
Wood moisture on delivery	12	%
Adhesive content in relation to overall mass	2.166	%
Water content in relation to overall mass	10.482	%

3.2 System boundary

The Declaration complies with an EPD "from cradle to plant gate, with options". It includes the production stage, i.e. from provision of the raw materials through to production (*cradle to gate*, Modules A1 to A3), Module A5, and parts of the end-of-life stage (Modules C2 and C3). It also contains an analysis of the potential benefits and loads over and beyond the product's entire life cycle (Module D).
Module A1 analyses the provision of wood from forestry resources, the provision of other pre-treated wood products and the provision of adhesives. Transport of these substances is considered in Module A2. Module A3 comprises the provision of fuels, resources and electricity as well as the production processes on site. These essentially involve debarking, cutting, drying, planing and profiling processes as well as glueing and packing the products. Module A5 exclusively covers the disposal of product packaging which includes the disposal of biogenic carbon and primary energy (PERM and PENRM).
Module C2 considers transport to the disposal company and Module C3 is concerned with preparing and sorting waste wood. In accordance with /EN 16485/, Module C3 also includes as outflows the CO_2 equivalents of the carbon inherent in the wood product as well as the renewable and non-renewable primary energy (PERM and PENRM) contained in the product.
Module D analyses the thermal utilisation of the product at its end of life as well as the ensuing potential benefits and loads in the form of a system extension.

3.3 Estimates and assumptions

As a general rule, all of the material and energy flows for the processes required by production are established on site. The emissions from incineration and other processes on site could only be estimated on the basis of literary references. All other data is based on average values. More detailed information on all estimates and assumptions made is documented in /S. Rüter, S. Diederichs: 2012/.
The basis for the calculated application of fresh water resources is depicted by blue water consumption.

3.4 Cut-off criteria

No known material or energy flows were ignored, including those which fell below the limit of 1 %. Accordingly, the total sum of input flows ignored is certainly less than 5 % of the energy and mass applied. This also safeguards against the possibility of any material or energy flows being ignored which display a particular potential for significant influences in terms of the environmental indicators. Detailed information on the cut-off criteria is documented in /S. Rüter, S. Diederichs: 2012/.

3.5 Background data

All background data was taken from version 6.155 of the /GaBi professional data base/ and the “Ökobilanz-Basisdaten für Bauprodukte aus Holz” final report /S. Rüter, S. Diederichts: 2012/.

3.6 Data quality

The data surveyed was validated on a mass basis and in accordance with plausibility criteria. With the exception of forest wood, the background data used for wood materials for material and energy purposes originates from 2008 to 2012. The provision of forest wood was taken from a 2008 publication which is essentially based on information from 1994 to 1997. All other information was taken from version 6.115 of the /GaBi professional data base/. Following written confirmation of the topicality of primary data used on the part of Studiengemeinschaft Holzleimbau e.V. and the topicality of all background data used, the overall data quality can be regarded as good.

3.7 Period under review

Data for the primary system was surveyed during the period 2009 to 2011, whereby data was always provided for the full calendar year. The data is therefore based on 2008 to 2010. All information is based on averaged data for 12 consecutive months. There is a Studiengemeinschaft Holzleimbau e.V.

document in place confirming that the primary data used continues to depict the association in a representative manner.

3.8 Allocation

The allocations comply with the specifications of the /EN 15804:2012/ and /EN 16485:2014/ and are explained in detail in /S. Rüter, S. Diederichs: 2012/. Essentially, the following system extensions and allocations were carried out.

General information

Flows of properties inherent to the material (biogenic carbon and primary energy contained therein) were allocated in accordance with physical causalities. All other allocations of associated co-products were carried out on an economic basis. One exception is represented by allocation of the requisite heat combined heat and power which was allocated on the basis of the exergy of electricity and process heat products.

Module A1

- Forestry: All expenses in the upstream forest chain were allocated using economical allocation methods to logs and industrial wood on the basis of their prices.
- The provision of waste wood does not take consideration of expenses incurred during the previous life cycle.

Module A3

- Wood-processing industry: For associated co-products, expenses were allocated economically to primary products and residual materials on the basis of their prices.
- With the exception of wood-based materials, the expenses incurred by the disposal of production waste are based on a system extension. The heat and electricity generated are credited to the system in the form of substitution processes. The credits achieved here account for significantly less than 1 % of overall expenses.
- All expenses associated with firing were allocated to firing after exergy of these two products in the case of combined generation of heat and power.
- The provision of waste wood does not take consideration of expenses incurred during the previous life cycle (as in Module A1).

Module D

- The system expansion process performed in Module D complies with an energetic recycling scenario for waste wood.

3.9 Comparability

Basically, a comparison or an evaluation of EPD data is only possible if all the data sets to be compared were created according to /EN 15804/ and the building context, respectively the product-specific characteristics of performance, are taken into account. The used background database has to be mentioned. The LCA was conducted using the /GaBi ts 2017/ software. All background data was taken from version 6.115 of the /GaBi professional data base/ or literary sources.

4. LCA: Scenarios and additional technical information

The scenarios on which the LCA is based are outlined in more detail below.

Construction installation process (A5)

Module A5 is declared but only contains details on disposal of the product packaging and no details on actual installation of the product in the building. The volume of packaging material incurred as waste material for thermal utilisation per declared unit in Module A5 and the ensuing exported energy are indicated below as technical scenario information.

Name	Value	Unit
Solid wood for thermal waste processing	1.546	kg
Biogenic carbon contained in solid wood	2.832	kg SO2 equiv.
Total efficiency of waste wood in waste incineration	38	%
PE foil for thermal waste processing	0.487	kg
Total efficiency of PE foil in waste incineration	38	%
Other plastic for thermal waste processing	0.045	kg
Total efficiency of other plastic in waste incineration	44	%
Percentage of electricity generated in exported energy	27 - 28	%
Total exported electrical energy	6.51	MJ
Total exported thermal energy	15.93	MJ

A transport distance of 20 km is assumed for disposal of the product packaging. As a conservative approach, disposal of all packaging components as waste in a waste incineration plant is assumed without waste wood being sorted as a material for energy recovery in a biomass heating power plant. Total efficiency of waste incineration for the respective packaging as well as the percentages of electricity and heat generation by means of heat and power combinations correspond with the allocated waste incineration processes in the /GaBi professional data base/.

End of Life (C1-C4)

Name	Value	Unit
Waste wood for energy recovery	483.21	kg
Redistribution transport distance for waste wood (Module C2)	20	km

A collection rate of 100 % without losses incurred by crushing the material is assumed for the scenario of thermal utilisation.

Reuse, recovery and recycling potential (D), relevant scenario information

Name	Value	Unit
Electricity generated (per t atro waste wood)	968.37	kWh
Waste heat used (per t atro waste wood)	7053.19	MJ
Electricity generated (per net flow of declared unit)	409.66	kWh
Waste heat used (per net flow of declared unit)	2984.66	MJ

The product is recycled in the form of waste wood in the same composition as the declared unit at the end-of-life stage. Thermal recovery in a biomass power station with an overall degree of efficiency of 54.69 % and electrical efficiency of 18.09 % is assumed, whereby incineration of 1 tonne atro wood (mass value in atro, consideration of efficiency, yet ~18 % wood moisture content) generates approx. 968.37 kWh electricity and 7053.19 MJ useful heat. Converted to the net flow of the atro wood percentage included in Module D and taking consideration of the percentage of adhesives in waste wood, 409.66 kWh electricity and 2984.66 MJ thermal energy are produced per declared unit in Module D. The exported energy substitutes fuels from fossil sources, whereby it is alleged that the thermal energy is generated from natural gas and the substituted electricity complies with the German power mix for 2017.

5. LCA: Results

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED)

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	X	MND	MND	MNR	MNR	MNR	MND	MND	MND	X	X	MND	X

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT: 1m³ glued laminated timber

Parameter	Unit	A1	A2	A3	A5	C2	C3	D
GWP	[kg CO_2-Eq.]	-7.15E+2	3.21E+1	6.82E+1	4.52E+0	4.85E-1	7.78E+2	-4.15E+2
ODP	[kg CFC11-Eq.]	7.14E-7	5.49E-8	1.18E-7	4.31E-12	9.69E-10	1.75E-11	-9.27E-10
AP	[kg SO_2-Eq.]	2.37E-1	1.32E-1	3.48E-1	3.91E-4	2.08E-3	6.90E-3	-4.30E-1
EP	[kg $(PO_4)^{3-}$-Eq.]	6.59E-2	2.91E-2	7.41E-2	8.23E-5	4.82E-4	1.10E-3	-6.42E-2
POCP	[kg ethene-Eq.]	4.02E-2	9.83E-3	7.38E-2	3.33E-5	1.85E-4	4.78E-4	-4.38E-2
ADPE	[kg Sb-Eq.]	5.53E-4	2.22E-6	1.65E-4	5.31E-8	1.03E-8	2.34E-6	-1.26E-4
ADPF	[MJ]	8.32E+2	4.38E+2	7.66E+2	7.61E-1	6.82E+0	4.52E+1	-5.52E+3

Caption: GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources

RESULTS OF THE LCA - RESOURCE USE: 1m³ glued laminated timber

Parameter	Unit	A1	A2	A3	A5	C2	C3	D
PERE	[MJ]	6.11E+2	2.47E+1	2.11E+3	2.99E+1	9.06E-3	2.54E+1	-1.36E+3
PERM	[MJ]	8.13E+3	0.00E+0	2.98E+1	-2.98E+1	0.00E+0	-8.13E+3	0.00E+0
PERT	[MJ]	8.75E+3	2.47E+1	2.14E+3	1.53E-1	9.06E-3	-8.11E+3	-1.36E+3
PENRE	[MJ]	8.26E+2	4.68E+2	9.25E+2	2.36E+1	6.88E+0	5.88E+1	-6.28E+3
PENRM	[MJ]	1.05E+2	0.00E+0	2.28E+1	-2.28E+1	0.00E+0	-1.05E+2	0.00E+0
PENRT	[MJ]	9.31E+2	4.68E+2	9.47E+2	8.45E-1	6.88E+0	-4.58E+1	-6.28E+3
SM	[kg]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
RSF	[MJ]	4.39E+1	0.00E+0	4.13E+1	0.00E+0	0.00E+0	0.00E+0	8.05E+3
NRSF	[MJ]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.05E+2
FW	[m³]	6.01E-1	1.08E-2	4.76E-1	9.32E-5	3.88E-5	1.49E-2	-7.95E-1

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

RESULTS OF THE LCA – OUTPUT FLOWS AND WASTE CATEGORIES: 1m³ glued laminated timber

Parameter	Unit	A1	A2	A3	A5	C2	C3	D
HWD	[kg]	4.26E-2	0.00E+0	7.33E-3	0.00E+0	0.00E+0	0.00E+0	0.00E+0
NHWD	[kg]	1.21E-2	0.00E+0	3.79E-3	0.00E+0	0.00E+0	0.00E+0	0.00E+0
RWD	[kg]	3.22E-2	1.14E-2	6.22E-2	3.31E-5	1.21E-5	5.41E-3	-2.89E-1
CRU	[kg]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
MFR	[kg]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
MER	[kg]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	4.83E+2	0.00E+0
EEE	[MJ]	0.00E+0	0.00E+0	0.00E+0	6.51E+0	0.00E+0	0.00E+0	0.00E+0
EET	[MJ]	0.00E+0	0.00E+0	0.00E+0	1.59E+1	0.00E+0	0.00E+0	0.00E+0

Caption: HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EEE = Exported thermal energy

6. LCA: Interpretation

The interpretation of results focuses on the production phase (Modules A1 to A3) as it is based on specific data provided by the company. The interpretation takes the form of a dominance analysis of the environmental impacts (GWP, ODP, AP, EP, POCP, ADPE, ADPF) and the use of renewable/non-renewable primary energy (PERE, PENRE). Accordingly, the most significant factors for the respective categories are listed below.

6.1 Global Warming Potential (GWP)

When considering the GWP, the CO_2 product system inputs and outputs inherent in wood require separate analysis. A total of approx. 1007 kg CO_2 enter the system in the form of carbon stored in the biomass, of which 54 kg CO_2 are emitted along the preliminary chains and 177 kg CO_2 are emitted within the framework of heat generation on site. Around 3 kg of CO_2 bound in the form of the packaging material are emitted in Module A5. The volume of carbon ultimately stored in the glued laminated timber is extracted from the system when recycled in the form of waste wood.

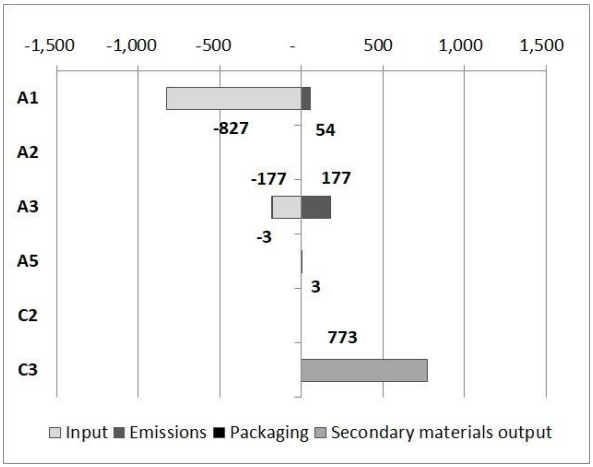

Fig. 1: CO_2 product system inputs and outputs inherent in wood [kg CO_2 equiv.]. The inverse indications suggested by inputs and outputs is in line with the LCO CO_2 flow analysis in terms of the atmosphere.

36 % of the analysed fossil greenhouse gases are accounted for by the provision of raw materials (entire Module A1), 20 % by transporting the raw materials (entire Module A2) and 44 % by the manufacturing process for glued laminated wood (entire Module A3). Electricity consumption in the plant as part of Module A3 represents 27 %, the provision of wood as a raw material as part of Module A1 accounts for 24 % and transporting the raw wood material in Module A2 contributes to 20 % of fossil greenhouse gases, making them essential influential factors.

6.2 Ozone Depletion Potential (ODP)

72 % of emissions with an ozone depletion potential are incurred by the provision of adhesives and 8 % by the provision of wood as a raw material (both Module A1). Product manufacturing and packaging (entire Module A3) contributes another 13 % to overall ODP.

6.3 Acidification Potential (AP)

The combustion of wood and diesel are the sources of essential relevance for emissions representing a potential contribution towards the acidification potential. Drying the bought-in products, provision of the requisite heat and utilisation of fuels in forestry account for around 30 % of emissions. At 3 %, the emissions from the provision of adhesives are negligible by comparison (both Module A1). Transporting raw materials accounts for a further 18 % (Module A2) and heat generation on site contributes a total of 34 % to the entire cradle-to-gate emissions (Module A3).

6.4 Eutrification Potential (EP)

30 % of the entire EP is attributable to drying and incinerating processes in the upstream chains for the provision of wood as a raw material and a further 9 % is accounted for by the provision of adhesives (both Module A1). Heat generation for the manufacturing process contributes 33 % to the EP (Module A3). Another 17 % is accounted for by transporting wood as a raw material to the production facility (Module A2).

6.5 Photochemical Ozone Creation Potential (POCP)

The primary POCP contributions are accounted for by the provision of wood as a raw material for the product (31 %) (Module A1) and the drying process as part of product manufacturing (32 %) (Module A3). Generation of heat required for the manufacturing process causes 24 % (Module A3) of the entire POCP while transporting wood as a raw material to the production facility (Module A2) accounts for a further 8 %.

6.6 Abiotic Depletion Potential non-fossil resources (ADPE)

The essential contributions to ADPE are represented by the provision of wood as a raw material (75 %) (Module A1), heat generation in the manufacturing process (11 %) (Module A3) and consumables used during manufacturing (9 %) (Module A3).

6.7 Abiotic Depletion Potential fossil fuels (ADPF)

Provision of wood as a raw material for the product accounts for 22 % and the manufacture of adhesives processed contributes 19 % to the entire ADPF (both Module A1). Other essential influences are represented by transporting wood as a raw material (21 %) (Module A2), electricity consumption (21 %) and heat generation (12 %) during the manufacturing process (both Module A3).

6.8 Renewable Primary Energy as Energy carrier (PERE)

20 % of PERE is attributable to the provision of wood for the product (module A1). But most of this application is accounted for by the manufacturing process (Module A3), i.e. electricity consumption (59 %) and heat generation (11 %).

6.9 Non-renewable primary energy as Energy carrier (PENRE)

PENRE is distributed relatively consistently across Module A1 by the provision of wood as a raw material (22 %) and the provision of adhesives (18 %). Transporting wood to the plant (Module A2) represents a further 20 %. In Module A3, PENRE is distributed across direct electricity consumption for manufacturing processes (24 %), heat generation (12 %) and the consumables and packaging materials used (5 %).

6.10 Waste
Special waste is primarily incurred during the provision of adhesives (approx. 74 %) and wood as a raw material (approx. 12 %) in Module A1 as well as the consumables used (approx. 11 %) in Module A3.

6.11 Range of results
The individual results for participating companies are distinguished from the average results in the Environmental Product Declaration. Maximum deviations of +44 % / -40 % (GWP), +30 % / -77 % (ODP), +49 % / -28 % (AP), +43 % / -26 % (EP), +49 % / -42 % (POCP), +101 % / -25 % (ADPE) and +40 % / -33 % (ADPF) were calculated in relation to the results outlined in section 5. These deviations are primarily attributable to differences in the fuels used and specific electricity consumption values during the processes.

7. Requisite evidence

The following evidence of environmental and health relevance was provided:

7.1 Formaldehyde
A total of seven measurement reports were available on formaldehyde emissions. The measurements were carried out by experienced test laboratories. Equalisation concentrations were established. The measurements were performed in test chambers in accordance with /DIN EN 717-1: 2005/ at a uniform temperature of 23 °C, relative humidity of 45 % and a ventilation rate of 1.0 per hour. Loading factors differed in some cases. The measured values were therefore initially used to calculate the area-specific emission rates.
As anticipated, most of the measured values (22) are available for glued laminated timber with MUF adhesive. The average area-specific emission rate is 34.8 µg/h x m². With reference to a loading factor of 0.3 m²/m³ suggested by the Stuttgart Materials Testing Institute and specified in the /DIN EN 14080:2005/, this gives rise to a formaldehyde equalisation concentration in the test chamber of 0.008 ml/m³. This value is less than one-tenth of the limit value of 0.1 ml/m³ in accordance with the Ordinance on Chemicals. If the highest values measured (71 µg/h x m²) are taken as a basis for derivation, this results in an equalisation concentration of 0.017 ml/m³. Laminated timber glued using formaldehyde-free PUR adhesive gives rise to area-specific emission rates in the range of non-adhesive wood. The derived equalisation concentration is approx. 0.004 ml/m³. Similar values were also measured for other, non-adhesive types of wood and comply with the natural formaldehyde emissions by wood.

7.2 MDI
When glued laminated timber is glued, the MDI contained in the polyurethane adhesives reacts out in full. MDI emissions from the hardened glued solid timber are not therefore possible: there is no test standard in place.
The tests submitted are concerned with the temporary MDI emissions arising during glueing in the factory. As there is no standardised measurement process in place for these emissions, one of the tests submitted determined the MDI emissions on the basis of the measurement method for determining formaldehyde emissions outlined in /EN 717-2: 1995/.
Result: MDI emissions were not detected in any of the seven glued laminated timbers examined within the framework of the detection limit (0.05 µg/m³).
An additional test based on a project-related measurement method involving a wooden slat glued with PUR adhesive but not hardened displayed MDI emissions slightly above the detection limit (0.05 µg/m³) during the first two hours after applying the adhesive. MDI emissions could not be measured after that.

7.3 Fire gas toxicity
The toxicity of fire gas arising when glued laminated wood burns corresponds with the toxicity of fire gases arising when natural wood is burned.

7.4 VOC emissions
Building authority evidence is not currently required.

8. References

Institut Bauen und Umwelt
Institut Bauen und Umwelt e.V., Berlin(pub.): Generation of Environmental Product Declarations (EPDs);
General Principles
for the EPD range of Institut Bauen und Umwelt e.V. (IBU), 2013/04
www.ibu-epd.de

/ISO 14025/
DIN EN /ISO 14025:2011-10/, Environmental labels and declarations — Type III environmental declarations — Principles and procedures

/EN 15804/
/EN 15804:2012-04+A1 2013/, Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products

/EN 16485/
EN 16485:2014-07, Round and sawn timber – Environmental Product Declarations – Product category rules for wood and wood-based products for use in construction

/DIN EN 4108-4/
DIN 4108-4:2017-03, Thermal Protection and Saving Energy in Buildings – Part 4: Hygrothermal design values

/DIN EN 68800-1/
DIN 68800-1:2011-10, Wood protection – Part 1: General information

/DIN 68800-2/
DIN 68800-2:2012-02, Wood protection – Part 2: Preventive constructional measures in buildings

/DIN EN 68800-3/
DIN 68800-3:2012-02, Wood protection – Part 3: Preventive protection of wood with wood preservatives

/DIN EN 717-1/
DIN EN 717-1:2005-01, Wood Materials; Determining Formaldehyde Emissions – Part 1: Formaldehyde emission by the chamber method

/DIN EN 717-2/
DIN EN 717-2:1995-01, Wood Materials; Determining Formaldehyde Emissions – Part 2: Formaldehyde emission by the gas analysis method

/DIN EN 1912/
DIN EN 1912:2013-10, Structural timber – Strength classes – Assignment of visual grades and species

/DIN EN 1995-1-1/
DIN EN 1995-1-1:2010-12, Euro code 5: Design of timber structures – Part 1-1: General – Common rules and rules for buildings

/DIN EN 1995-1-1/NA/
DIN EN 1995-1-1/NA:2013-07, National Annex – Nationally determined parameters – Eurocode 5: Design of timber structures – Part 1-1: General – Common rules and rules for buildings

/DIN EN 12664/
DIN EN 12664: 2001-05, Thermal performance of buildings materials and products – Determination of thermal resistance by means of guarded hot plate and heat flow meter methods – Products of medium and low thermal resistance

/DIN EN 13183-1/
DIN EN 13183-1:2002-07,
Moisture content of a piece of sawn timber – Part 1: Determination by oven dry method; German version

/DIN EN 13356/
DIN EN 13556:2003-10, Round and sawn timber – Nomenclature of commercial wood used in Europe

/DIN EN 13501-1/
DIN EN 13501-1:2010-01, Classification of Building Products and Methods by Fire Performance – Part 1: Classification with the results of tests on reaction to fire of construction products

/DIN EN 13501-2/
DIN EN 13501-2:2016-12, Classification of Building Products and Methods by Fire Performance – Part 2: Classification using data from fire resistance tests, excluding ventilation services

/DIN EN 14080/
DIN EN 14080: 2013-09, Timber structures – Glued laminated timber – Requirements

/DIN EN ISO 12572/
DIN EN 12572: 2017-05, Hygrothermal performance of building materials and products – Determination of water vapour transmission properties – Test vessel method

Other sources:

/Waste Wood Act (AltholzV)/
Waste Wood Act (AltholzV): Act governing the requirements on utilisation and disposal of waste wood, 2017

/AVV/
Ordinance on the List of Wastes dated 10 December 2001 (BGBI. I p. 3379), last amended by Article 2 of the Directive dated 17 July 2017 (BGBl. I, p. 2644)

/Glued Laminate Timber Data Sheet/
The latest version of the Glued Laminated Timber Data Sheet published by Studiengemeinschaft Holzleimbau e.V.

/Federal Immission Control Act (BImSchG)/
Federal Immission Control Act (BImSchG) Act protecting against harmful environmental impact caused by air pollution, noise, shocks and similar processes, 2013

/CPR/
Directive (EU) No. 305/2011 of the European Parliament and Council dated 9 March 2011 establishing harmonised conditions for marketing construction products and replacing Council Guideline 89/106/EEC

/ECHA List of Candidates/
List of substances of very high concern requiring approval (last revised: 15.01.2018) in accordance with Article 59, paragraph 10 of the REACH Directive; European Chemicals Agency

/GaBi professional data base/
GaBi professional data base, version 6.115. thinkstep AG, 2017

/GaBi ts 2017/
GaBi ts 2017, version 7.3.3: Software and data base for comprehensive analysis; thinkstep AG, 2017

/Product Category Rules for Construction Products, Part B/
PCR solid wood products, 2017-11, from the range of Environmental Product Declarations of Institut Bauen und Umwelt e.V. (IBU)

/REACH Directive/
Directive (EC) No. 1907/2006 of the European Parliament and Council of 18 December 2006 on the Registration, Evaluation, Authorisation of Chemicals (REACH), last revised: 25.03.2014

/S. Rüter and S. Diederichs, 2012/
S. Rüter, S. Diederichs: 2012, Basic Life Cycle Assessment data for construction products made of wood, Hamburg, Johann Heinrich von Thünen Institut, Institut für Holztechnologie und Holzbiologie; Final report

Publisher
Institut Bauen und Umwelt e.V.
Panoramastr. 1
10178 Berlin
Germany

Tel +49 (0)30 3087748- 0
Fax +49 (0)30 3087748- 29
Mail info@ibu-epd.com
Web **www.ibu-epd.com**

Programme holder
Institut Bauen und Umwelt e.V.
Panoramastr 1
10178 Berlin
Germany

Tel +49 (0)30 - 3087748- 0
Fax +49 (0)30 – 3087748 - 29
Mail info@ibu-epd.com
Web **www.ibu-epd.com**

Author of the Life Cycle Assessment
Thünen-Institut für Holzforschung
Leuschnerstr. 91
21031 Hamburg
Germany

Tel +49(0)40 73962 - 619
Fax +49(0)40 73962 - 699
Mail holzundklima@thuenen.de
Web **www.thuenen.de**

Owner of the Declaration
Studiengemeinschaft Holzleimbau e.V.
Elfriede-Stremmel-Straße 69
42369 Wuppertal
Germany

Tel +49 (0)202 978 35-81
Fax +49 (0)202 978 35-79
Mail info@brettschichtholz.de
Web **www.brettschichtholz.de**