Background report for an

IBU environmental product declaration

raw HDF

KRONOSPAN-MOFA Hungary Kft.

This form serves as a guide to the information required by the DIN EN 15804 Background or project report for Environmental Product Declarations (EPDs), which have been developed based on the general guidelines of the Institute Construction and Environment (IBU) and the relevant category rules (PCR).

The report for the verification of the IBU environmental declaration is based on the requirements of EN 15804.

The report is prepared for submission to the independent expert group, the IBU for review and approval of the EPD.

The use of this template is not mandatory, but is recommended.

In general, the background report should be geared to the needs and requirements of a scientific elaboration.

This means, among other things: Redundant texts should be avoided, proper citation should be used, internal text references should be used only in reverse.

☒ **IBU/ECO Environmental Declaration (EPD)**

☐ **ECO Environmental Declaration**

Product:	**raw HDF - raw High Density Fibreboards**
Manufacturer:	**KRONOSPAN-MOFA Hungary Ltd.** **Budapesti út 72** **7700 Mohács** **Hungary**
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Title of the study: **Environmental Declaration of the product group raw HDF – raw High Density Fibreboards**

Client of the study: **KRONOSPAN-MOFA Hungary Ltd.**

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Glossary

Shortcut	Explanation
IBU	Institute of Construction and Environment (dt. Institut Bauen und Umwelt e.V.)
EPD	Environmental Product Declaration (dt. Umweltproduktdeklaration)
LCI	Life Cycle Inventory
PB	Particle Board
HDF	High Density Fibreboard
FCPM	Food Contact Packaging Material

1 Goal of the Study

KRONOSPAN-MOFA Hungary Ltd. operates production facilities in Mohács for the manufacture of raw High Density Fibreboards (raw HDF). They are produced in a range sizes from 2.0 to 8.0 mm thickness. The boards can be used or further processed for Packaging, FCPM, Door industry, Furniture industry, Lacquering-, Laminating-, Mounting-, Finish foil-, Sandwich panel lines.

In addition to an energy-optimized production method, the comprehensive consideration of all environmentally relevant aspects with a seal of quality for sustainable construction is increasingly coming to the fore. A seal of quality as an environmental label should be based on reliable criteria with indicators for ecological, economic, social and functional aspects and should be of technical quality. The product declaration, the so-called EPD - Environmental Product Declaration, is a type III environmental label in accordance with ISO EN 14025, i.e. it contains a life cycle assessment in accordance with ISO EN 14040 and 14044, which has been checked by an independent expert.

The Life Cycle Assessment (LCA) study has been conducted in accordance with the criteria outlined in EN 15804:2021+A2:2019+AC:2021, as well as the Product Category Rules (PCR) Part A, *"Calculation Rules for the Life Cycle Assessment and Requirements on the Project Report according to EN 15804+A2:2019 (Version 1.4, Institut Bauen und Umwelt e.V., 2024)"*, and Part B, *"Requirements on the EPD for Wood-based panels (PCR Version 8, Template Version 11, Institut Bauen und Umwelt e.V., 2025)"*.

The EPD-study of the raw High Density Fibreboard helps KRONOSPAN-MOFA Hungary Ltd. to ensure and document continuous improvement of its production processes and environmental impact. The results are also used for marketing purposes. The target groups for this study are both business partners (business-to-business) and consumers (business-to-consumer).

This average study looks at 1 m^3 raw HDF in 3.82 mm thickness.

This background report is a confidential document prepared by GfBU-Consult GmbH for submission to Institut Bauen und Umwelt e.V. for verification of the associated Environmental Product Declaration as part of an IBU EPD.

2 Declared Product, its Preparation and Application

2.1 Product Description

HDF boards are highly compressed wood-based panels made of (hard-, soft- and pine-) wood fibres impregnated with glue and pressed under pressure and heat. The result is a homogeneous panel with a smooth surface and even, firm edges. They are used where solid wood and other wood-based materials are inadequate or completely unsuitable.

Raw HDF is a non-load-bearing product for interior use in dry conditions. Due to its very fine surface, is suitable for different coatings – veneering, laminating, painting and varnishing. The special thing about the thin, raw HDF is their formability.

The technical specifications can be found in Table 1.

2.2 Application of the Construction Product

The boards can be used or further processed for Packaging, FCPM, Door industry, Furniture industry, Lacquering-, Laminating-, Mounting-, Finish foil-, Sandwich panel lines.

2.3 Technical Specifications

The technical data for raw HDF is not available exactly in the form required by PCR Part B, Chapter 2.3 (see Table 1).

Table 1: Technical Data of raw HDF in accordance with PCR Part B, Chapter 2.3

Name	Value	Unit	explanation
Gross density	---	kg/m^3	not available in this form
Grammage	---	kg/m^2	not available in this form
Bending strength (longitudinal)	---	N/mm^2	not available in this form
Bending strength (transverse)	---	N/mm^2	not available in this form
E-module (longitudinal)	---	N/mm^2	not available in this form
E-module (transverse)	---	N/mm^2	not available in this form
Material dampness at delivery	---	%	not available in this form
Dimension change on plate level	---	mm	not available in this form
Tensile strength rectangular	---	N/mm^2	not available in this form
Impact resistance classification	---	-	not available in this form
Joint opening	---	mm	not available in this form
Height difference between elements	---	mm	not available in this form
Thermal conductivity	---	W/(mK)	not available in this form
Water vapour diffusion resistance factor	---	-	not available in this form
Sound absorption	---	%	not available in this form
Room sound improvement	---	Sone	not available in this form
Formaldehyde emissions acc. to EN 717-1	---	µg/m^3	not available in this form

Performance data of the product in accordance with the declaration of performance with respect to its essential characteristics according to *EN 622-1* and with *EN 622-5* norm table 3 – Requirements for general purpose boards for use dry conditions.

The performance data of raw HDF is according to the standards mentioned in the headline in the table for constructional data (see Table 2).

Table 2: Technical information in accordance to Kronospan Data Sheet for raw HDF

Characteristic (incl. control standards)	**Specification Value for raw HDF**
Board size (most common)	2800 mm x 2070 mm
Thickness	2.0 – 8.0 mm
Thickness tolerance (EN 324-1)	± 0.2 mm/m
Length and width tolerance (EN 324-1)	± 0.2 mm/m (max. ± 5.0 mm)
Straightness (EN 324-2)	max. 1.5 mm/m
Squareness tolerance (EN 324-2)	± 2.0 mm/m
Density (EN 323)	820 kg/m^3 (Standard) 855 kg/m^3 (Plus) 890 kg/m^3 (Extra)
Density tolerance (EN 323)	± 7 %
Moisture content (EN 322)	4.0 – 11.0 w/w %
Thickness Swelling – 24 h (EN 317)	2.0 – 2.5 mm: 45 w/w % > 2.5 – 4.0 mm: 35 w/w % > 4.0 – 6.0 mm: 30 w/w % > 6.0 – 8.0 mm: 17 w/w %
Bending strength (EN 310)	Standard: 30 N/mm² 2.0 – 2.5 mm: 35 N/mm² (Plus) or 40 N/mm² (Extra) > 2.5 mm: 40 N/mm² (Plus) or 45 N/mm² (Extra)
Modulus of elasticity (EN 310)	Standard: 3000 N/mm² 2.0 – 2.5 mm: 3300 N/mm² (Plus) or 3800 N/mm² (Extra) > 2.5 – 4.0 mm: 3500 N/mm² (Plus) or 4000 N/mm² (Extra) > 4.0 mm: 4000 N/mm² (Plus) or 4400 N/mm² (Extra)
Internal Bond (EN 319)	2.0 – 2.5 mm: 0.65 N/mm² (Standard), 0.75 N/mm² (Plus), 0.8 N/mm² (Extra) > 2.5 – 4.0 mm: 0.70 N/mm² (Standard), 0.75 N/mm² (Plus), 0.9 N/mm² (Extra) > 4.0 – 6.0 mm: 0.70 N/mm² (Standard), 0.75 N/mm² (Plus), 1.2 N/mm² (Extra) > 6.0 – 8 mm: 0.65 N/mm² (Standard), 0.75 N/mm² (Plus), 0.9 N/mm² (Extra)

Characteristic (incl. control standards)	Specification Value for raw HDF
Surface soundness (EN 311)	0.8 N/mm² (Standard) 1.0 N/mm² (Plus) 1.1 N/mm² (Extra)
Surface (Toluene) adsorption (EN 382-1)	150 – 300 mm
Surface (Water) adsorption (EN 382-2)	300 – 600 g/m²
Sand (grit) content (ISO 3340)	max. 0.05 w/w %
Perforator-value (EN ISO 12460-5:2015)	≤ 5.0 (E1); ≤ QCL (CARB Phase 2 / EPA TSCA Title VI - § 770.10; ISO-MAT-0003 v15), Articles: all
Gas analysis (EN ISO 12460-3:2015)	≤ QCL (IOS-MAT-0003 v15 or IOS-MAT-018 v3), Articles: 20197 / 20239 / 20279; 20203 / 20268 / 20288
Chamber test-1 (EN 717-1:2005)	≤ 0.124 (E1), Articles: all
	≤ 0.05 (GPCO, IOS-MAT-0181 v3) Articles: 20197 / 20239 / 20279; 20203 / 20268 / 20288
Chamber test-2 (EN 16516:2017)	≤ 0.1 (GPCO, IOS-MAT-0181 v3); Articles: 20197 / 20239 / 20279; 20203 / 20268 / 20288
Chamber test-3 (ASTM E 1333-14 or ASTM D 6007-14)	≤ 0.13 (CARB Phase 2/ EPA TSCA Title VI - § 770.10) ≤ 0.08 (IOS-MAT-0003 v15) Articles: all

The current technical data is available on the homepage https://kronospan.com/en_HU.

2.4 Delivery status

Raw HDFs can be produced in many different sizes. The most common size is 2800 mm x 2070 mm in thicknesses of 2.0 - 8.0 mm. The range of raw HDF products covered by the EPD in Business Year 2022/2023 is shown in Table 3.

Table 3: Range of raw HDF Products covert by the EPD in Business Year 2022/2023

Thickness [mm]	Ratio in production during the business year 2022/2023 [%]
2.0	2.5
2.2	1.6
2.3	3.2
2.5	17.2

Thickness [mm]	Ratio in production during the business year 2022/2023 [%]
2.6	4.3
2.7	1.7
2.8	4.2
3.0	39.9
3.2	0.7
3.5	1.3
3.8	0.2
4.0	6.3
4.8	0.9
5.0	12.1
6.0	2.4
6.5	1.4
8.0	0.1

The provided data covers the production of all raw HDF products in the business year 2022/2023. The calculated results are applicable for a raw HDF with a thickness of 3.82 mm (weighted average) (see Chapter 3.1).

2.5 Base Materials

The product consists of (hard-, soft- and pine-) wood fibre, hardened (effects of ammonium-nitrate and temperature) melamine-urea-formaldehyde artificial resin, and formaldehyde catching urea and hydrophobic effects (paraffin-emulsion) was added on the production (see table 4).

Table 4: Base Materials

Carbon-related materials	Total business year	Unit originally	Share from business year for raw HDF	Quantities per 1 t raw HDF	Quantities per 1 m³ raw HDF	Density
	[t]		[%]	[kg]	[kg]	[kg/m³]
Raw materials for raw HDF						
Hardwood (atro)	26902.44	t	38,97	482.04	393.65	
Softwood (atro)	17785.25	t	25,76	318.67	260.24	
Pine Wood (atro)	18839.86	t	27,29	337.57	275.67	
Wood Chips (atro)	29.32	t	0,04	0.53	0.43	
subtotal	*63556.87*	*t*				
Additional raw materials for raw HDF						
mUF Resin (atro)	4687.76	t	6,79	83.99	68.59	
UAN Hardener (atro)	487.25	t	0,71	8.73	7.13	
Parafin emulsion (atro)	308.65	t	0,45	5.53	4.52	
Urea (atro)	1.82	t	0,00	0.03	0.03	
subtotal	*5485.48*	*t*				
Emissions to air, not included in raw HDF						
Water from chemicals (from lutro therefore not in atro values)	3358.68	t		60.18	49.15	
HCHO (from lutro therefore not in atro values)	5.20	t		0.09	0.08	

Carbon-related materials	Total business year	Unit originally	Share from business year for raw HDF	Quantities per 1 t raw HDF	Quantities per 1 m³ raw HDF	Density
	[t]		[%]	[kg]	[kg]	[kg/m³]
VOC (from lutro therefore not in atro values)	62.10	t		1.11	0.91	
Total Emissions to Air (from lutro therefore not it atro values)	*67.30*	*t*		**1.21**	**0.98**	
Additional calculations						
Total input for raw HDF (businessyear)	**69042.35**	**t**				
Material for declared unit of raw HDF including offcuts/waste				**1237.09**	**1010.26**	
Material for declared unit of raw HDF (final raw boards)				**1000.00**	**816.64**	816.64
offcuts/waste from the production				**237.09**	**193.62**	
Packaging material						
PET strips	7.50	t	0.01	0.000134	0.000110	
Paper	2.90	t	0.01	0.000052	0.000042	
Wooden legs_half impact	2.00	t	0.02	0.000036	0.000029	
Strech foil waste	1	t				
metal strip waste	2	t				

kg	m³
816.64	1.00
1000.00	1.22

Carbon-related materials	Total business year	Unit originally	Share from business year for raw HDF	Quantities per 1 t raw HDF	Quantities per 1 m³ raw HDF	Density
	[t]		[%]	[kg]	[kg]	[kg/m³]
Total Input packaging material (businessyear)	**12.40**	**t**				
Total packaging material for product	**9,4**	**t**				
Auxiliary values for calculation						
raw HDF (MOFA)_raw [t] (Values without offcuts/waste)	**55810.09**	**t**		**1.00000**	**0.81664**	
raw HDF (MOFA)_packaged [t]	**55819.49**	**t**		**1.00022**	**0.81682**	
offcuts/waste material from balance	**13232.26**	**t**		**0.23709**	**0.19362**	
raw HDF (MOFA)_raw [t] (brutto)	**69042.35**	**t**		**1.23709**	**1.01026**	

Waste for internal incineration						
Bark and wood dust/waste	4395.10	t	0.33215	78.75	64.31	
sludge from BU3	15.00	t	0.00113	0.27	0.22	
dust from BU3	5.10	t	0.00039	0.09	0.07	
fibre by-product from BU3	597.03	t	0.04512	10.70	8.74	

Carbon-related materials	Total business year	Unit originally	Share from business year for raw HDF	Quantities per 1 t raw HDF	Quantities per 1 m³ raw HDF	Density
	[t]		[%]	[kg]	[kg]	[kg/m³]
dust during panel production, BU4	0.60	t	0.00005	0.01	0.01	
saw dust from BU 5	1448.16	t	0.10944	25.95	21.19	
HDF waste BU 5 for heat production	696.68	t	0.05265	12.48	10.19	
rejects from BU 6	1.86	t	0.00014	0.03	0.03	
Lost wood from BU1 for heat production	1050.25	t	0.07937	18.82	15.37	
Small fraction from BU1 for heat production	4037.76	t	0.30514	72.35	59.08	
Vacuum-forming line waste from BU2 for heat production	984.74	t	0.07442	17.64	14.41	
Total Productionwaste for Heatgeneration (businessyear)	**13232.26**	**t**		237.09	193.62	
Produtionwaste for Disposal						
metal strip waste	0,1	t				

Carbon-related materials	Total business year	Unit originally	Share from business year for raw HDF	Quantities per 1 t raw HDF	Quantities per 1 m³ raw HDF	Density
	[t]		[%]	[kg]	[kg]	[kg/m³]
Sludge from the refiner water treatment BU2	15	t				
Auxiliary and operating materials	3,6	t				
Total Productionwaste for Disposal (businessyear)	**18.70**	**t**		**0.34**	**0.27**	
Waste water from Chemicals (from lutro therefore not it atro values)	3358.68	t				
Total waste water from chemicals (from lutro therefore not it atro values)	3358.68	t				
HCHO (from lutro therefore not in atro values)	5.20	t		**0.09**	**0.08**	
VOC (from lutro therefore not in atro values)	62.10	t		**1.11**	**0.91**	

Carbon-related materials	Total business year	Unit originally	Share from business year for raw HDF	Quantities per 1 t raw HDF	Quantities per 1 m³ raw HDF	Density
	[t]		[%]	[kg]	[kg]	[kg/m³]
Total Emissions to Air (from lutro therefore not in atro values)	67.30	t		**1.21**	**0.98**	
data uncertainty	**0.00**			**237.43**	**193.89**	

2.6 Manufacturing Process of the Construction Product

KRONOSPAN-MOFA Hungary Ltd. produces different high-quality boards at Mohács site. The manufacturing process of raw HDF is shown schematically and described in Figure 1.

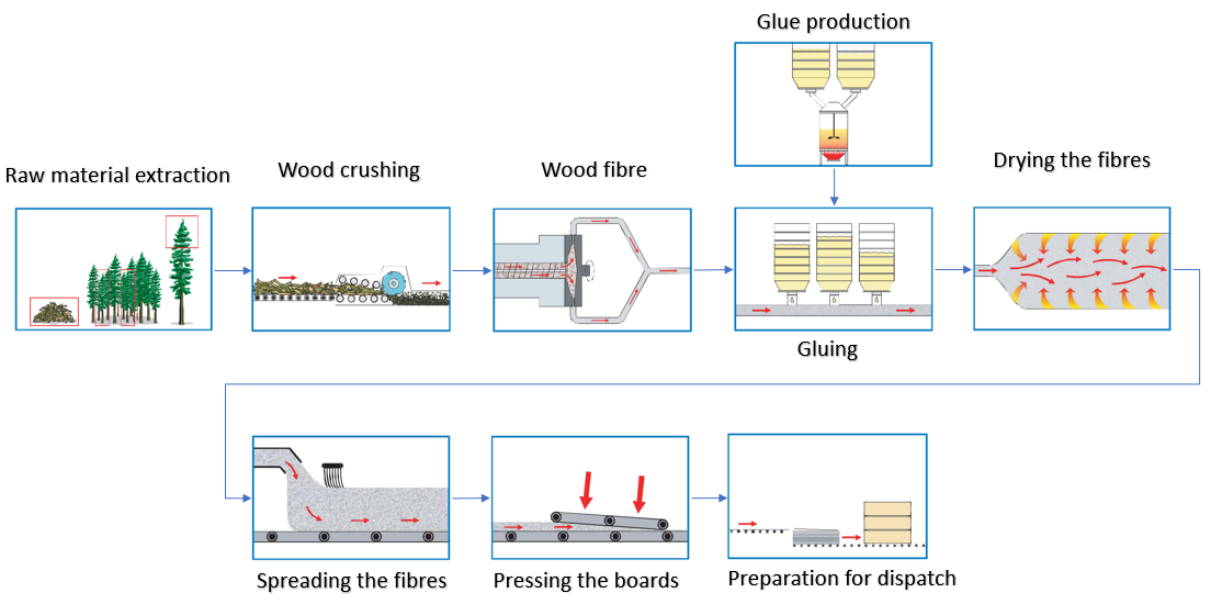

Figure 1: Manufacturing Process of raw HDF

The production of a raw HDF begins at the KRONOSPAN-MOFA site with the delivery of fresh wood (raw material extraction). The fresh wood (soft, hard and pine log) is delivered as round timber (whole logs) and comes mainly from Hungarian and 110 forests within a radius of approx. 130 km in order to minimize transport distances.

The wood is temporarily stored in a wood yard and then transported to the chipper. There the wood is shredded.

The shredded wood is then cleaned and processed into wood fibres in a refiner. The wood fibres are then cleaned with air-cleaner.

During the gluing process, the fibres are mixed with glue, urea, hardener and emulsion. The glue is MUF glue (melamine-urea-formaldehyde glue), which is produced in Sebes (Romania) and transported by trucks.

The fibres are then dried. The drying process is carried out with the help of heat, which is provided on site. The heat is generated in the energy centre by burning wood, by-products (SRF: bark, classified chips, fibre, dumped map, HDF waste), recycled wood and in optional natural gas.

The next production step is panel production. Here, the dried and glued fibres are spread out on a continuously running belt and then fed into a board press. The aim here is to achieve in average a nominal density of 816.64 kg / m³ atro.

The pressing process requires heat, which is generated in the energy centre using wood (and optional natural gas).

The continuous board is then sawn and the resulting raw HDF boards are temporarily stored.

In the final step, the raw HDF boards are assembled and packaged in shipping units. For this purpose, the raw HDF boards are stored on squared timber, wrapped in film and strapped with plastic straps. They are then loaded onto lorries and transported away from the factory premises.

2.7 Environment and health during production

During some procedures of the product's manufacturing (grinding, dimensioning by sawing) dust can occur, which can form an explosive compound if mixed with air. During production processes, use suitable dust extraction equipment to minimize dust generation and accumulation. Clean the work area and equipment regularly.

During the manufacturing procedures with dust formation the usage of breathing apparatus of the class FFP1S is obligatory. The determination of other special measures is not necessary. During handling of the product, the related general rules of labour security and labour hygiene should be kept (e.g.: Safety glasses are recommended when cutting or sanding the finished product.). With wood sensitive individuals, precautions should be taken to avoid skin contact.

2.8 Product Processing / Installation

Precautions for safe handling

Some processes for working the product (grinding, dimensioning by sawing) can generate dust that can form an explosive compound when mixed with air. With regard to further production processes, a suitable dust extraction system must be installed to minimise the generation and accumulation of dust.

Conditions for safe storage, including any incompatibilities

Storage should happen in a dry storing place with good airing, where the flat positioning of the plates can be secured. The product has to be protected from high temperatures, open

fire and moisture. The product cannot be stored together with inflammable liquids. Suggested storage temperature: 15 - 30 °C and relative humidity 45 - 70 %.

2.9 Packaging

The product raw HDF according to the 1272/2008/EK policy (regarding the classification, labeling and packaging of substances and mixtures) and its annexes is not considered to be dangerous. Hazardous goods labelling is therefore not required.

The raw HDF panels are stored on squared timber, wrapped in film and strapped with plastic straps.

The packaging material is disposed of by the customer in accordance with local regulations.

2.10 Conditions of Use

The product is not reactive under normal conditions of use, storage and transport.

2.11 Environment and Health during Use

The product emits formaldehyde emission at E1 class ≤ 8.0 mg/ 100 g dry material (measured in acc. with MSZ EN 12460-5).

2.12 Reference Service Life

The service life of raw HDF depends mainly on the service life of the building or furniture in which the panels are installed and the ambient conditions. Due to the wide range of applications, it can very between 18 und 40 years according to BBSR service life.

2.1 External Influences

2.1.1 Fire

Autoignition temperature is 341 °C in acc. TR. In case of fire, dangerous products of disintegration can evolve (smoke, CO and CO_2; NO_x, NH_3, aldehydes). These products of disintegration should not be inhaled, they can be dangerous for human health.

During the processing of the product, wood dust is generated. Wood dust mixed in the air can form an explosive mixture above a certain concentration, avoid contact between the dust cloud and ignition source.

Extinguishing media: the method of fire-fighting is determined by the fires of the environment. Recommended materials for fighting the fire: water, fire-extinguishing powder, carbon dioxide, foam.

2.1.2 Water

Toxicity: not applicable for the product. Product is not classified as hazardous for the aquatic environment.

2.2 Disposal

The raw HDF is considered as a non-hazardous waste according to Euoropean Waste Code: 03 01 05.

Dispose of packaging according to regulations on the disposal of packaging.

3 Methodological Framework of the LCA

3.1 Declared Unit

KRONOSPAN-MOFA Hungary Ltd. declares itself as the sole manufacturer of the raw HDF within the framework of a manufacturer's declaration.

The raw HDF product group at KRONOSPAN-MOFA Hungary Ltd. includes all raw HDF in various thicknesses (2.0 to - 8.0 mm) and sizes (max. 2800 mm long / 2070 mm wide). The range of specifications offers the customer maximum flexibility, while the panels always go through the same production steps.

The environmental indicators in this EPD study are calculated for an average and therefore virtual raw HDF product. The total input and output quantities of raw HDF as well as the total quantity of raw HDF produced in the 2022/2023 business year from 10.2022 to 09.2023 were used for the modelling. It is important to note that atro values for the wood and chemicals used were applied to calculate the production process. The calculation of the tkm data, on the other hand, was carried out using lutro values for the wood and the chemicals. The respective data was standardised to 1 m^3 and then entered into life cycle assessment software (Umberto 11). The output LCI and LCIA data refer to 1 m^3 of average raw HDF.

A thickness of 3.82 mm as a weighted average was selected for the study. The entire range of raw HDF covered by the EPD is shown in Table 3.

Variations in the environmental impact arise only in relation to the proportion of wood and glue depending on the board thickness and in relation to the proportion of input materials per board size. For the board size, the largest possible board shape was therefore selected in the sense of a worst-case approach in order to map the maximum amount of energy and

glue and thus the maximum possible environmental impact. Finally, the average layer thickness of 3.82 mm was selected for the panel thickness.

The results shown are therefore considered an average of the raw HDF product group.

The declared unit of this study is 1 m^3 raw HDF. The board is manufactured at the KRONOSPAN-MOFA Hungary Ltd. site in Mohács, Hungary. The functional unit comprises the following boundary conditions (Table 5):

Table 5: Boundary Conditions

Designation	Value	Unit
Layer thickness	0.00382	m
Weight per unit area	3.12	kg/m^2 atro
Bulk density[1]	816.64	kg/m^3 atro
Declared unit	1	m^3
Declared unit	not applicable	m^2

[1] With 5,0w/w% av. Moisture content the bulk density is 857 kg / m^3 and thus matches the range of densities specified in the technical data sheet.

3.2 System Boundaries

The system boundaries are declared in the EPD report to be cradle to gate with modules C1–C4 and module D (A1–A3 + C + D) (see table 6).

Table 6: Declared Modules of the Study (MND = module not declared)

Production			Installation		Use stage							End-of-Life				Next product system
Raw material supply (extraction, processing, recycled material)	Transport to manufacturer	Manufacturing	Transport to building site	Installation into building	Use / application	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport to EoL	Waste processing for reuse, recovery or recycling	Disposal	Reuse, recovery or recycling potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	ND	ND	ND	ND	MNR	MNR	MNR	ND	ND	x	x	x	x	x

The system boundaries are shown above in Table 6 The required raw materials for the raw HDF are included in module A1. It is distinguished between the raw materials required for crushing & fibre preparation (pine wood, hardwood, softwood and wood chips with bark) and the raw materials required for the gluing & fibre drying process (mUF resin, UAN hardener, Paraffin emulsion and urea).

All materials are transported (module A2) to the production site (Mohács, H) where they are used for manufacturing.

The manufacturing processes, the arising waste and its transport as well as the raw materials and production of packaging materials are considered in module A3.

Rejects incur during the processes raw material supply, crusing & fibre preparation, gluing & fibre drying, panel production, cutting and packaging of the final product. At the production site, heat is produced in a self-owned central biomass heater and gas boiler system. Utilisable losses are directly used for internal heat production. Additionally required raw materials for heat production (natural gas & fire wood) are considered in module A3.

The raw HDF is removed manually so no efforts arise during the demolition (module C1). The transport to the waste treatment facilities is considered in module C2. At the end of life, the raw HDF is incinerated with energy recovery with a rate higher than 60 % (R1 > 0,6) (module C3).

No remaining wastes are disposed of so that no impacts arise in module C4.

Resulting credits from energy recovery are accounted for in module D.

As the end of life of the packaging is not declared in module A5, its carbon uptake is not taken into account in the modules A1-A3. There is no secondary material used. There were no CO_2 certificates available.

3.3 Allocations

3.3.1 Co-Product Allocations

As there are no co-products, no co-product allocations were required.

3.3.2 Allocation in Multi-input Processes

No processes were modelled that require a multi-input allocation.

3.3.3 Allocation Process for Reuse, Recycling and Recovery

The allocation, cut-off, EN 15804 system model is used. This model is following the underlying principles of the cut-off approach of the EN15804 norm where producers of waste bear the burden of the waste treatment, based on the “polluter pays” principle, and consumers of recycled products receive them burden-free.

3.3.4 Allocation in the background data

All background datasets are taken from the ecoinvent EN 15804 3.10 (Rev. 1) database. The system model "Allocation, cut-off, EN 15804" is applied. The system model is compliant with an attributional interpretation of EN 15804. It provides all Life Cycle Inventory (LCI) indicators required by the aforementioned standard and adheres to the end-of-waste criteria set by the European Commission (Ecoinvent EN 15804).

3.4 Further Methodological Subsidence

3.4.1 Electricity Mix

As the production processes are not separately metered, the overall energy consumption, including electricity and heat, for the raw HDF is considered in an additional overhead process.
The Hungarian production site in Mohács does not have a specific electricity mix with guaranteed electricity mix delivery so the Hungarian residual mix is used.

The GWP for the electricity mix balanced in modules A1-A3 is 0.411 kg CO_2e/kWh.

The GWP for the gas mix balanced in modules A1-A3 is 0.0987 kg CO_2e/MJ.

3.4.2 Additional Assumptions

The required amounts of hardwood, softwood, pine wood and wood chips with bark were given in m³ and in atro and lutro tons. For adequate consideration of transport weight, the given weights in lutro tons were used.

For the downstream transport in module C2, 68.4 km transport distance per kg raw HDF were considered.

The finished products are arranged on wooden pallets for shipping. The pallets used are not standardized EURO pallets according to DIN EN 13698-1, the available information suggests that they are equivalent to roughly one half of a standardized EURO pallet. For evaluating the production effort of one pallet, the ecoinvent dataset for EURO-flat pallets was used. But since this dataset represents the production of one EURO pallet, and the pallet used for shipping only corresponds to one half of the weight of one EURO pallet, the factor of this dataset has been reduced by half.

Raw HDF contains biogenic carbon. Biogenic carbon content and PERM/PENRM values of the materials in the product as well as of the packaging materials are listed in Table 7 to 11. The values are taken from ecoinvent (Ecoinvent EN 15804) and Vares (2005).

Table 7: Biogenic Carbon Content per Declared Unit [1 m³ raw HDF in 3.82 mm thickness and 816.64 kg/m³ atro Bulk density]

				Annahme C content = 0.51					
	raw HDF 1 m³			Spruce					
Average weight of a product	816.64	offcuts	kg	biogenic carbon content	Biogenic Carbon of product / packaging	Biogenic Carbon of offcuts for internal heat generation	**Biogenic CO_2 product**	**Biogenic CO_2 offcuts**	**Biogenic CO_2 packaging**
Hardwood (atro)	393,65	75,44	kg	0,51	200,76	38,48	736,12	141,08	
Softwood	260,24	49,88	kg	0,51	132,72	25,44	486,65	93,27	
Pine Wood	275,67	52,83	kg	0,51	140,59	26,95	515,51	98,80	
Wood Chips	0,43	0,08	kg	0,1432	0,06	0,01	0,23	0,04	
mUF Resin	68,59	13,15	kg	0	0,00		0,00	0,00	
UAN Hardener	7,13	1,37	kg	0	0,00		0,00	0,00	
Parafin emulsion	4,52	0,87	kg	0	0,00		0,00	0,00	
Urea	0,03	0,01	kg	0	0,00		0,00	0,00	
PET strips	0,10974		kg	0,00	0,00				0,00
Paper	0,04243		kg	0,24	0,01				0,04
Wooden legs_half impact	0,02926		kg	0,51	0,01				0,05
Total			kg		**4,74E+02 (product)**	**9,09E+01**	**1,74E+03**	**3,33E+02**	**9,21E-02**
			kg		**2,51E-02 (packaging)**				

The PERM and PENRM indicators of the modules A1 – A3 considers the packaging. Since it is disposed of in module A5 (which is not declared), the calorific values of the packaging materials are not considered in module C3.

The incineration of the raw HDF is considered in module C3. For the non-biogenic materials (adhesives), the dataset “waste emulsion paint (Europe without Switzerland, treatment of waste emulsion paint, municipal incineration)” is applied (Ecoinvent EN 15804). For the biogenic materials, the dataset “waste wood, untreated (RoW, treatment of waste wood, untreated, municipal incineration)” is applied (Ecoinvent EN 15804).

Table 8: Heating values for 1 m³ raw HDF

Position	Material	dry mass [kg]	lower heating value, measure on dry mass (hu MJ/kg)	Primary Energy [MJ]
Hardwood (atro)	PERM	318,203	17,5	5,57E+03
Softwood	PERM	210,365	15,35	3,23E+03
Pine Wood	PERM	222,839	15,35	3,42E+03
Wood Chips	PERM	0,347	15,35	5,32E+00
mUF Resin	PENRM	55,447	30,67	1,70E+03
UAN Hardener	PENRM	5,763	12,39	7,14E+01
Parafin emulsion	PENRM	3,651	12,39	4,52E+01
Urea	PENRM	0,021	12,39	2,66E-01
PET strips	PENRM	0,000110	20	2,20E-03
Paper	PERM	0,000042	13,5	5,67E-04
Wooden legs_half impact	PERM	0,000029	17,5	5,08E-04
Embodied renewable energy	PERM (A1)			1,22E+04
Embodied non-renewable- energy	PENRM (A1)			5,59E+00
Embodied renewable energy	PERM (A3)			1,07E-03
Embodied non-renewable- energy	PENRM (A3)			2,20E-03
Embodied renewable energy	PERM (A5)			-1,07E-03

Position	Material	dry mass [kg]	lower heating value, measure on dry mass (hu MJ/kg)	Primary Energy [MJ]
Embodied non-renewable- energy	PENRM (A5)			-2,20E-03
Embodied renewable energy	PERM (C3)			-1,22E+04
Embodied non-renewable- energy	PENRM (C3)			-5,59E+00

Table 9: Secondary calculation for 1 t raw HDF

Material	mass wet mass [t]	Total	mass [kg/m³]	mass offcuts [kg/m³]	Share [%]	mass [kg/m³]	mass offcuts [kg/m³]
Hardwood (atro)	393.6473	1010.26	816.636	193.62	38.97	318.20311	75.4441729
Softwood	260.2409				25.76	210.36462	49.8762725
Pine Wood	275.6724				27.29	222.83864	52.8337928
Wood Chips	0.4290				0.04	0.34675	0.0822119
mUF Resin	68.59				6.79	55.44695	13.146162
UAN Hardener	7.13				0.71	5.76324	1.36643258
Parafin emulsion	4.52				0.45	3.65078	0.86557851
Urea	0.03				0.00	0.02148	0.00509208

Table 10: Energy Export for 1 m³ raw HDF

Position	fraction	flow	mass	energy recovery [MJ/kg]	Exported Energy & Heat
GLO, treatment of waste wood, untreated, municipal incineration	Wood*	Energy	939.691	1.74	1.64E+03
GLO, treatment of waste wood, untreated, municipal incineration	Wood*	Heat	939.691	3.500	3.29E+03
_Europe without Switzerland, treatment of waste emulsion paint, municipal incineration	Hazardous Waste	Energy	64.882	1.13	7.33E+01
_Europe without Switzerland, treatment of waste emulsion paint, municipal incineration	Hazardous Waste	Heat	64.882	2.520	1.64E+02
Energy Exported Electricity (C3)		EEE			1.708E+03
Energy Exported Thermal (C3)		EET			3.452E+03

* According to the data set, 20 % moisture is included, but since atro was modelled here, a water correction factor of 1.25 is applied to the respective mass.

Table 11: Heating values offcuts for 1 m³ raw HDF

Position	Material	dry mass [kg]	lower heating value, measure on dry mass (hu MJ/kg)	Primary Energy [MJ]
Hardwood (atro)	PERM	75.44	17.50	1.32E+03
Softwood	PERM	49.88	15.35	7.66E+02
Pine Wood	PERM	52.83	15.35	8.11E+02
Wood Chips	PERM	0.08	15.35	1.26E+00
mUF Resin	PENRM	13.15	30.67	4.03E+02
UAN Hardener	PENRM	1.37	12.39	1.69E+01
Parafin emulsion	PENRM	0.87	12.39	1.07E+01
Urea	PENRM	0.01	12.39	6.31E-02
Embodied renewable energy	PERM (A1)			2.90E+03
Embodied non-renewable- energy	PENRM (A1)			1.33E+00
Embodied renewable energy	PERM (A3)			-2.90E+03
Embodied non-renewable- energy	PENRM (A3)			-1.33E+00

3.5 Requirements for Data Quality

The requirements listed in table 12 and 13 below illustrate the data quality requirements for the foreground processes of this study. The background system is evaluated in chapter 3.6. KRONOSPAN-MOFA Hungary Ltd provided all the necessary production-related data required for the development of the EPD for the analysed product. No allocations to by-products were necessary.
The data was reviewed for plausibility by the study team and, where needed, verified and adjusted in collaboration with KRONOSPAN-MOFA Hungary Ltd.

Table 12: Requirements for Data Quality - Foreground Processes

Material/Energy	Chemical designation / CAS	Survey	Representativeness		
		Measured / Calculated / Estimated	Time-based	Techno-logical	Geogra-phical
Ash		measured	2	1	1
Auxiliary and operating materials		measured	2	1	1
Auxiliary and operating materials (Output)		measured	2	1	1
Bark and wood dust/waste		measured	2	1	1
Bark and wood dust from BU1		measured	2	1	1
Dust during panel production		measured	2	1	1
dust during panel production, BU4		measured	2	1	1
Dust from BU3		measured	2	1	1
dust from gluing & fibre drying		measured	2	1	1
Electricity		measured	2	1	1
electricity recovery		Calculated	2	1	1
fibre by-product		measured	2	1	1
Fibre by-product from BU3		measured	2	1	1
Fire Wood		measured	2	1	1
Fire Wood_transported		Calculated	2	1	1
Fire Wood_Raw Material		measured	2	1	1
Flue ash	68131-74-8	measured	2	1	1
Glue		Calculated	2	1	1
Glue_transported		Calculated	2	1	1

Material/Energy	Chemical designation / CAS	Survey	Representativeness		
		Measured / Calculated / Estimated	Time-based	Techno-logical	Geogra-phical
Glued fibers		Calculated	2	1	1
hardwood		measured	2	1	1
HCHO	50-00-0	measured	2	1	1
HCHO (Input)	50-00-0	measured	2	1	1
HDF (MOFA) incineration waste		measured	2	1	1
HDF waste BU 5		measured	2	1	1
HDF waste BU 5 for heat production		measured	2	1	1
Heat		measured	2	1	1
heat recovery		Calculated	2	1	1
Lost wood		measured	2	1	1
Lost wood from BU1 for heat production		measured	2	1	1
metal strip waste		measured	2	1	1
mUF Resin		measured	2	1	1
Natural Gas	8006-14-2	measured	2	1	1
other waste from production		measured	2	1	1
Packaging material		Calculated	2	1	1
Paper		measured	2	1	1
Parafin emulsion		measured	2	1	1
PET strips		measured	2	1	1
pine wood		measured	2	1	1
raw HDF (MOFA)		measured	2	1	1
raw HDF (MOFA)_downstream		measured	2	1	1
raw HDF (MOFA)_packaged		Calculated	2	1	1
raw HDF (Step I)		Calculated	2	1	1
raw HDF (Step II)		Calculated	2	1	1
refiner water_input		measured	2	1	1
Refiner water_output		measured	2	1	1
Rejects during packaging		measured	2	1	1
rejects from BU 6		measured	2	1	1
Release agent		measured	2	1	1
Release agent (Output)		measured	2	1	1
Round wood		Calculated	2	1	1

Material/Energy	Chemical designation / CAS	Survey	Representativeness		
		Measured / Calculated / Estimated	Time-based	Techno-logical	Geogra-phical
Round wood_transported		Calculated	2	1	1
Saw dust during press and curing		measured	2	1	1
saw dust from BU 5		measured	2	1	1
Sludge from BU3		measured	2	1	1
Sludge from refiner water treatment BU3		measured	2	1	1
Sludge from the refiner water treatment BU2		measured	2	1	1
Small fraction		measured	2	1	1
Small fraction from BU1 for heat production		measured	2	1	1
Softwood		measured	2	1	1
Strech foil waste		measured	2	1	1
Transport		measured	2	1	1
Transport Downstream		Calculated	2	1	1
Transport of Rejects		measured	2	1	1
Transport of Waste/Rejects		measured	2	1	1
Transport_train		Calculated	2	1	1
Transported_Waste_raw HDF (MOFA)_downstream		measured	2	1	1
UAN Hardener		measured	2	1	1
Urea	57-13-6	measured	2	1	1
Vacuum-forming line waste from BU2		measured	2	1	1
Vacuum-forming line waste from BU2 for heat production		measured	2	1	1
VOC		measured	2	1	1
VOC (Input)		measured	2	1	1
Waste_raw HDF (MOFA)		measured	2	1	1
Waste_raw HDF (MOFA)_downstream		measured	2	1	1
Water_input	7732-18-5	measured	2	1	1
Water_output		measured	2	1	1
Water from chemicals	7732-18-5	Calculated	2	1	1

Material/Energy	Chemical designation / CAS	Survey	Representativeness		
		Measured / Calculated / Estimated	Time-based	Techno-logical	Geogra-phical
wood chips with bark		measured	2	1	1
wood fibers		measured	2	1	1
Wooden legs_half impact		Calculated	2	1	1

3.6 Selection and Data Quality of Background Data

The results are influenced not only by the specific product and production information in the foreground model but also significantly by the datasets used in the background model. To better contextualize the results, an evaluation of the datasets was carried out and is presented in Table 12 and 13.

For each dataset, the geographical coverage and the validity period are specified. These details are provided by the ecoinvent database (Ecoinvent EN 15804).

The two indicators, **Representativeness** and **Data Quality**, are based on the evaluation matrix for assessing data source quality from ecoinvent (Weidema, 2013). The **Data Quality** indicator evaluates how well the dataset represents the materials and technologies used.

The **Representativeness** indicator is an average of the categories *Reliability*, *Completeness*, *Geographical Correlation*, and *Further Technological Correlation*.

Overall, the data sets used are of good quality. All data sets were rated level 1, 2 or 3 (Table 13).

Table 13: Overview of the rating of the data sets

Rating	Time-based	Technological	Geographical
1	1	-	2
2	12	32	24
3	19	-	6
	32	32	32

Most of the data sets performed well in terms of temporal representativeness: one data set received the highest rating (indicator = 1) and twelve were rated ‘good’ (indicator = 2). Nineteen data sets were classified as ‘neutral’ (indicator = 3), including ‘market for transport, freight, trucks 16–32 tonnes, EURO6’, ‘market for lubricating oil’, ‘market for extrusion,

plastic film' and 'market for hazardous waste, for incineration'. None of the data sets were rated poorly (i.e. indicator = 4 or 5), indicating a solid overall foundation.

In terms of technological representativeness, all data sets were rated 'good' (indicator = 2).

In terms of geographical representativeness, two data sets were rated with the highest score (indicator = 1). Twenty-four data sets are considered 'good' (indicator = 2) and six are considered 'neutral' because data sets with geographical references RER, RoW and GLO were used.

Table 14: Overview Data Quality - Background Processes

Material/ Energy	Chemical designation / CAS	Name Data set	Database	Time Period	Representativeness			
					Time-based	Tech no-logical	Geographical	
Ash	68131-74-8	market for wood ash mixture, pure	ecoinvent-en15804-3.10 (Rev. 1)	2010-2023	3	2	Europe without Switzerland	2
Auxiliary and operating materials_not transported		lubricating oil production	ecoinvent-en15804-3.10 (Rev. 1)	2000-2023	3	2	RER	2
Electricity		electricity, medium voltage, residual mix	ecoinvent-en15804-3.10 (Rev. 1)	2022-2023	1	2	HU	1
electricity recovery		market for electricity, medium voltage	ecoinvent-en15804-3.10 (Rev. 1)	2020-2023	2	2	HU	1
Fire wood		market for wood pellet, measured as dry mass	ecoinvent-en15804-3.10 (Rev. 1)	2019-2024	2	2	RER	2
hardwood		hardwood forestry, oak, sustainable forest management	ecoinvent-en15804-3.10 (Rev. 1)	2010-2023	3	2	RoW	2

Material/ Energy	Chemical designation / CAS	Name Data set	Database	Time Period	Representativeness			
					Time-based	Tech no-logical	Geographical	
hardwood		hardwood forestry, beech, sustainable forest management	ecoinvent-en15804-3.10 (Rev. 1)	2010-2023	3	2	RoW	2
hardwood		market for pulpwood, hardwood, measured as solid wood under bark	ecoinvent-en15804-3.10 (Rev. 1)	2019-2023	2	2	RoW	2
HDF (MOFA) incineration waste		treatment of waste wood, untreated, municipal incineration	ecoinvent-en15804-3.10 (Rev. 1)	2006-2022	3	2	GLO	3
HDF (MOFA) incineration waste		treatment of waste emulsion paint, municipal incineration	ecoinvent-en15804-3.10 (Rev. 1)	2006-2023	3	2	Europe without Switzerland	2
heat recovery		market for heat, district or industrial, other than natural gas	ecoinvent-en15804-3.10 (Rev. 1)	2011-2023	3	2	Europe without Switzerland	2
Internal Transport		market for transport, freight, lorry 16-32 metric ton, EURO6	ecoinvent-en15804-3.10 (Rev. 1)	2009-2023	3	2	RER	2
metal strip waste		market for ferrous metal, in mixed metal scrap	ecoinvent-en15804-3.10 (Rev. 1)	2012-2023	3	2	Europe without Switzerland	2
mUF Resin		market for melamine urea formaldehyde adhesive	ecoinvent-en15804-3.10 (Rev. 1)	2010-2023	3	2	GLO	3

Material/ Energy	Chemical designation / CAS	Name Data set	Database	Time Period	Representativeness			
					Time-based	Tech no-logical	Geographical	
Natural Gas	8006-14-2	market group for heat, central or small-scale, other than natural gas	ecoinvent-en15804-3.10 (Rev. 1)	2016-2023	3	2	RoW	3
Oil as a release agent		market for lubricating oil	ecoinvent-en15804-3.10 (Rev. 1)	2011-2023	3	2	RER	2
other waste from production		market for hazardous waste, for incineration	ecoinvent-en15804-3.10 (Rev. 1)	2011-2023	3	2	Europe without Switzerland	2
Paper		market for paper, woodcontaining, lightweight coated	ecoinvent-en15804-3.10 (Rev. 1)	2000-2023	3	2	RER	2
Parafin emulsion		market for paraffin	ecoinvent-en15804-3.10 (Rev. 1)	2011-2023	3	2	GLO	3
PET strips		market for polyethylene terephthalate, granulate, amorphous	ecoinvent-en15804-3.10 (Rev. 1)	2011-2023	3	2	GLO	3
Pine wood (logs)		market for pulpwood, softwood, measured as solid wood under bark	ecoinvent-en15804-3.10 (Rev. 1)	2019-2023	2	2	Europe without Switzerland	2
refiner water_output		Market for wastewater, average	ecoinvent-en15804-3.10 (Rev. 1)	2010-2024	2	2	Europe without Switzerland	2

Material/ Energy	Chemical designation / CAS	Name Data set	Database	Time Period	Representativeness			
					Time-based	Tech no-logical	Geographical	
refiner water_output		treatment of wastewater, average, wastewater treatment	ecoinvent-en15804-3.10 (Rev. 1)	2006-2022	3	2	Europe without Switzerland	2
Rejects during packaging		market group for waste wood, untreated	ecoinvent-en15804-3.10 (Rev. 1)	2018-2023	2	2	Europe without Switzerland	2
softwood		softwood forestry, mixed species, sustainable forest management	ecoinvent-en15804-3.10 (Rev. 1)	2010-2023	3	2	CH	2
Strech foil waste		market group for waste plastic, mixture	ecoinvent-en15804-3.10 (Rev. 1)	2018-2023	2	2	RER	2
Transport_train		market group for transport, freight train	ecoinvent-en15804-3.10 (Rev. 1)	2015-2023	2	2	RER	2
UAN Hardener		market for chemical, inorganic	ecoinvent-en15804-3.10 (Rev. 1)	2011-2023	3	2	GLO	3
Urea		market for urea	ecoinvent-en15804-3.10 (Rev. 1)	2016-2023	2	2	RER	2
Water	7732-18-5	market group for tap water	ecoinvent-en15804-3.10 (Rev. 1)	2015-2023	2	2	RER	2
wood chips with bark		market for bark chips, wet, measured as dry mass	ecoinvent-en15804-3.10 (Rev. 1)	2019-2023	2	2	Europe without Switzerland	2

Material/ Energy	Chemical designation / CAS	Name Data set	Database	Time Period	Representativeness			
					Time-based	Tech no-logical	Geographical	
Wooden legs		market for EUR-flat pallet	ecoinvent-en15804-3.10 (Rev. 1)	2019-2023	2	2	RER	2

Table 15: Requirements for Data Quality - Background Processes

	Background Processes
Data quality	The background processes are modelled using ecoinvent EN15804 3.10 (Rev. 1)
Time related coverage	All datasets are taken from the most recent ecoinvent EN15804 3.10 (Rev. 1) version. Here, all datasets are representative for current production technologies.
Geographical coverage	Background materials are modelled corresponding with the affected geography, if available. If no information available a global dataset was used.
Technological coverage	Average technology is selected in ecoinvent if different technologies are available.
Precision of data	Measured and validated data.
Completeness	All relevant processes regarding material and energy input are covered. Furthermore, there are no inputs or outputs with environmental significance neglected.
Representativeness	Time related, geographical and technological coverage met.
Consistency	System model cut-off applied, unless stated otherwise.
Reproducibility	Transparent modelling including all assumptions and underlying data in order to enable reproducibility of the results.
Sources	Are transparently provided and documented
Uncertainty of the information	Addressed individually.

4 Collection of the Operating Data

4.1 Data Collection

For the study on raw HDF, a detailed inventory with the input and output quantities was compiled in accordance with ISO 14044, section 4.3.2.

The data was collected for the period from 01.10.2022 to 30.09.2023. The period is to be considered representative, as it covers both winter and summer months, which means that heat generation at the site includes both favorable and unfavorable weather conditions. During the period under review, a total of 68,353 m³ of raw HDF was produced.

KRONOSPAN-MOFA Hungary Ltd. provided specific production process data for the collection of foreground data. The site is organized with the help of a certified management system from ISO 14001:2015 (see appendix on IBU platform). The collection and evaluation of environmental data are subject to a continuous improvement process and regularly audited. There were no complaints during the last external audit. The data collection process is considered valid.

The quality of the foreground data was assessed in accordance with the criteria of PCR Part A, Annex 2.

Generic background data from the ecoinvent EN 15804 database, version 3.10 (Rev. 1), was used to model the upstream and downstream processes. The data sets were available in ILCD format and were checked for plausibility in accordance with the requirements of PCR Part A, Chapter 7.4.

The quality of the background data was assessed in accordance with DIN EN 15804, Table 14.

The specific data collection is documented in chapter 3.5 and 3.6.

4.1.1 Bill of Material Data

For the raw HDF production, a detailed inventory was provided along with the mass of each ingredient / material. KRONOSPAN-MOFA Hungary Ltd. provided this data system. This primary data was mapped to datasets in the ecoinvent EN 15804 3.10 (Rev. 1) database. The overview with all datasets mapped can be found in Appendix A.

4.1.2 Packaging Data

Packaging data is based on a specific system breakdown for the raw HDF. Packaging consists of the primary packaging of the product and secondary packaging for transportation to the installation sites.

4.1.3 Transport

Distances for the raw material transport were identified based on the supplier location and the production site in Hungary. The distances are listed in table 16.

4.1.4 Transport Downstream

The downstream transport is considered in module C2. No primary data is available for downstream transport. However, in order to take this into account, transport information from the ecoinvent dataset “market for waste wood, untreated [DE]” was used. This indicates an average transport of 0.0684 tkm/kg, which corresponds to 68.4 km.

4.1.5 Losses and Wastes

Rejects and wastes incur during the processes raw material supply, crushing & fibre preparation, gluing & fibre drying, panel production, cutting, lacquering and packaging of the final product. At the production site heat is produced in a self-owned central biomass heater and gas boiler system. Utilisable materials are directly used for internal heat production and do not leave the system boundaries. According to PCR A they are not considered for the MER indicator. They reach the end of waste state, but have an irrelevant economic value. Their biogenic carbon content is documented in Table 7.

The waste of the final product at the end of life occuring in module C3 is treated by incineration with energy recovery. The raw HDF is considered as a non-hazardous waste according to EWC: 03 01 05.

The transport and the packaging waste in module A5 is not declared.

4.2 Calculation Method

The method “Environmental Footprint 3.1” which is developed by the European Union is used for the life cycle impact assessment indicators. The standard GWP calculation is adapted to the EN 15804 requirement which includes biogenic carbon dioxide uptake and emissions and biogenic carbon stored in the product. Additionally, the indicators required in EPDs are provided by the ecoinvent EN 15804 system model.

4.3 Criteria for the Exclusion of Inputs and Outputs and their Application

The cut-off criteria according to EN 15804 which requires a minimum of 95 % of total inflows (mass and energy) is applied. There are no known cut-offs.

4.4 Income from Operations Data Collection

All raw materials which are needed to produce the raw HDF are included in the LCI based on primary data from KRONOSPAN-MOFA Hungary Ltd. (100 % mass inflows). Electricity consumption is determined based on the equipment involved in the production chain. Transports are modelled material specific for the raw materials and product specific for the downstream transport. Rejects are measured for the manufacturing phase and waste treatment is considered.

The site has a certified integrated management system based on ISO 14001. The collection and evaluation of environmental data are subject to a continuous improvement process and regularly audited.

5 Presentation of the Unit Processes

The modelling was conducted using the sustainability software tool Umberto 11 (version 11.13 Rev. 1), developed by iPoint-systems. A Sankey diagram of the model is shown below in Figure 2 and 3.

There are two main objects: places and processes. The green and red round circles, called places, represent the system boundary. Material and energy flows coming from a green place are entering the system boundary, while flows going to the red place are leaving the system boundary. Yellow places symbolize a connection between two processes, which are illustrated as black framed squares. Each process represents the actual manufacturing step to produce the raw HDF. Arrows respresent the flows of inputs and outputs and point to their direction. The thickness of the arrow corresponds to the quantity for the respective unit type and follows the Sankey approach.

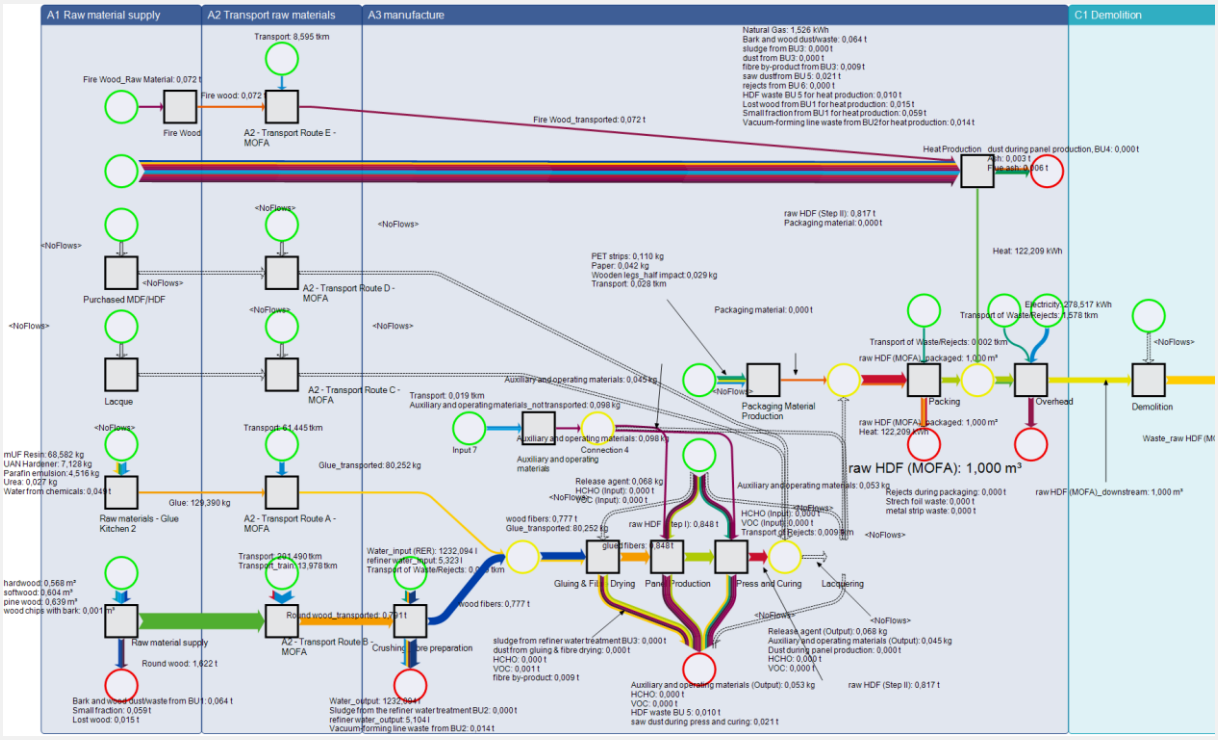

Figure 2: Umberto Model of raw HDF - Part 1

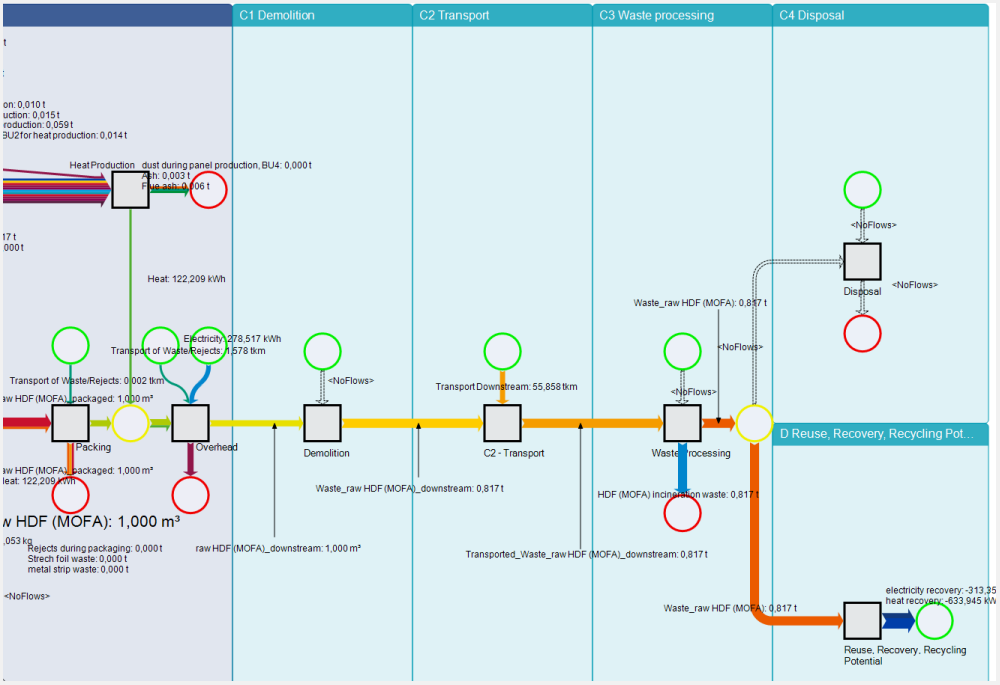

Figure 3: Umberto Model of raw HDF – Part 2

The assignment of the provided data to datasets of the ecoinvent EN 15804 3.10 (Rev. 1) database is documented in Table 16 in Appendix A. All input and output data as well as the packaging materials and the transport distances are given in 16 to Table 18.

Table 16: Life Cycle Inventory in Umberto – Raw Data for 1 m³ raw HDF*

Process	Input	Output	Unit
Raw material supply			
hardwood	5.680E-01		m³
softwood	6.044E-01		m³
pine wood	6.387E-01		m³
wood chips with bark	9.560E-04		m³
Bark and wood dust/waste from BU1		6.430E-02	t
Small fraction		5.907E-02	t
Lost wood		1.537E-02	t
Round wood_transported		7.910E-01	t
A2 Transport Route B - Mofa			
Round wood	1.622E+00		t
Transport	2.015E+02		tkm
Transport_train	1.398E+01		tkm
Crushing_fibre preparation**			
Round wood_transported	7.910E-01		t
Water_input	1.232E+03		l
refiner water_input	5.323E+00		l
Transport of Waste/Rejects	3.912E-02		tkm
Water_output		1.232E+03	l

Process	Input	Output	Unit
refiner water_output		5.104E+00	l
Sludge from the refiner water treatment BU2		2.194E-04	t
Vacuum-forming line waste from BU2		1.441E-02	t
Wood fibres		7.770E-01	t
Raw materials - Glue Kitchen 2			
mUF Resin	6.858E+01		kg
UAN Hardener	7.128E+00		kg
Parafin emulsion	4.516E+00		kg
Urea	2.656E-02		kg
Water from chemicals	4.914E-02		t
Glue		1.294E+02	kg
A2 Transport Route A - Mofa			
Glue	1.294E+02		kg
Transport	6.144E+01		tkm
Glue_transported		8.025E+01	kg
Gluing & Fibre Drying			
Wood fibres	7.770E-01		t
Glue_transported	8.025E+01		kg
sludge from refiner water treatment BU3		2.194E-04	t
dust from gluing & fibre drying		7.461E-05	t
HCHO		6.437E-05	t
VOC		8.354E-04	t
fibre by-product		8.734E-03	t
glued fibres		8.480E-01	t
Auxiliary and operating materials			
Auxiliary and operating materials_not transported	9.801E-02		kg
Transport	1.941E-02		tkm
Auxiliary and operating materials		9.800E-02	kg
Panel Production			
glued fibres	8.480E-01		t
Release agent	6.818E-02		kg
Release agent (Output)		6.818E-02	kg
Auxiliary and operating materials		4.532E-02	kg
Dust during panel production		8.778E-06	t
HCHO (Input)	5.852E-06		t
HCHO		5.852E-06	t
VOC (Input)	3.657E-05		t
VOC		3.657E-05	t
raw HDF (Step I)		8.480E-01	t
Press and Curing			
raw HDF (Step I)	8.480E-01		t
Auxiliary and operating materials	5.268E-02		kg
HCHO (Input)	5.852E-06		t

Process	Input	Output	Unit
HCHO		5.852E-06	t
VOC (Input)	3.657E-05		t
VOC		3.657E-05	t
Transport of Rejects	9.377E-03		tkm
HDF waste BU 5		1.019E-02	t
saw dust during press and curing		2.119E-02	t
raw HDF (Step II)		8.170E-01	t
Fire Wood			
Fire Wood_Raw Material	7.162E-02		t
A2 – Transport Route E - Mofa			
Transport	8.595E+00		tkm
Fire Wood_transported		7.200E-02	t
Heat Production* **			
Natural Gas	1.526E+00		kWh
Fire Wood_transported	7.200E-02		t
Bark and wood dust/waste	6.430E-02		t
sludge from BU3	2.194E-04		t
dust from BU3	7.461E-05		t
fibre by-product from BU3	8.734E-03		t
dust during panel production, BU4	8.778E-06		t
saw dust from BU 5	2.119E-02		t
HDF waste BU 5 for heat production	1.019E-02		t
rejects from BU 6	2.721E-05		t
Lost wood from BU1 for heat production	1.537E-02		t
Small fraction from BU1 for heat production	5.907E-02		t
Vacuum-forming line waste from BU2 for heat production	1.441E-02		t
Ash		2.995E-03	t
Flue ash		5.871E-03	t
Heat		1.222E+02	kWh
Overhead			
Electricity	2.785E+02		kWh
Transport of Waste/Rejects	1.578E+00		tkm
Reuse, Recovery, Recycling Potential			
electricity recovery		-3.837E+02	kWh
heat recovery		-7.763E+02	kWh
C2 - Transport			
Transport Downstream	5.586E+01		tkm
Waste Processing			
HDF (MOFA) incineration waste		8.166E-01	t

* The table 16 and 17 reflects the model values within Umberto. The life cycle inventory of the raw data is shown in section 2.5.

** Between raw material supply and crushing fiber preparation the transportation takes place. The transportation is considered for lutro tonnes, the values for manufacturing are measured for atro tonnes. The conversion from lutro to atro tonnes is not reflected in this table.

*** The internal material flows that flow into the heat supply do not appear in the mapping. They flow into the model as primary data.

Table 17: Life Cycle Inventory - Packaging Material

Process	Input	Output	Unit
Packaging Material Production			
PET strips	1.097E-01		kg
Paper	4.243E-02		kg
Wooden legs_half impact	2.926E-02		kg
Transport	2.827E-02		tkm
Packing			
Transport of Waste/Rejects	1.975E-03		tkm
Rejects during packaging		2.721E-05	t
Strech foil waste		1.463E-05	t
metal strip waste		2.926E-05	t

Table 18: Transport Distances*

Entry	Distance Truck [km]	Distance Rail [km]
hardwood	133	131
softwood	133	131
pine wood	133	131
wood chips with bark	133	131
mUF Resin	476	
UAN Hardener	476	
Paraffin emulsion	460	
Urea	476	
Wooden legs	240	
PET strips	119	
Paper	193	
Fire Wood	145	
sludge (Output BU 2)	178	
stretch foil waste (Output BU 6)	45	
metal strip waste (Output BU 6)	45	

Entry	Distance Truck [km]	Distance Rail [km]
Ash (Output BU 8)	178	
Flue ash (Output BU 8)	178	
Downstream Transport	68.4	

* As the internal transport distances for the production of the raw HDF are only a few metres due to an optimised plant concept, internal transport routes are not considered.

6 Life Cycle Inventory and Impact Assessment

6.1 Indicators for Inventory Analysis in Accordance with /DIN EN 15804/

RESULTS OF THE LCA - RESOURCE USE according to EN 15804+A2: 1 m³ raw HDF in 3.82 mm thickness											
Indicator	**Indicator***	**Unit**	**A1**	**A2**	**A3**	**A1-A3**	**C1**	**C2**	**C3**	**C4**	**D**
PERE	Renewable primary energy as energy carrier	[MJ]	3.945E+03	1.358E+01	3.050E+03	7.002E+03	0	2.562E+00	1.315E+01	0	1.891E+04
PERM	Renewable primary energy resources as material utilization	[MJ]	1.512E+04	0.000E+00	-2.897E+03	1.222E+04	0	0.000E+00	-1.222E+04	0	-1.950E+04
PERT	Total use of renewable primary energy resources	[MJ]	1.906E+04	1.358E+01	1.534E+02	1.922E+04	0	2.562E+00	1.315E+01	0	-5.895E+02
PENRE	Non-renewable primary energy as energy carrier	[MJ]	4.420E+03	7.349E+02	3.262E+03	8.417E+03	0	1.493E+02	2.336E+02	0	-4.875E+03
PENRM	Non-renewable primary energy as material utilization	[MJ]	6.914E+00	0.000E+00	-1.325E+00	5.589E+00	0	0.000E+00	-5.589E+00	0	0.000E+00
PENRT	Total use of non-renewable primary energy resources	[MJ]	4.420E+03	7.349E+02	3.262E+03	8.417E+03	0	1.493E+02	2.336E+02	0	-4.875E+03
SM	Use of secondary material	[kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.00E+00
RSF	Use of renewable secondary fuels	[MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.00E+00
NRSF	Use of non-renewable secondary fuels	[MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.00E+00
FW**	Use of net fresh water	[m³]	7.40E+00	1.02E-01	2.60E+00	1.01E+01	0	2.01E-02	1.57E+00	0	-2.69E+00
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										

	* The energy-related indicators are calculated in relation to the atro mass of the combustible components using the corresponding calorific values as stated in Table 7 to 11. ** Considered background datasets include use of net fresh water in the upstream chain. Water is also used to clean the wood fibres (it is circulated).

RESULTS OF THE LCA – OUTPUT FLOWS AND WASTE CATEGORIES according to EN 15804+A2: 1 m³ raw HDF in 3.82 mm thickness

Indicator	Indicator	Unit	A1	A2	A3	A1-A3	C1	C2	C3	C4	D
HWD	Hazardous waste disposed	[kg]	2.147E+01	1.103E+00	5.341E+00	2.791E+01	0	2.177E-01	6.363E+01	0	-1.880E+01
NHWD	Non-hazardous waste disposed	[kg]	4.102E+02	2.346E+01	4.036E+02	8.373E+02	0	4.599E+00	1.026E+03	0	-8.897E+02
RWD	Radioactive waste disposed	[kg]	2.381E-03	2.602E-04	2.386E-02	2.650E-02	0	4.811E-05	2.135E-04	0	-2.588E-02
CRU	Components for re-use	[kg]	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0	0.000E+00	0.000E+00	0	0.000E+00
MFR	Materials for recycling	[kg]	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0	0.000E+00	0.000E+00	0	0.000E+00
MER	Materials for energy recovery*	[kg]	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0	0.000E+00	0.000E+00	0	0.000E+00
EEE	Exported electrical energy**	[MJ]	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0	0.000E+00	1.708E+03	0	0.000E+00
EET	Exported thermal energy***	[MJ]	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0	0.000E+00	3.452E+03	0	0.000E+00

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 *Weight of product at end of life for incineration (R>0.6) entered in C3. **Combustion of rejects / internal heat production (R>0.6) with irrelevant economic value; biogenic carbon content of wastes for incineration declared in chapter 3.4.2. ***Waste is generated during production in A3 and is thermally utilised at the site. Energy is therefore recovered. The quantity in MJ is therefore entered in C3.

6.2 Indicators of impact assessment in accordance with /DIN EN 15804/

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT according to EN 15804+A2: 1 m³ raw HDF in 3.82 mm thickness											
Core Indicator	**Core Indicator**	**Unit**	**A1**	**A2**	**A3**	**A1-A3**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-total	Global warming potential total	[kg CO_2-Eq.]	-1,78E+03	5,23E+01	4,50E+02	-1,28E+03	0	1,06E+01	1,88E+03	0	-2,79E+02
GWP-fossil	Global warming potential fossil fuels	[kg CO_2-Eq.]	2,85E+02	5,22E+01	1,16E+02	4,54E+02	0	1,06E+01	1,43E+02	0	-2,78E+02
GWP-biogenic	Global warming potential biogenic	[kg CO_2-Eq.]	-2,07E+03	3,95E-02	3,34E+02	-1,74E+03	0	7,16E-03	1,74E+03	0	-1,16E+00
GWP-luluc	GWP from land use and land use change	[kg CO_2-Eq.]	1.626E+00	1.796E-02	1.907E-02	1.663E+00	0	3.529E-03	8.138E-03	0	-1.654E-01
ODP	Depletion potential of the stratospheric ozone layer	[kg CFC11-Eq.]	4.159E-06	1.035E-06	4.779E-06	9.974E-06	0	2.110E-07	3.480E-07	0	-3.778E-06
AP	Acidification potential of land and water	[mol H+-Eq.]	1.496E+00	1.122E-01	3.774E-01	1.985E+00	0	2.210E-02	1.700E-01	0	-1.810E+00
EP-freshwater	Eutrophication aquatic freshwater	[kg PO_4-Eq.]	8.657E-02	3.694E-03	7.779E-02	1.681E-01	0	7.187E-04	8.336E-03	0	-1.817E-01
EP-marine	Eutrophication aquatic marine	[kg N-Eq.]	2.985E-01	2.761E-02	8.668E-02	4.128E-01	0	5.308E-03	7.958E-02	0	-2.615E-01
EP-terrestrial	Eutrophication terrestrial	[mol N-Eq.]	3.604E+00	2.978E-01	7.796E-01	4.681E+00	0	5.727E-02	7.764E-01	0	-2.558E+00
POCP	Formation potential of tropospheric ozone photochemical oxidants	[kg NMVOC-Eq.]	1.360E+00	1.843E-01	5.717E-01	2.116E+00	0	3.673E-02	2.101E-01	0	-8.378E-01
ADPE	Abiotic depletion potential for non-fossil resources	[kg Sb-Eq.]	2.320E-03	1.735E-04	1.806E-04	2.674E-03	0	3.530E-05	1.073E-04	0	-2.306E-04

Core Indicator	Core Indicator	Unit	A1	A2	A3	A1-A3	C1	C2	C3	C4	D
ADPF	Abiotic depletion potential for fossil resources	[MJ]	4.415E+03	7.349E+02	3.262E+03	8.412E+03	0	1.493E+02	2.336E+02	0	-4.875E+03
WDP	Water (user) deprivation potential	[m³ world-Eq deprived]	3.196E+02	3.719E+00	4.201E+01	3.653E+02	0	7.299E-01	8.363E+01	0	-6.999E+01

RESULTS OF THE LCA – additional impact categories according to EN 15804+A2-optional: 1 m³ raw HDF in 3.82 mm thickness

Indicator	Indicator	Unit	A1	A2	A3	A1-A3	C1	C2	C3	C4	D
PM	Potential incidence of disease due to PM emissions	[Disease Incidence]	2.406E-05	3.853E-06	2.234E-06	3.015E-05	0	7.814E-07	1.936E-06	0	-1.575E-05
IR	Potential Human exposure efficiency relative to U235	[kBq U235-Eq.]	9.543E+00	1.044E+00	1.001E+02	1.107E+02	0	1.936E-01	8.248E-01	0	-1.086E+02
ETP-fw	Potential comparative toxic unit for ecosystems	[CTUe]	3.433E+03	2.023E+02	6.374E+02	4.273E+03	0	4.065E+01	2.530E+03	0	-6.113E+02
HTP-c	Potential comparative toxic unit for humans	[CTUh]	4.875E-06	3.751E-07	1.238E-06	6.488E-06	0	7.536E-08	2.668E-07	0	-3.822E-07
HTP-nc	Potential comparative toxic unit for humans	[CTUh]	2.622E-06	4.750E-07	4.771E-06	7.868E-06	0	9.662E-08	1.566E-06	0	-2.256E-06
SQP	Potential soil quality index	[-]	8.208E+04	4.442E+02	6.090E+02	8.313E+04	0	9.015E+01	1.276E+02	0	-1.760E+03

The characterisation factors (CF) published in EN 15804:2012+A1 (October 2013) (Annex C) were used to calculate the impact categories. Long-term emissions > 100 years are not considered in the impact assessment. The impact assessment results are only relative statements that make no statements about endpoints of the impact categories, exceedance of threshold values, safety margins or risks.

Table 19: Classification of disclaimers of the declaration of core and additional environmental impact indicators

ILCD classification	Indicators	Disclaimer
ILCD type 1	Global warming potential (GWP)	none
	Depletion potential of the stratospheric ozone layer (ODP)	none
	Potential incidence of disease due to PM emissions (PM)	none
ILCD type 2	Acidification potential, Accumulated Exceedance (AP)	none
	Eutrophication potential, Fraction of nutrients reaching freshwater end compartment (EP-freshwater)	none
	Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)	none
	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	none
	Formation potential of tropospheric ozone (POCP)	none
	Potential Human exposure efficiency relative to U235 (IRP)	1
ILCD type 3	Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	2
	Abiotic depletion potential for fossil resources (ADP-fossil)	2
	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	2
	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	2
	Potential Comparative Toxic Unit for humans (HTTP-c)	2
	Potential Comparative Toxic Unit for humans (HTTP-nc)	2
	Potential Soil quality index (SQP)	2
Disclaimer 1 - This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.		
Disclaimer 2 - The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.		

7 Interpretation

7.1 Indicators of the Life Cycle Inventory

A dominance analysis was carried out to improve the interpretation of the life cycle assessment results. This analysis determines the relevant influences of individual categories in the separate impact categories. The following figure 4 shows the relative contributions of various life cycle processes of the impact categories GWP, ODP, AP, EP, POCP, ADP-elem. and ADP-fossil of the modules A1: Raw material supply, A2: Transport of intermediate products, A3: Manufacturing, C1: Demolition, C2: Transport during disposal, C3-4: Disposal, and D: Credits (avoided environmental impacts in the other system).

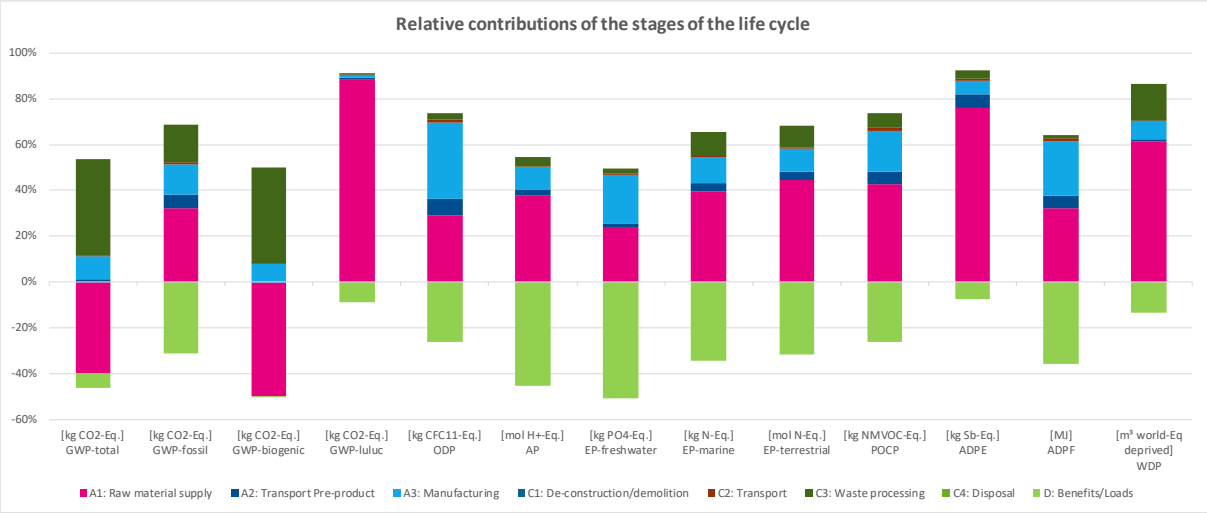

Figure 4: Relative contributions of life cycle processes to the impact categories for 1 m³ of raw HDF

The impact categories throughout the raw HDF life cycle are mainly determined by the supply of raw materials. A key driver here is the use of raw materials, which account for approximately 78 % of the GWP within production (A1-3). As the largest driver, manufacturing contributes 20 % to the GWP, while transport accounts for only a marginal share of around 2 % of the GWP.

In terms of global warming potential (GWP), manufacturing accounts for 20 % of the total within production (A1-3), followed by the raw materials themselves (A1) with 78 %. Transportation (A2) contributes 2 % to the GWP.

The picture is similar for ozone depletion potential (ODP): the ODP factor is determined by raw materials, which account for 42 %. Manufacturing contributes 48 % to the ODP value, while transportation contributes 10 %.

Acidification potential (AP) is influenced by raw material supply (75 %), manufacturing (19 %), and transportation (6 %).

The eutrophication potential (EP) is mainly determined by the precursor products: approx. 52 % (EP freshwater), 72 % (EP saltwater) and 77 % EP terrestrial, followed by transport 2 % (EP freshwater), 7 % (EP-saltwater) and 6 % (EP-terrestrial) and manufacturing with 46 % (EP-freshwater), 21 % (EP-saltwater) and 17 % (EP-terrestrial).

Approximately 64 % of the photochemical oxidant potential (POCP) is dominated by the precursor products. A further 9 % and 27 % are attributable to transport and manufacturing in A2 and A3.

Abiotic resource consumption (ADP elemental) is almost exclusively determined by raw material provision (87 %), with approximately 6 % attributable to the transport of precursor products and 7 % manufacturing.

Abiotic resource consumption (ADP fossil) within production (A1–3) results predominantly from pre-products (approx. 52 %), transport (approx. 9 %) and manufacturing (approx. 39 %).

7.2 Indicators of the impact assessment

Within the cradle-to-gate system boundary (A1-3), the total primary energy demand is divided between approximately 70 % from non-renewable energy sources and approximately 30 % from renewable energies.

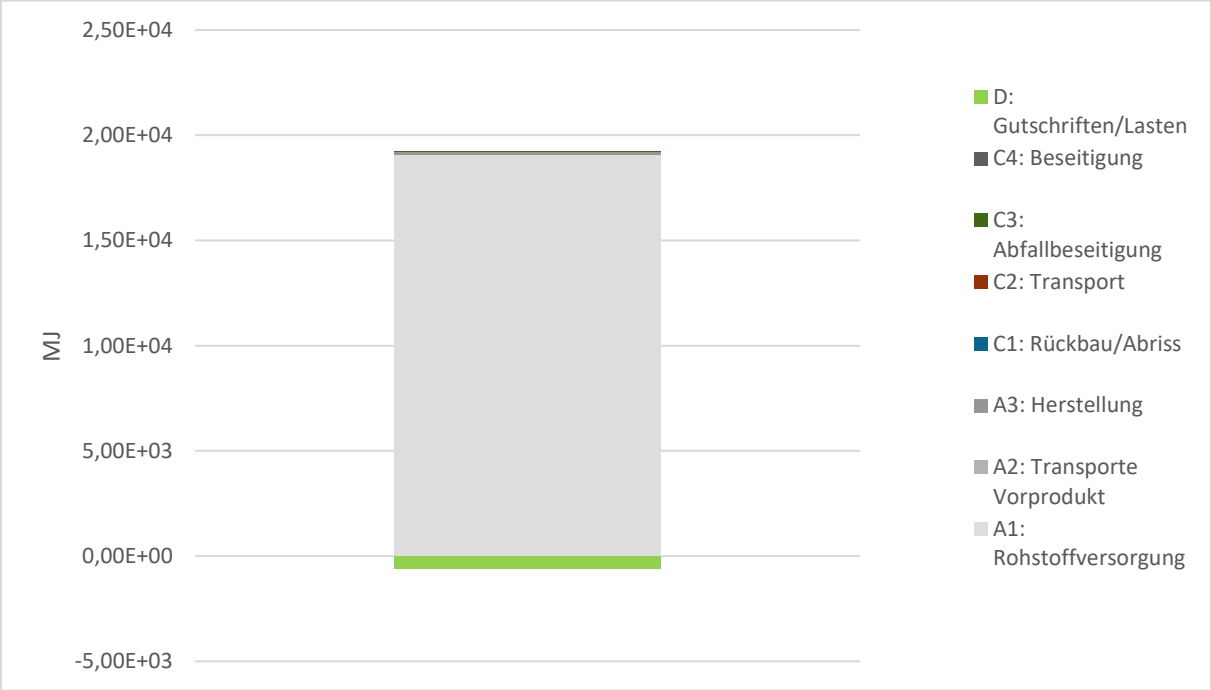

Figure 5: Contribution by Life Cycle Phase

When considering the total renewable primary energy demand (PERT) in A1 to A3, the preliminary products account for just under 99.17 % and the energy required for production accounts for approximately 0.8 %.

7.3 Documentation of the data quality

The results show the highest impacts in modules A1 - A3. Here. the weights for the LCI of the raw materials which are used in the product are specific primary data from the production processes. The background data for the raw materials is taken from the database version of ecoinvent EN15804 3.10 (Rev. 1) as no primary data is available. The most relevant materials could at least be mapped directly to a corresponding dataset and only to a minor extent assumption had to be made for the mapping. The transport distances of module A2 were provided as primary data.

For the downstream processes in the modules C1 – D KRONOSPAN-MOFA Hungary Ltd. provided the type of waste treatment. The transport distance of module C2 is based on secondary data. The background data is taken from ecoinvent EN 15804 3.10 (Rev. 1). There

are no known emissions in module C1. The raw HDF is removed manually so no efforts arise during the demolition (module C1).

Requirements and assessment of data quality are discussed in detail in chapters 3.5 (foreground data) and 3.6 (background data).

7.4 Sensitivity Analysis

A sensitivity analysis in Table 19 was carried out to evaluate the influence of product thickness on the environmental impacts reported in this EPD. The analysis considered a panel product with three different volume scenarios:

Dispensing width of raw HDF [mm]	Impact on the declared unit [m³]
2	0,524
3,82	**1,000**
8	2,094

In this analysis, all material inputs and associated outputs were adjusted proportionally to the ratio of the respective volume to the average case. A constant material density of 816.64 kg/m³ was assumed across all scenarios. Therefore, changes in thickness directly correspond to proportional changes in product mass. The packaging processes was kept constant across all scenarios, as these components were considered independent of panel thickness.

The core environmental impact indicators were calculated for all scenarios in accordance with EN 15804, covering the product stage (A1–A3), end-of-life stages (C1–C4), and module D.

The results demonstrate that most environmental impacts scale almost linearly with the product thickness. This effect is most pronounced in the A1–A3 stages, where material production is the dominant contributor.

For thicker panels (8 mm), higher environmental impacts were calculated across nearly all indicators, due to increased material consumption based on the constant density assumption.

For thinner panels (2 mm), lower environmental impacts were observed accordingly.

As packaging remained constant, their relative contribution to the total impacts increased for thinner panels and decreased for thicker ones. This results in a slight deviation from purely linear scaling.

Compared to the average raw HDF (1 m³ LHDF in 3,82 mm layer thickness), the results of the 1 m³ raw HDF in 2 mm fluctuate -47.6 % across the life cycle. The results of the 1 m³ raw HDF in 8 mm fluctuate between + 109.3 % across the life cycle.

Table 20: Classification of disclaimers of the declaration of core and additional environmental impact indicators

		2 mm							Average						8 mm						
Core Indicator	Unit	A1-A3	C1	C2	C3	C4	D	Deviation 2 mm / average (excluding D)	A1-A3	C1	**C2**	**C3**	**C4**	**D**	**A1-A3**	**C1**	**C2**	**C3**	**C4**	**D**	**Deviation 8 mm / average (excluding D)**
GWP-total	[kg CO2-Eq.]	-6,71E+02	0	5,57E+00	9,85E+02	0	-1,46E+02	-47,6%	-1,28E+03	0	1,062E+01	1,88E+03	0	-2,790E+02	-1,40E+03	0	2,22E+01	2,06E+03	0	-5,84E+02	109,4%
GWP-fossil	[kg CO2-Eq.]	2,38E+02	0	5,56E+00	7,51E+01	0	-1,46E+02	-47,6%	4,54E+02	0	1,061E+01	1,43E+02	0	-2,777E+02	9,50E+02	0	2,22E+01	3,00E+02	0	-5,82E+02	109,4%
GWP-biogenic	[kg CO2-Eq.]	-9,12E+02	0	3,75E-03	9,12E+02	0	-6,06E-01	-47,6%	-1,74E+03	0	7,163E-03	1,74E+03	0	-1,156E+00	-1,90E+03	0	1,50E-02	1,90E+03	0	-2,42E+00	109,4%
GWP-luluc	[kg CO2-Eq.]	8,72E-01	0	1,85E-03	4,26E-03	0	-8,67E-02	-47,6%	1,663E+00	0	3,529E-03	8,138E-03	0	-1,654E-01	3,48E+00	0	7,39E-03	1,70E-02	0	-3,46E-01	109,5%
ODP	[kg CFC11-Eq.]	5,23E-06	0	1,11E-07	1,82E-07	0	-1,98E-06	-47,6%	9,974E-06	0	2,110E-07	3,480E-07	0	-3,778E-06	2,09E-05	0	4,42E-07	7,29E-07	0	-7,91E-06	109,4%
AP	[mol H+-Eq.]	1,04E+00	0	1,16E-02	8,91E-02	0	-9,49E-01	-47,6%	1,985E+00	0	2,210E-02	1,700E-01	0	-1,810E+00	4,16E+00	0	4,63E-02	3,56E-01	0	-3,79E+00	109,4%
EP-freshwater	[kg PO4-Eq.]	8,81E-02	0	3,77E-04	4,37E-03	0	-9,52E-02	-47,6%	1,681E-01	0	7,187E-04	8,336E-03	0	-1,817E-01	3,52E-01	0	1,50E-03	1,75E-02	0	-3,81E-01	109,3%
EP-marine	[kg N-Eq.]	2,16E-01	0	2,78E-03	4,17E-02	0	-1,37E-01	-47,6%	4,128E-01	0	5,308E-03	7,958E-02	0	-2,615E-01	8,64E-01	0	1,11E-02	1,67E-01	0	-5,48E-01	109,4%
EP-terrestrial	[mol N-Eq.]	2,45E+00	0	3,00E-02	4,07E-01	0	-1,34E+00	-47,6%	4,681E+00	0	5,727E-02	7,764E-01	0	-2,558E+00	9,80E+00	0	1,20E-01	1,63E+00	0	-5,36E+00	109,4%
POCP	[kg NMVOC-Eq.]	1,11E+00	0	1,92E-02	1,10E-01	0	-4,39E-01	-47,6%	2,116E+00	0	3,673E-02	2,101E-01	0	-8,378E-01	4,43E+00	0	7,69E-02	4,40E-01	0	-1,75E+00	109,4%
ADPE	[kg Sb-Eq.]	1,40E-03	0	1,85E-05	5,62E-05	0	-1,21E-04	-47,6%	2,674E-03	0	3,530E-05	1,073E-04	0	-2,306E-04	5,60E-03	0	7,39E-05	2,25E-04	0	-4,83E-04	109,4%
ADPF	[MJ]	4,41E+03	0	7,82E+01	1,22E+02	0	-2,55E+03	-47,6%	8,412E+03	0	1,493E+02	2,336E+02	0	-4,875E+03	1,76E+04	0,00E+00	3,13E+02	4,89E+02	0,00E+00	-1,02E+04	109,4%
WDP	[m³ world-Eq deprived]	1,91E+02	0	3,82E-01	4,38E+01	0	-3,67E+01	-47,6%	3,653E+02	0	7,299E-01	8,363E+01	0	-6,999E+01	7,65E+02	0,00E+00	1,53E+00	1,75E+02	0,00E+00	-1,47E+02	109,4%

8 Bibliography

8.1 Standards

ASTM E 1333	ASTM E 1333:2022, Standard Test Method for Determining Formaldehyde Concentrations in Air and Emission Rates from Wood Products Using a Large Chamber
EN 310	DIN EN 310:1993-08, Wood-based panels - Determination of modulus of elasticity in bending and of bending strength.
EN 311	DIN EN 311:2002-08, Wood-based panels - Surface soundness - Test method.
EN 317	DIN EN 317:1993-08, Particleboards and fibreboards; determination of swelling in thickness after immersion in water
EN 319	DIN EN 319:1993-08, Particleboards and fibreboards; determination of tensile strength perpendicular to the plane of the board.
EN 322	DIN EN 322:1993-08, Wood-based panels; determination of moisture content.
EN 323	DIN EN 323:1993-08, Wood-based panels; determination of density.
EN 324-1	DIN EN 324-1:1993-08, Wood-based panels; determination of dimensions of boards; part 1: determination of thickness, width and length.
EN 324-2	DIN EN 324-2:1993-08, Wood-based panels; determination of dimensions of boards; part 2: determination of squareness and edge straightness.
EN 382-1	DIN EN 382-1:1993-08, Fibreboards; determination of surface absorption; part 1: test method for dry process fibreboards
EN 382-2	DIN EN 382-2:1994-02, Fibreboards; determination of surface absorption; part 2: test method for hardboards
EN 622-1	DIN EN 622-1:2003-09, Fibreboards - Specifications - Part 1: General requirements.
EN 622-5	DIN EN 622-5:2010-03, Fibreboards - Specifications - Part 5: Requirements for dry process boards (MDF).
EN 717-1	DIN EN 717-1:2005-01, Wood-based panels - Determination of formaldehyde release - Part 1: Formaldehyde emission by the chamber method.
EN 15804	DIN EN 15804:2022-03, Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products.

EN 16516	DIN EN 16516:2020-10, Construction products: Assessment of release of dangerous substances - Determination of emissions into indoor air.
ISO 12460-3	DIN EN ISO 12460-3:2023-12, Wood-based panels - Determination of formaldehyde release - Part 3: Gas analysis method (ISO 12460-3:2023).
ISO 12460-5	ISO 12460-5:2015-11, Wood-based panels - Determination of formaldehyde release - Part 5: Extraction method (called the perforator method)
ISO 14001	DIN EN ISO 14001:2015-11, Environmental management systems - Requirements with guidance for use.
ISO 14025	DIN EN ISO 14025:2011-10, Environmental labels and declarations - Type III environmental declarations - Principles and procedures (ISO 14025:2006).
ISO 14040	DIN EN ISO 14040:2021-02, Environmental management - Life cycle assessment - Principles and framework (ISO 14040:2006 + Amd 1:2020).
ISO 14044	ISO 14044:2006-07, Environmental management - Life cycle assessment - Requirements and guidelines (ISO 14044:2006 + Amd 1:2017 + Amd 2:2020).
ISO 3340	ISO 3340:1976-04, Fibre building boards; Determination of sand content
PCR Part A	Product Category Rules (PCR) Part A, Calculation Rules for the Life Cycle Assessment and Requirements on the Project Report according to EN 15804+A2:2019, Version 1.4. (Institut Bauen und Umwelt e.V), 15.04.2024.
PCR Part B	Product Category Rules (PCR) Part B, Requirements on the EPD for Wood-based panels, Version 11 (Institut Bauen und Umwelt e.V), 01.08.2024.

8.1 Software / Database

Umberto 11	Software for modelling life cycle assessments, iPoints-systems GmbH, Hamburg
Ecoinvent 15804	Database version 3.10. Revision 1

8.2 Further References

1272/2008/EK	Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and

packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006.

BBSR — Federal Ministry of Housing, Urban Development and Construction (2025): Information portal on sustainable construction. BBSR table of service life. Available at: https://www.nachhaltigesbauen.de/fileadmin/pdf/Nutzungsdauer_Bauteile/25.11.04_BBSR_Nutzungdsdauern_final.xlsx

Biomass Association Upper Austria — Masse und Energieinhalt von Hackgut in Abhängigkeit vom Wassergehalt (2024), https://www.biomasseverband-ooe.at/uploads/media/Downloads/Publikationen/Umrechnungstabellen_Brennstoff_Holz-BMV-OOe.pdf, last accessed: August 5, 2024.

Weidema, 2013 — Weidema, Bo Pedersen; et al., 2013: Overview and methodology – Data quality guideline for the ecoinvent database version 3 (final); Ecoinvent report No. 1(v3); (06.05.2013). Weidema B. P., Bauer C., Hischier R., Mutel C., Nemecek T., Reinhard J., Vadenbo C. O., Wernet G.; St. Gallen (Swiss Centre for Life Cycle Inventories).

Appendix A: Additional Specifications

Table 21: Mapping of ecoinvent Datasets

Input (From)	Quantity	Unit	Process Name	Quantity	Unit	Geography
Pine wood (logs)	1	m^3	pulpwood. softwood. measured as solid wood under bark	1	m^3	Europe without Switzerland
Internal Transport	1	tkm	transport. freight. lorry 16-32 metric ton. EURO6	1	metric ton*km	RER
Water	1	l	tap water	1	kg	RER
Oil as a release agent	1	l	lubricating oil	0.83	kg	RER
Wooden legs	1	kg	EUR-flat pallet	0.04545455	unit	RER
Stretch foil	1	kg	packaging film. low density polyethylene	1	kg	GLO
Rejects during packaging	1	t	waste wood. untreated	1000	kg	Europe without Switzerland
Natural Gas	1	kWh	heat, central or small-scale, other than natural gas, market group	3.6	MJ	RoW
Electricity	1	kWh	electricity. medium voltage	1	kWh	HU
Wooden legs_for reuse	1	kg	EUR-flat pallet	-0.0454545	unit	RER
Transport	1	tkm	transport. freight. lorry 16-32 metric ton. EURO6	1	metric ton*km	RER
Transport of Rejects	1	tkm	transport. freight. lorry 16-32 metric ton. EURO6	1	metric ton*km	RER
Transport Downstream	1	tkm	transport. freight. lorry 16-32 metric ton. EURO6	1	metric ton*km	RER
Electricity - primary data	1	kWh	electricity (GLO. ElectricityMixerHungaryEPD)	1	kWh	GLO
Wooden legs_half impact	1	kg	EUR-flat pallet	0.02272727	unit	RER
Transport_train	1	tkm	transport. freight train	1	metric ton*km	RER
Release agent	1	kg	lubricating oil	1	kg	RER
Fire Wood_Raw Material	1	t	wood pellet. measured as dry mass	1000	kg	RER

Input (From)	Quantity	Unit	Process Name	Quantity	Unit	Geography
Purchased MDF/HDF_Raw Material	1	kg	medium density fibreboard	0.00146199	m^3	RER
Urea	1	kg	urea	1	kg	RER
Parafin emulsion	1	kg	paraffin	1	kg	GLO
UAN Hardener	1	kg	chemical. inorganic	1	kg	GLO
mUF Resin	1	kg	melamine urea formaldehyde adhesive	1	kg	GLO
Paper	1	kg	paper. woodcontaining. lightweight coated	1	kg	RER
VOC	1	t	VOC. volatile organic compounds	1000	kg	
HCHO	1	t	Formaldehyde	1000	kg	
PET strips	1	kg	polyethylene terephthalate. granulate. amorphous	1	kg	GLO
			extrusion. plastic film	1.02459016	kg	GLO
N-Butyl-Acetate	1	kg	butyl acetate	1	kg	RER
Degreaser	1	kg	ethoxylated alcohol (AE7)	0.1	kg	RER
			water, deionised	0.9	kg	Europe without Switzerland
Strech foil waste	1	t	waste plastic, mixture	1000	kg	RER
metal strip waste	1	t	ferrous metal, in mixed metal scrap	1000	kg	Europe without Switzerland
hardwood	1	m^3	pulpwood, hardwood, measured as solid wood under bark	0.283	m^3	RoW
			pulpwood, hardwood, measured as solid wood under bark	0.412	m^3	RoW
			pulpwood, hardwood, measured as solid wood under bark	0.315	m^3	RoW
softwood	1	m^3	pulpwood, softwood, measured as solid wood under bark	1	m^3	CH
pine wood	1	m^3	pulpwood, softwood, measured as solid wood under bark	1	m^3	Europe without Switzerland

Input (From)	Quantity	Unit	Process Name	Quantity	Unit	Geography
wood chips with bark	1	m³	bark chips, wet, measured as dry mass	448.6217143	kg	Europe without Switzerland
Ash	1	t	wood ash mixture, pure	1000	kg	Europe without Switzerland
Flue ash	1	t	wood ash mixture, pure	1000	kg	Europe without Switzerland
other waste from production	1	t	hazardous waste, for incineration	1000	kg	Europe without Switzerland
refiner water_output	1	l	wastewater, average	0.001	m³	Europe without Switzerland
HDF (MOFA) incineration waste	1	t	waste emulsion paint	143.8342918	kg	Europe without Switzerland
			waste wood, untreated	856,1657082	kg	GLO
electricity recovery	1	kWh	electricity, medium voltage	1	kWH	HU
heat recovery	1	kWh	heat, district or industrial, other than natural gas	3.6	MJ	Europe without Switzerland
Auxiliary and operating materials_not transported	1	kg	lubricating oil	1	kg	RER
Auxiliary and operating materials	1	kg	lubricating oil	1	kg	RER
Fire wood	1	t	wood pellet, measured as dry mass	1000	kg	RER
Transport of Waste/Rejects	1	tkm	transport, freight, lorry 16-32 metric ton, EURO6	1	metric ton*km	RER
Water (from chemicals)	1	t	wastewater, average	1	m³	Europe without Switzerland
refiner water_input	1	l	tap water	1	kg	RER

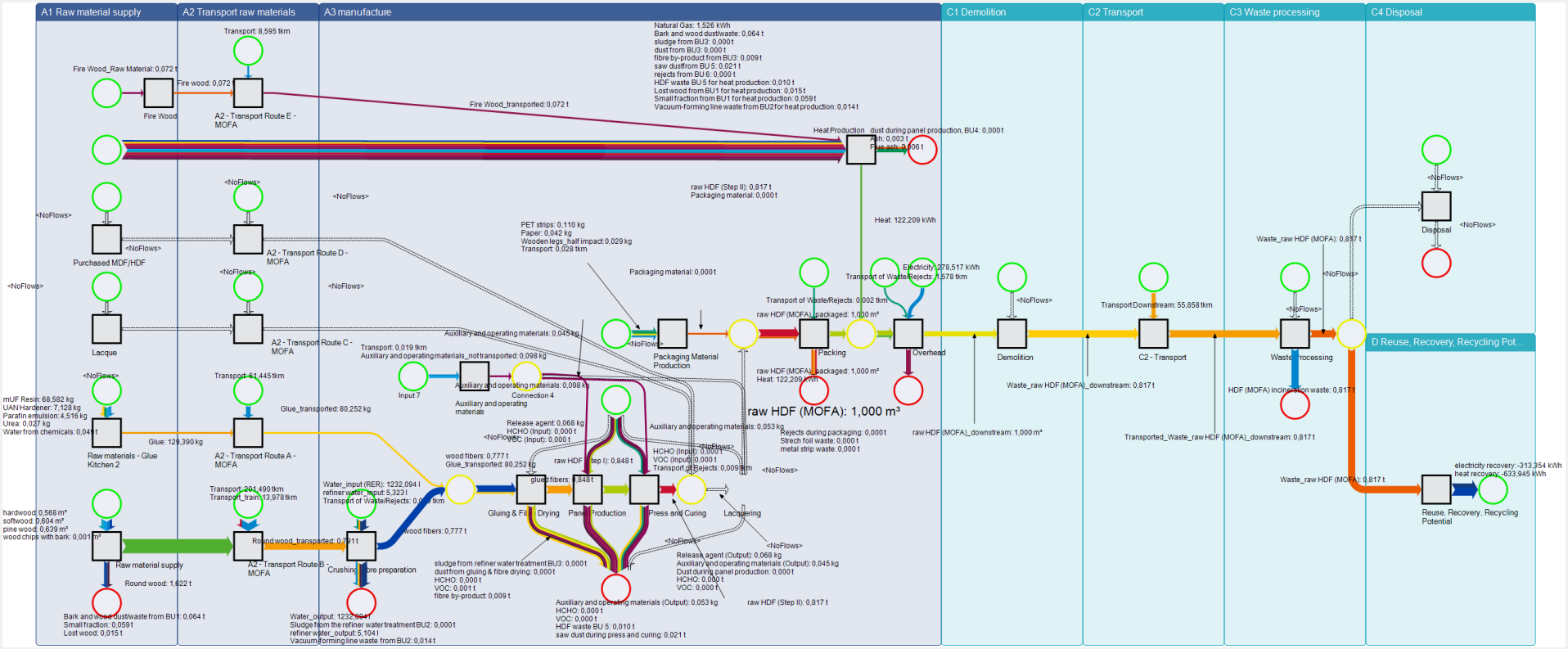

Figure 6: Sankey Diagram – Full View