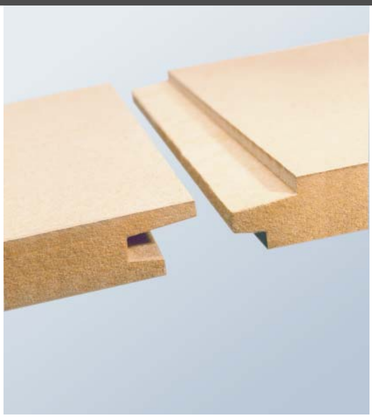
Environmental Product Declaration

according to ISO 14025



EGGER
DHF / DFF
Wood Fibre Boards

Declaration number
EPD-EHW-2008611-E

Institut Bauen und Umwelt e.V.
www.bau-umwelt.com

Institut Bauen
und Umwelt e.V.

Summary

Umwelt-Produktdeklaration

Environmental Product-Declaration

Program holder

Institut Bauen und Umwelt e.V.

www.bau-umwelt.com

Declaration holder

Fritz EGGER GmbH & Co. OG
Company Head Office
Weiberndorf 20
A – 6380 St. Johann in Tyrol

Declaration number

EPD-EHW-2008611-E

Declared building products

Egger DHF / DFF wood fibre boards for construction

This declaration is an environmental product declaration according to ISO 14025 and describes the environmental rating of the building products listed herein. It is intended to further the development of environmentally compatible and sustainable construction methods.
All relevant environmental data is disclosed in this validated declaration.
The declaration is based on the PCR document "Wood-based materials", year 2009-01.

Validity

This validated declaration authorises the holder to bear the official stamp of the Institut Bauen und Umwelt. It only applies to the listed products for one year from the date of issue.
The declaration holder is liable for the information and evidence on which the declaration is based.

Content of the declaration

The declaration is complete and contains in its full form:
- Product definition and physical building-related data
- details of raw materials and material origin
- description of how the product is manufactured
- instructions on how to process the product
- data on usage condition, unusual effects and end of life phase
- life cycle analysis results
- evidence and tests

Date of issue

25 February 2012

Signatures

Prof. Dr.-Ing. Horst J. Bossenmayer (President of the Institut Bauen und Umwelt)

Verification of the declaration

This declaration and the rules on which it is based have been examined by an independent expert committee (SVA) in accordance with ISO 14025.

Signatures

Prof. Dr.-Ing. Hans-Wolf Reinhardt (chairman of the expert committee)

Dr. Frank Werner (tester appointed by the expert committee)

Summary

Umwelt-Produktdeklaration

Environmental Product-Declaration

Product description

DHF and DFF boards are board-shaped wood-based materials made out of wood fibre according to EN 622-5 (DHF) and EN 13171 (DFF). They have a tongue and groove profile along the edges. The boards are manufactured using the so-called dry method in a hot press process and with addition of a PMD glue and paraffin wax emulsion for hydrophobising.

Application

DHF boards are used as permeable and, if applicable, supplemental load-bearing cladding in roof and exterior wall structures in accordance with DIBt approval Z-9.1-454 according to GK0 in accordance with DIN 68800-2.

DFF boards are used as permeable, rigid thermal insulating underlay / cladding in roof and exterior wall structures.

Scope of the LCA

The Life Cycle Assessment (LCA) was performed according to DIN ISO 14040 following the requirements of the IBU guideline for type III declarations. Both specific data from the reviewed products and data from the “GaBi 4” database were used. The life cycle assessment encompasses the raw material and energy production, raw material transport, the actual manufacturing phase and the end of life in a biomass generating plant with energy recovery. One m³ of DHF/DFF is declared.

Results of the LCA

		DHF boards			DFF boards		
Evaluation variable	**Unit per m³**	**Total**	**Manu-facturing**	**End of Life**	**Total**	**Manu-facturing**	**End of Life**
Primary energy, non renew able	[MJ]	-3.904	8.538	-12.443	-420	5.205	-5.624
Primary energy renew able	[MJ]	11.126	11.271	-144,9	4.526	4.591	-65,7
Global w arming potential (GWP 100)	[kg éqv. CO_2]	-182,2	-508,3	326,2	30,8	-116,8	147,6
ozone depletion potential (ODP)	[kg eqv. R11]	1,97E-05	5,01E-05	-3,05E-05	1,07E-05	2,45E-05	-1,38E-05
Acidification potential (AP)	[kg éqv. SO_2]	1,59E+00	1,78E+00	-1,97E-01	9,19E-01	9,25E-01	-5,88E-03
Eutrophication potential (EP)	[kg éqv. PO_4]	1,87E-01	2,22E-01	-3,50E-02	1,27E-01	1,24E-01	2,11E-03
Photochemical oxidation formation potential (POFP)	[kg C_2H_4 eqv.]	2,00E-01	2,49E-01	-4,93E-02	1,24E-01	1,43E-01	-1,99E-02

Prepared by: PE INTERNATIONAL, Leinfelden-Echterdingen
in cooperation with Fritz EGGER GmbH & Co. OG

PE INTERNATIONAL
EXPERTS IN SUSTAINABILITY

Evidence and verifications

In addition, the results of the following tests are shown in the environmental product declaration:

- Formaldehyde according to EN 120 / EN 717-1
  Testing institute: WKI Fraunhofer Wilhelm-Klauditz-Institute
- MDI according to procurement regulations UZ 76 and NIOSH (P&CAM 142)
  Testing institute: Wessling – Beratende Ingenieure GmbH, Altenberge
- Eluate analysis according to DIN 38406-4 and EN 71-3
  Testing institute: MFPA Leipzig GmbH
- EOX (extractable organic halogen compounds) according to DIN 38414-17
  Testing institute: MFPA Leipzig GmbH
- Toxicity of the fire gases according to 4102-2 and DIN 53 436
  Testing institute: MFPA Leipzig GmbH
- Pre-treatment of the component materials: PCP/lindane (scrap wood provision)
  Testing institute: WKI Fraunhofer Wilhelm-Klauditz-Institute

Area of application This document refers to wood fibre boards (dry method) used in construction, which are produced in the following group of company plants:

Egger Holzwerkstoffe Wismar GmbH & Co. KG, Am Haffeld 1, D–23970 Wismar

0 Product definition

Product definition DHF / DFF boards are board-shaped wood-based materials made out of wood fibre according to EN 622-5 (DHF) and EN 13171 (DFF). The DHF and DFF boards have a tongue-and-groove profile along the edges. The boards are manufactured using the so-called dry method in a hot press process and with addition of a PMD glue and paraffin wax emulsion for hydrophobising.

Wood fibre boards for construction are divided into different board types – a description of the classes is found in the EN 622 and EN 13171 requirements.
The board types are primarily differentiated or divided based on their application as load-bearing or non-load-bearing elements in dry and humid areas (usage class 1, 2).
Relevant board types for this EPD are:

EN 622-5 – Fibreboard – Requirements of boards after the dry process (MDF), MDF.RWH – boards for use as rigid underlay for roofing and walls

EN 13171 – Thermal insulation materials for buildings – factory-made products out of wood fibres [WF]

Application DHF boards are used as permeable and, if applicable, load-bearing cladding in roof and exterior wall structures in accordance with DIBt approval Z-9.1-454 according to GK0 in accordance with DIN 68800-2.

DFF boards are used as permeable, thermal insulating rigid underlay / cladding in roof and exterior wall structures.

Product standard / approval

- EN 622 – Fibreboard –Board requirements after the drying process (MDF)
- EN 13171 – Thermal insulation materials for buildings – factory-made products out of wood fibres [WF]
- EN 13986 – CE-labelling of wood-based material for use in construction

Accreditation

- CE-labelling according to EN 13986 – Notified Body WKI – Braunschweig, Germany
- CE-labelling according to EN 13171 – Notified Body WKI – Braunschweig, Germany
- PEFC, Chain of Custody HCA-CoC-183
- EN ISO 9001:2000 – ÖQS Vienna, Austria
- DHF: General DIBt Z-9.1-454 building inspection approval

Delivery status, characteristics

Table 1: Delivery sizes

	Thickness (mm)		
Length x Width (mm)	**13**	**15**	**30**
DHF Z-9.1-454, EN622-5 MDF.RWH			
N&F 4 unsanded			
2500 x 1250		X	
2500 x 675		X	
N&F 2 unsanded			
2800 x 1250	X	X	
3000 x 1250		X	
DFF EN 13171			
N&F 4 unsanded			
2500 x 675			X

Table 2: DHF* - Physical building-related calculation values and properties

Property	Standard	Units	EGGER DHF
Thickness range	Z-9.1-454	mm	12 - 20
Raw density	DIN EN 323	kg/m³	≥ 600-650
Diffusion resistance factor μ	DIN 52615		11
Bending strength	DIN EN 310	N/mm²	17
Bending modulus of elasticity	DIN EN 310	N/mm²	2000
Thermal conductivity λ_R	DIN 4108-3	W / mK	0.1
Dimensional change due to moisture	DIN EN 318	%/%	0.04
Building material class	DIN 4102-1		B2 - normal flammability
Reaction to fire	EN 13986		D-s2, d0
Emission class	DIN EN 120	mg/100g absolutely dry	E1 (<0.8 mg/100g absolutely dry)

*DHF boards according to Z-9.1-454 and EN 622-5 – MDF.RWH

Table 3: DFF - Physical building-related calculation values and properties**

Property	Standard	Units	EGGER DFF
Thickness range		mm	30
Raw density	EN 1602	kg/m³	280
Diffusion resistance factor μ	EN 12086		3
Nominal thermal conductivity λ_D	EN 12667	W / mK	0.051
Calculated thermal conductivity λ_R	EN 12667	W / mK	0.061
Thermal resistance R	EN 12667	m²K / W	0.49
Specific heat capacity	EN 12524	J / kgK	2100
Building material class	DIN 4102-1		B2 – normal flammability
Reaction to fire	EN 13501-1		C-s2, d0
Emission class	EN 120	mg/100g dry matter	E1 (<0.8 mg/100g absolutely dry)

**DFF boards according to EN 13171:2001 – (Thermal insulation materials for buildings – factory-made products out of wood fibres [WF]), usage class 2 according to DIN 1052:2004

1 Raw materials

Raw materials Primary products

DHF boards with thicknesses between 12 and 20 mm and an average density of 600-650 kg/m³ and DFF boards with a thickness of 30 mm and an average density of 280 kg/m³ consisting of (specified in mass % per 1 m³ of production):

- Wood fibres, primarily spruce and pine wood, approx. 88%
- Water approx. 5-7%
- PMDI glue, approx. 4%
- Paraffin wax emulsion <1%
- Additive

DFF boards with a thickness of 30 mm and an average density of 280 kg/m³ consisting of (specified in mass per 1 m³ of production):

- Wood fibres, primarily spruce and pine wood, approx. 86%
- Water approx. 5%
- PMDI glue, approx. 8%
- Paraffin wax emulsion <1%
- Additive

Material explanation

Wood compound: The production of DHF and DFF boards utilises only fresh wood from thinning measures as well as sawmill leftovers, primarily spruce and pine wood.

PMDI glue: MDI (diphenylmethane diisocyanate), a polyurea primary product which is converted to PUR (polyurethane) and polyurea during the DHF/DFF manufacturing process, is used. This originates from the category of polyurethane resins and serves to bind the wood fibres.

Paraffin wax emulsion: A paraffin wax emulsion is added to the formulation during gluing for improving resistance to moisture.

Additive: Separating agent which is a component in the PMDI binding agent and acts along the boundary layer to prevent sticking to the press board metal.

Raw material extraction and origin

Wood from indigenous, predominantly regional forest stands or sawmill leftovers from the neighbouring KNT sawmill are used to manufacture DHF/DFF wood fibre board using the dry method (MDF). The wood is sourced from forests within an average radius of approx. 200 km from the plant site. The short transportation distances contribute a considerable measure to minimizing the logistical costs of raw materials acquisition. In the selection process, preference is given to woods that are certified according to PEFC regulations.

The bonding agents and additives used come from suppliers located at a maximum distance of 700 km from the production site.

Local and general availability of the raw materials

The wood used in the production of wood fibre board using the dry method (MDF) is sourced exclusively from cultivated forests managed in a sustainable manner. The selection is composed exclusively out of greenwood from thinning and silviculture as well as sawmill leftovers (wood chips). The bonding agents and the paraffin emulsion are synthesised out of crude oil, a fossil raw material with limited availability.

2 Manufacturing of the building product

Manufacturing of the building product

Structure of the manufacturing process:

1. Debarking of the logs
2. Chipping of the wood into wood chips and shavings
3. Cooking of the chips and shavings
4. Defibration in the refiner
5. Drying the fibres to approx. 2-3 % residual moisture content
6. Gluing of the fibres with resins

7. Spreading of the glued fibres onto a moulding conveyor
8. Compression of the fibre mat using a continuous hot press
9. Cutting and edge-trimming of the fibre strip to rough board sizes
10. Cooling of the rawboard in radial coolers
11. Destacking onto large stacks
12. Finishing / tongue and groove application

Production health and safety

Measures to avoid hazards to health / exposures during the production process:

Due to the manufacturing conditions, no health and safety measures above and beyond the ones required by law and other regulations are required. At all points on site, readings fall significantly below (Germany's) maximum allowable concentration values.

Environmental protection during production

- Air: The exhaust air resulting from production processes is cleaned according to legal requirements. Emissions are significantly below TA Luft (Technical Instructions on Air Quality Control).
- Water/soil: Contamination of water and soil does not occur. Effluent resulting from production processes is processed internally and routed back to production.
- Noise protection measurements have shown that all readings from inside and outside the production plant fall below German limit levels. Noise-intensive system parts such as chipping are structurally enclosed.

3 Working with the building product

Processing recommendations

DHF and DFF boards can be sawn and drilled with normal (electric) tools. Hard metal-tipped tools are recommended, especially for circular saws. Wear a respiratory mask if using hand tools without a dust extraction device.

Detailed information and processing recommendations are available at www.egger.com/holzbau.

Job safety, Environmental protection

Apply all standard safety measures when processing / installing DHF and DFF boards (safety glasses, face mask if dust is produced). Observe all liability insurance association regulations for commercial processing operations.

Residual material

Residual material and packaging: Waste material accumulated on site (cutting waste and packaging) shall be collected and separated into waste types. Disposal shall comply with local waste disposal authority instructions and instructions given in no. 6 "End of life phase".

Packaging

Spacers out of wood-based material strips, paperboard, steel bands, and recyclable PE film (only for tongue and groove boards) are used.

4 Usage condition

Components

Components in usage condition: The components of DHF and DFF boards correspond in their fractions to those of the material composition in point 1 "Raw Materials". During pressing the MDI bonding agent reacts fully and irreversibly with the moisture in the wood to form three-dimensionally cross-linked polyurethane (PUR) and polyurea. The bonding agent is chemically inert and bonded firmly to the wood. Very small quantities of formaldehyde which occur naturally in the wood are emitted (see formaldehyde certificate chapter 8.1).
The PUR gluing is formaldehyde-free. The selected bonding agents contribute to the high strength properties and at the same time result in a consistent high board quality. DHF / DFF boards distinguish themselves through their low sensitivity to changes in the relative humidity of the air.

Interactions Environment - Health

Environmental protection: According to the current state of knowledge, hazards to water, air, and soil cannot occur during proper use of the described products (see point 8. Evidence).

Health protection: Health aspects: No damage to health or impairment is expected under normal use corresponding to the intended use of DHF / DFF boards. Natural wood substances may be emitted in small amounts. With the exception of small quantities of formaldehyde harmless to health, no emission of pollutants can be detected (see Evidence 8.1 formaldehyde, 8.2 MDI, 8.3 eluate, 8.4 toxicity of the fire gases, 8.5 PCP/lindane, 8.6 EOX).

Long term durability in usage condition

The durability under usage conditions for the DHF boards is defined through the class of application according to EN 622-5 (see chapter 0 “Product definition" as well as tables 2 through 3).

5 Unusual effects

Fire

Reaction to fire of DHF boards 12 – 20 mm thick and >600 kg/m³:
Classification according to flammability rating D according to EN 13986
Smoke development S2 – normally smoky
d0 – non-dropping

Reaction to fire of DFF boards 30 mm thick and <280 kg/m³:
Classification according to flammability rating C according to EN 13501-1 , Classification report MA 39,
Vienna, MA 39 – VFA 2007-0419.01
Smoke development S2 – normally smoky
d0 – non-dropping

Toxicity of the fire gases (test report chapter 8.4)

Change of phase (dripping by combustion/precipitation): Dripping by combustion is not possible, since the DHF and DFF boards do not liquefy when hot.

Water effects

No component materials which could be hazardous to water are washed out. Wood fibre boards are not resistant to sustained exposure to water, but damaged areas can be replaced easily on site.

Mechanical destruction

The breaking pattern of DHF and DFF boards illustrates relatively brittle behaviour, and sharp edges can form at the breaking edges of the DHF boards (risk of injury).

6 End of life phase

Reuse

During remodelling or at the end of the utilisation phase of a building, DHF and DFF boards can easily be separated and used again for the same applications if selective deconstruction is practiced.

Reclamation

During remodelling or at the end of the utilisation phase of a building, DHF and DFF boards can easily be separated and used again for other applications if selective deconstruction is practiced.

This is only possible if the wood-based boards have not been bonded over their entire surface.

Energy utilisation (in correspondingly approved systems): With a high calorific value of approx. 17 MJ/kg, energy utilisation for the generation of process energy and electricity (cogeneration systems) from construction board leftovers as well as boards from deconstruction measures is preferable to putting them in the landfill.

Disposal

DHF and DFF board leftovers which arise on the construction site as well as those from deconstruction measures should primarily be routed to a material utilisation stream. If this is not possible, then they must be used for energy utilisation rather than being placed in the landfill (refuse code according to European Waste Catalogue: 170201/030103).

Packaging: The transport packaging out of chipboard spacers and steel strapping as well as the PE film can be recycled if they are sorted correctly. External disposal can be arranged with the manufacturer on an individual basis.

7 Life cycle assessment

7.1 Manufacturing of DHF and DFF boards

Declared unit

The declaration refers to the production of one cubic meter of DHF board and one cubic meter of DFF board.

The average raw density of the boards is 625 kg/m³ for the DHF board and 280 kg/m³ for the DFF board (moisture 5.5 % +/- 1 %).

The end of life is calculated as energy recovery in a biomass generating plant.

System boundaries

The selected system boundaries encompass manufacturing of the DHF/DFF board including raw materials production through to the final packaged product at the factory gate (cradle to gate) as well as the end of life process (gate to grave).

The database GaBi 2006 was used for the energy generation and transportation. In detail, the observed parameters encompass:

- Forestry processes for the provisioning and transporting of wood
- Production of all raw materials, primary products and secondary materials including the associated relevant transportation
- Relevant transportation and packaging of raw materials and primary products
- Production processes for the DHF/DFF boards (energy, waste, thermal utilisation, production waste, emissions) and energy provisioning ex resource
- Packaging including its thermal utilisation

All reviewed products were produced in the Wismar plant.

The usage phase of the DHF/DFF boards was not investigated in this declaration. The end of life scenario was assumed to be a biomass generating plant with energy utilisation (credits according to substitution approach) ("gate to grave"). The assessment region begins at the factory gate of the utilisation facility. On the output side, it is assumed that the produced ash is placed in a landfill.

Cut-off criteria

On the input side, at least all those material streams which enter into the system and comprise more than 1% of its entire mass or contribute more than 1% to the primary energy consumption are considered. The output side involves at least all those material flows out of the system which comprise more than 1% of the total effects of the considered analysis effect categories.

All inputs used as well as all process-specific waste and emissions were assessed. In this manner the material streams which were below 1 % mass percent were captured as well. In this manner the cut-off criteria according to the IBU guideline are fulfilled.

Transportation

Transport of the raw materials and secondary materials used is included in principle.

Period under consideration

The data used refer to the actual production processes during the business year 1/5/2007 to 30/4/2008. The life cycle assessment was prepared for the reference area of Germany. This has the effect that in addition to the production processes under these framework conditions, the preliminary stages such as electricity or energy source provisioning which are relevant for Germany were used.

Background data

To model the life cycle for the manufacturing and disposal of Egger DHF/DFF boards, the software system for comprehensive accounting "GaBi 4" was used (GaBi 2006). All background data sets relevant to the manufacturing and disposal were taken from the GaBi 4 software database. The upstream chain for the harvesting was accounted for according to /Schweinle & Thoroe/ 2001 or, as the case may be, /Hasch 2002/ in the update from Rüter and Albrecht (2007).

Scrap wood is considered from the scrap wood dealer gate. A CO2 content of 1.851 kg CO2 per kg of wood dry matter and a primary energy content of 18.482 MJ per kg of wood dry matter were considered. No impacts from the upstream chain were considered, but the chipping of the scrap wood as well as transportation from the scrap wood dealer to the production site (30% wood humidity) were included in the calculation.

Assumptions

The results of the life cycle assessment are based on the following assumptions:

The transportation of all raw materials and/or secondary materials is calculated according to the means of transportation (truck, bulk carrier - ocean-going vessel, rail) with data from the GaBi database.

The energy carriers and sources used at the production site were considered for the energy supply.

All leftovers which arise during production and finishing (trimming, cutting, and milling leftovers) are routed to a thermal utilisation process in a biomass generating plant as "combustible materials". The credits from the energy extraction of the combustion systems are included in the balance board calculation.

The end of life scenario was assumed to be a biomass generating plant and modelled according to the composition of the boards.

Data quality

The age of the utilised data is less than 5 years.

Data capture took place directly in the production facility of the Wismar plant. All input and output data of the Egger company were made available. Therefore it can be assumed that the data is very representative.

The predominant part of the data for the upstream chain comes from industrial sources, which were collected under consistent time and methodical framework conditions. The process data and the utilised background data are consistent. Great value was placed on a high degree of completeness in the capturing of environmentally relevant material and energy flows.

The delivered data (processes) were checked for plausibility. They come from the operational data capturing and measurements and the data quality can therefore be described as very good.

Allocation

Allocation refers to the allocation of the input and output flows of a life cycle assessment module to the product system under investigation /ISO 14040/.

The DHF and DFF board manufacturing system in question and the associated energy supply do not require any allocations; waste materials are utilised as a source of energy. The combustion is accounted for using GaBi 2006 and, similar to end of life, energy credits are assigned.

The modelled thermal utilisation of the boards in the end of life process takes place in a biomass generating plant. The allocation of energy credits for the electricity and gas produced in the biomass generating plant is done based on the calorific value of the input. The credit for the gas is calculated based on "steam from natural gas"; the credit for electricity from the German power mix. The calculation of emissions (e.g. CO_2, HCl, SO_2 or heavy metals) which are dependant on the input is performed based on the material composition of the introduced range. The technology-dependant emissions (e.g. CO) are assigned based on the exhaust gas volume.

Notes on usage phase The usage conditions as well as possible associated unusual effects were not researched in the life cycle assessment. For system comparisons, the lifespan of the DHF/DFF boards must be accounted for under consideration of the stress and loading aspects.

7.2 Thermal utilisation of DHF and DFF

Choice of disposal process For this life cycle assessment basis, thermal utilisation in a biomass generating plant was assumed for both products and modelled according to the respective board composition. The system is equipped with SCNR exhaust has denitrification, dry sorption for desulphurisation, and a fabric particle filter to remove particles. The fuel efficiency factor is 93%.

Credits The substitution approach is used for energy production. Credits are assigned to the generated products electricity and heat in a suitable manner. They represent the savings in fossil fuels and their emissions which would occur during conventional energy generation (also see allocation). The German: Electricity and German: Thermal energy from natural gas (GaBi 2006 in each case) are substituted.

7.3 Results of the assessment

Life cycle inventory In the following chapter, the life cycle inventory assessment with regard to the primary energy consumption and wastes and, in following, the impact assessment is shown.

Primary energy Table 4 shows the primary energy consumption (renewable and non-renewable, lower calorific value H_u respectively) subdivided for the sum total, production, and end of life for one cubic meter of DHF/DFF board mix.

The consumption of non-renewable energy for the DHF board production (cradle to gate) is a scant 8538 / 5205 (DHF / DFF) MJ per m^3.

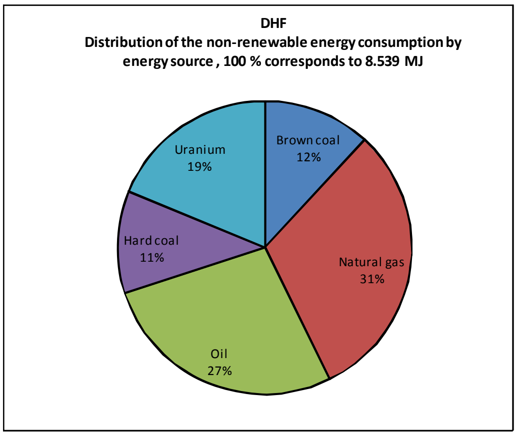
In addition, another 11 271/4591 MJ of renewable energy (solar energy stored in the biomass as well as approx. wind and water power) are used to produce one cubic meter of DHF/DFF board.

Table 4: Primary energy consumption for the production of 1 cubic meter of DHF/DFF board

Evaluation variable	Unit per m³	Total	Manufacturing	End of Life
DHF				
Primary energy, non-renewable	[MJ]	-3.904	8.538	-12.443
Primary energy, renewable	[MJ]	11.126	11.271	-145
DFF				
Primary energy, non-renewable	[MJ]	-420	5.205	-5.624
Primary energy, renewable	[MJ]	4.526	4.591	-66

A closer investigation of the composition of the renewable primary energy consumption indicates that energy stored primarily in the re-growing raw material through photosynthesis mainly stays in the DHF/DFF board product until its “end of life”. 1 m³ of finished DHF board has a lower calorific value of approx. 10 938 MJ. 1 m³ of finished DFF board has a lower calorific value of approx. 4984 MJ.

In figure 1, a more detailed evaluation of the non-renewable energy required to produce one cubic meter of DHF/DFF board shows that the main primary energy sources are natural gas (31 % / 34 %) and crude oil (27 % / 32 %) The rest comes from hard coal (11 % / 9 %), brown coal (12 % / 10 %), and uranium (19 % / 15 %) which comes from the power mix for the energy supply of the upstream chains.



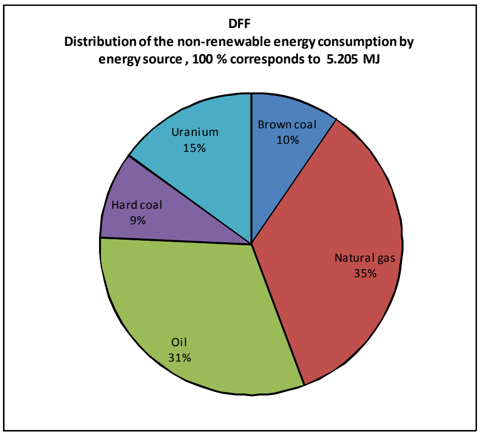


Figure 1: Distribution of the non-renewable energy consumption by energy source for the production of 1 m³ of DHF/DFF board

Figure 2 provides a further level of detail for the non-renewable energy consumption, where production of the DHF / DFF accounts for approx. 44 % / 32 %, supply of raw materials for 48% / 62%, transportation for 7 % / 5 % and packaging makes up around 0.5 % / 1 %.

The thermal utilisation of the packaging and other wastes is modelled by the average waste incineration of the respective material fraction with steam and electricity generation. This results in electricity credits through the substitution of electricity in the public grid according to the German power mix and a credit according to the average production of steam from natural gas per produced m^3 of finished DHF/DFF board. The wood waste is burned in a biomass generating plant. This also results in credits.

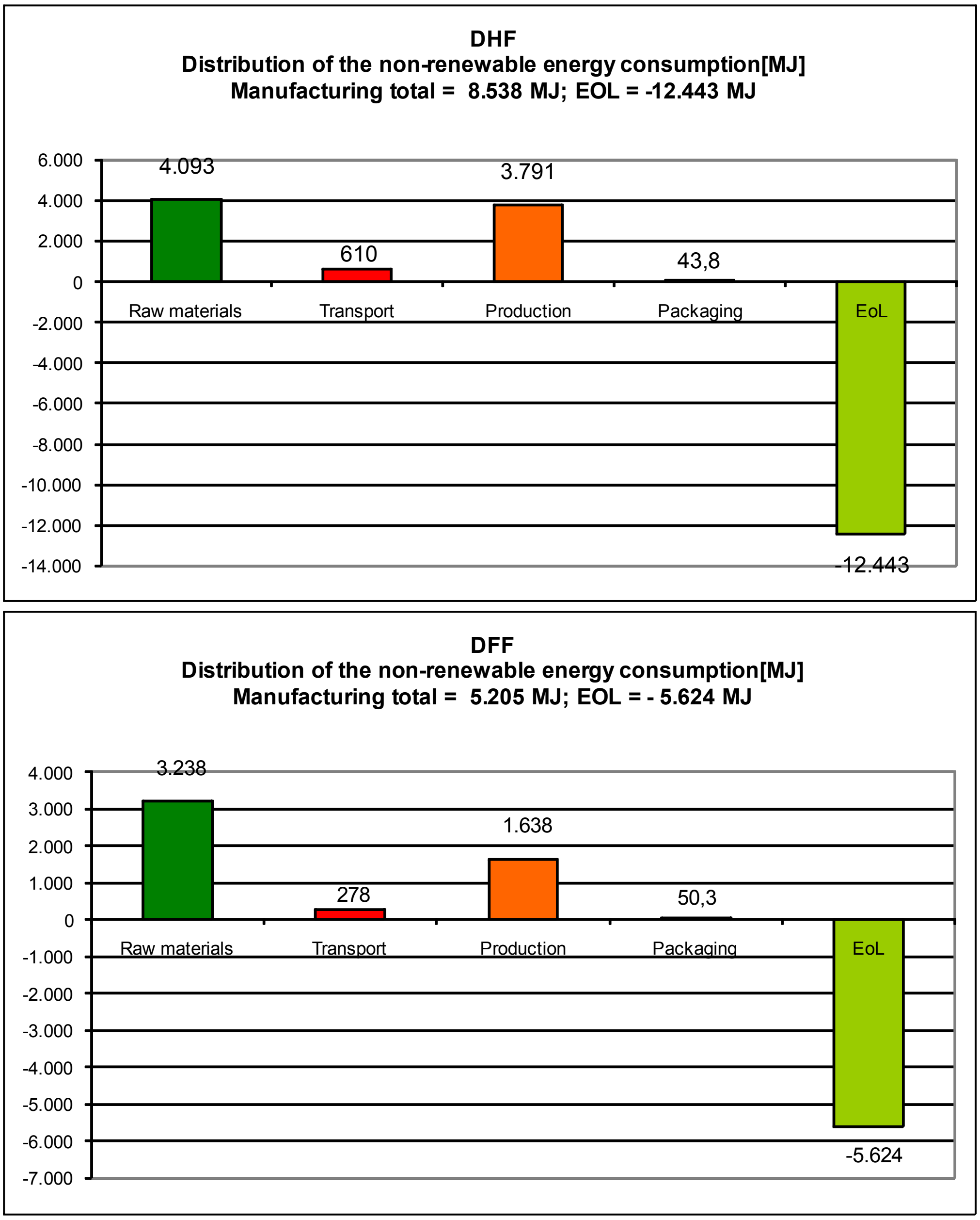
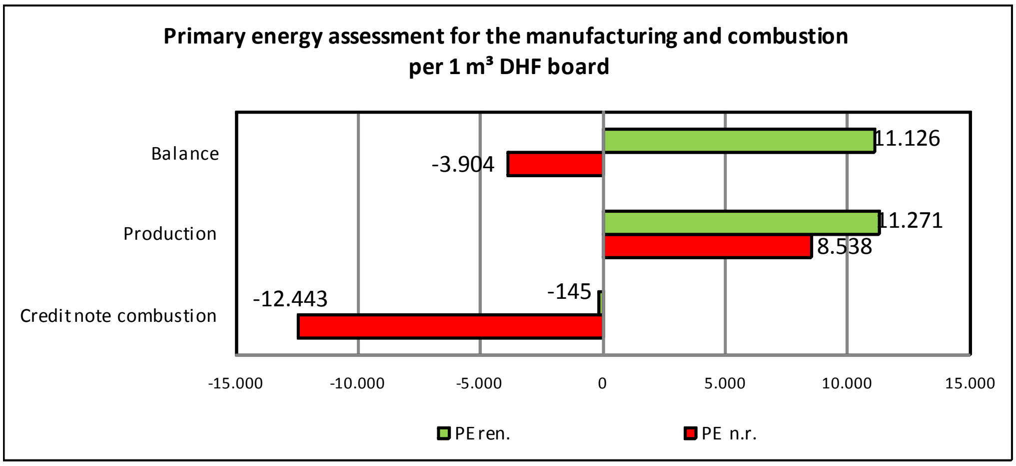


Figure 2: Distribution of the non-renewable energy consumption for the Manufacturing of one cubic meter of DHF/DFF board

If one considers manufacturing and end of life as shown in figure 3 (biomass generating plant), then one discovers that the energy credit for electricity and steam (credit for German power mix and German thermal energy from natural gas) amounts to 12 443 MJ / 5624 MJ of non-renewable energy sources per m^3 of DHF/DFF board. This reduces the non-renewable primary energy consumption of 8538 MJ/m³ / 5205 MJ/m³ to a value of -3904 MJ/m³ / -420 MJ/m³ when manufacturing and combustion are calculated.



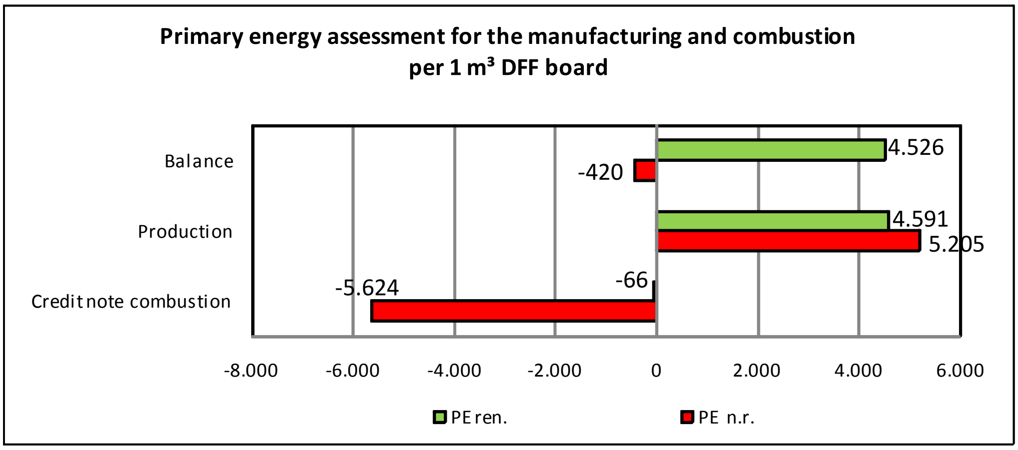
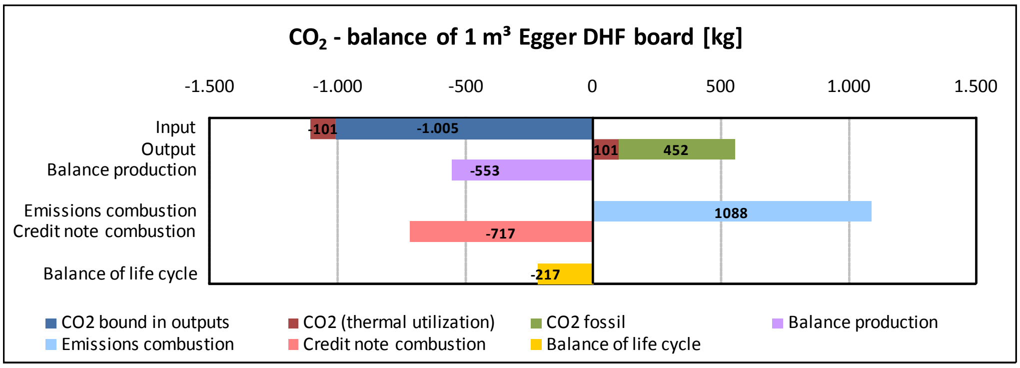


Figure 3: Primary energy assessment of renewable and non-renewable energy sources for the manufacturing and combustion of 1 m³ of DHF/DFF board.

CO_2 balance board

The CO_2 balance board in figure 4 shows that manufacturing causes approx. 553 / 149 kg of emissions per m^3 of DHF/DFF, of which approx. 101 / 28 kg of CO_2 are the result of the direct thermal utilisation of wood and 452 / 274 kg of CO_2 are fossil emissions from production and its upstream chain. On the other hand, due to manufacturing a total of 1106 / 451 kg of CO_2 per m^3 of DHF / DFF is removed from the air and stored in re-growing wood through photosynthesis, of which 1005 / 423 kg of CO_2 per m^3 remains bound in the wood over the service life. The CO_2 component bound in the DHF / DFF is only released again at the end of the lifecycle, that is, during thermal utilisation of the DHF / DFF. If one allocates the manufacturing CO_2 intake (intake bar) and CO_2 emissions (output bar), one obtains, on balance, a CO_2 reduction for this phase of the lifecycle of -553 / -149 kg per m^3 of DHF (bar total manufacturing) through binding in the product and substitution of non-renewable energy sources. 1088 / 494 kg of CO_2 is emitted during combustion. At the same time, however, a substitution of fossil fuels and therefore of CO_2 from the combustion of these fossil energy sources of -717 / -327 kg of CO_2 takes place. Consideration of this energy substitution effect results in a total balance of -217 / -1.6 kg CO_2 over the entire life cycle.



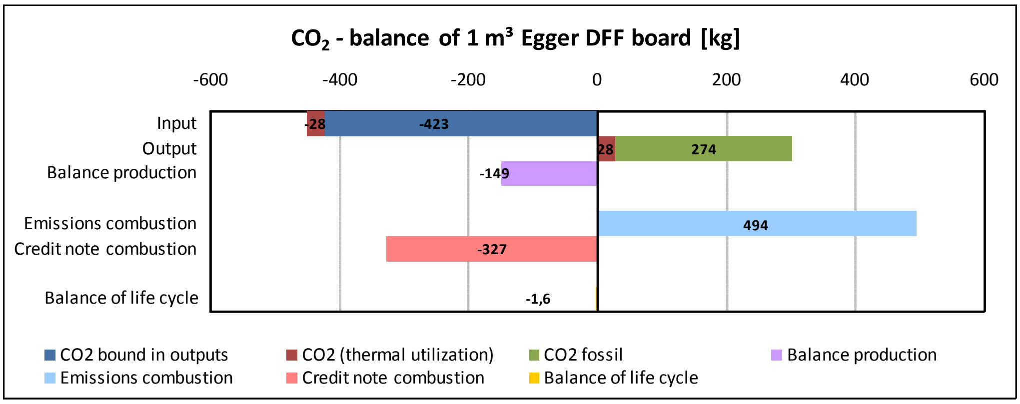


Figure 4: CO_2 balance board for the manufacturing of 1 m³ of DHF/DFF board.

Waste

The evaluation of waste produced to manufacture 1 m³ of DHF/DFF board is shown separately for the three segments construction/mining debris (including ore processing residues), municipal waste (including household waste and commercial waste) and hazardous waste including radioactive wastes (table 5).

Table 5: Waste accumulation during the manufacturing and combustion of 1 m³ of DHF/DFF board.

Waste [kg / m³ DHF]			
Evaluation	**Manufacturing**	**End of Life**	**Total**
Mining debris	1.372,0	-1.035,9	336,1
Minicipal waste	0,341	0,000	0,341
Hazardous waste	1,348	-0,409	0,938
of it radioactive waste	0,575	-0,409	0,166
Waste [kg / m³ DFF]			
Evaluation	**Manufacturing**	**End of Life**	**Total**
Mining debris	676,3	-472,0	204,3
Minicipal waste	0,406	0,000	0,406
Hazardous waste	0,929	-0,187	0,743
of it radioactive waste	0,059	-0,034	0,024

Quantitatively, the mining debris is by far the most significant fraction, followed by hazardous waste and municipal waste.

For the **mining debris** the rubble generated during manufacturing is by far the most significant quantity at > 99 %, followed by deposited ore dressing residues with a fraction of < 1 %. Rubble is produced primarily during the mining of mineral raw materials and coal in the production of raw materials and energy sources. The combustion of the DHF at the end of its lifecycle substitutes mining debris in energy production in the amount of approx. 1036 / 472 kg/m^3 DHF.

Significant fractions within the **municipal waste** segment are waste similar to household waste and liquid waste. All other fractions play a minor role. The combustion at EoL results in a small increase in the total amount of municipal waste produced.

Hazardous w astes here are primarily the waste produced during the upstream stages. The “sludge” fraction contains the largest percentage of hazardous waste (> 90 %). This is followed immediately by slag.

0.575 / 0.929 kg of radioactive waste is also produced per m³ of DHF / DFF board, of which 98.5 % is ore dressing residue which is allocated to the power mix upstream chain. However, radioactive waste is substituted through the energy generated at end of life, which results in an overall value of 0.166 / 0.024 kg.

Impact assessment

The following tables 6 and 7 show the contributions from the production and combustion of 1 m^3 of DHF/DFF board to the impact categories global warming potential (GWP 100), ozone depletion potential (ODP), acidification potential (AP), eutrophication potential (EP), and photochemical oxidation formation potential (summer smog potential POFP). In addition the renewable primary energy (PE ren.) and the non-renewable primary energy (PE n.r.) are listed again.

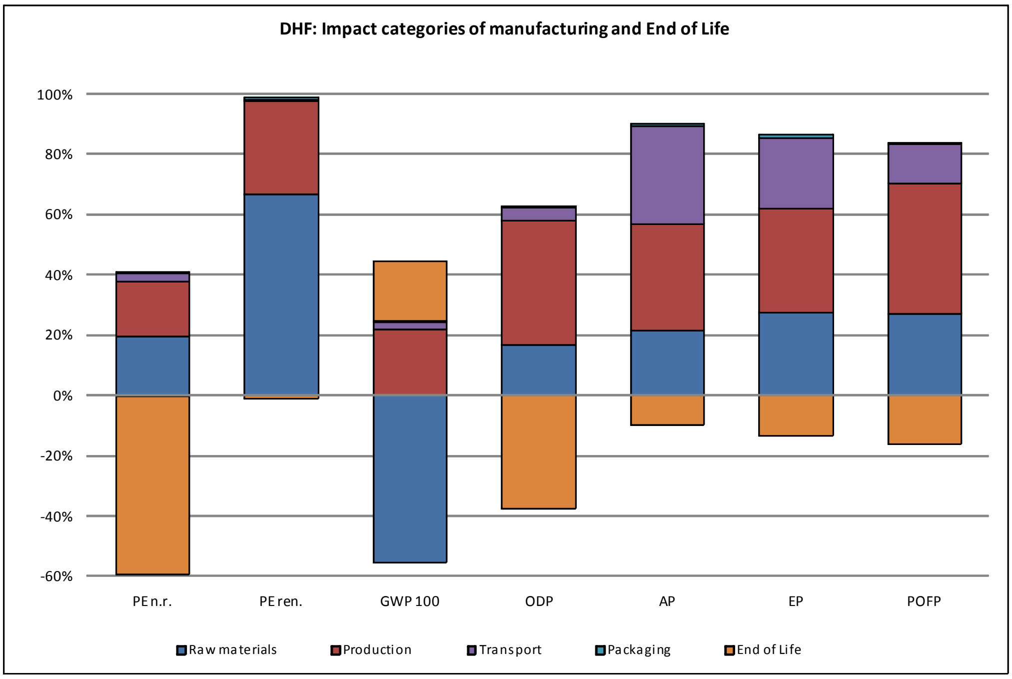
Table 6: **Absolute contributions of manufacturing and end of life per cubic meter of DHF board to PE n.r., PE ren.,, GWP 100, ODP, AP, EP, and POFP.**

	PE n.r.	PE ren.	GWP 100	ODP	AP	EP	POFP
Unit	MJ	MJ	kg CO_2-eqv.	kg R11-eqv.	kg SO_2-eqv.	kg PO_4-eqv.	kg C_2H_4-eqv.
Raw materials	4093.36	7569.3	-904.50	1.34E-05	0.418	0.0696	0.08050
Production	3791.35	3565.9	352.69	3.32E-05	0.702	0.0885	0.12872
Transport	609.91	21.274	39.49	3.36E-06	0.644	0.0609	0.03845
Packaging	43.84	114.08	4.01	1.35E-07	0.0180	0.0028	0.00149
Manufacturing total	**8538.5**	**11270.6**	**-508.31**	**5.01E-05**	**1.783**	**0.2219**	**0.24916**
End of Life	-12442.9	-144.93	326.15	-3.05E-05	-0.197	-0.0350	-0.04928
Total	**-3904.4**	**11125.6**	**-182.16**	**1.96E-05**	**1.586**	**0.1869**	**0.19988**

Table 7: **Absolute contributions of manufacturing and end of life per cubic meter of DFF board to PE n.r., PE ren., GWP 100, ODP, AP, EP, and POFP.**

	PE n.r.	PE ren.	GWP 100	ODP	AP	EP	POFP
Unit	MJ	MJ	kg CO_2-eqv.	kg R11-eqv.	kg SO_2-eqv.	kg PO_4-eqv.	kg C_2H_4-eqv.
Raw materials	3238.20	2919.5	-283.80	8.97E-06	0.291	0.0485	0.05505
Production	1638.39	1523.0	143.48	1.40E-05	0.333	0.0451	0.06980
Transport	277.68	8.610	18.19	1.36E-06	0.277	0.0272	0.01677
Packaging	50.32	140.20	5.34	1.54E-07	0.0233	0.0038	0.00185
Manufacturing total	**5204.6**	**4591.2**	**-116.79**	**2.45E-05**	**0.925**	**0.1245**	**0.14347**
End of Life	-5624.3	-65.72	147.60	-1.38E-05	-0.006	0.0021	-0.01992
Total	**-419.8**	**4525.5**	**30.81**	**1.07E-05**	**0.919**	**0.1266**	**0.12354**

When considering the **manufacturing system boundary under consideration of the end of life** in a biomass generating plant, the significance of the method of utilisation or disposal on the environmental impact over the entire life cycle becomes apparent. The resulting additional emissions or related substitution effects in the energy supply system are shown graphically in figure 5.



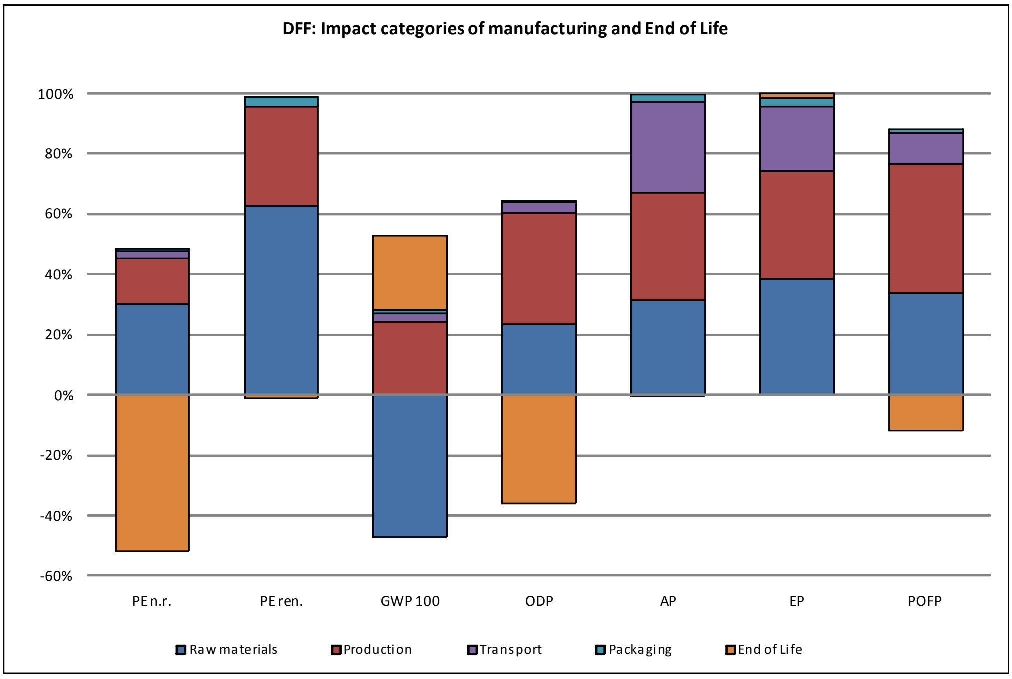


Figure 5 **Proportion of the processes relative to the impact categories – factory gate system boundary and combustion of the DHF/DFF board at end of life.**

The illustrated end of life fractions result from the allocation of the emissions resulting from the combustion process against the emissions avoided through the generation of electricity and steam. This is the difference between the emissions for combustion of the DHF/DFF boards and the emissions avoided as a result in the average German energy generation (credits). Through this substitution effect at the end of life, the need for non-renewable energy sources as well as the ozone depletion potential and the summer smog potential (POFP) are reduced.

(For DHF, the acidification potential and the eutrophication potential are reduced as well.) The effect on the need for renewable energy sources is small.

The **global w arming potential** in manufacturing is dominated by carbon dioxide. 1005 / 423 kg of CO_2 is bound in the DHF per m^3 of DHF/DFF, and an additional 101 / 28 kg of CO_2 is bound in the biomass used to generate energy. This binding of CO_2 during the tree growth phase is offset by emissions which cause global warming which are generated during provisioning of raw materials, production, transportation, and packaging. This results in a total of 508 / -116 kg CO_2 equivalent at the factory gate system boundary. Barely 97 % of the emissions are carbon dioxide, approx. 2.4 % is contributed by nitrous oxide, and around 0.6 % are VOC emissions (especially methane). This results in a greenhouse effect of -182 / 31 kg CO_2 equivalent per m³ over the product lifespan including the end of life. The emission values at the end of life result from the combustion less the credit (substitution effect as well as the average German steam production) for the energy utilisation of 1 m^3 of finished DHF (625 kg) and DFF (280 kg).

Production (approx. 65% / 58%) is the main contributor to the **ozone depletion potential**. A total ozone depletion potential of 5.01E-05 / 2.45E-05 kg R11 is caused during production per m³ of DHF / DFF. Under consideration of the substitution of power generated at the end of life, this results in an ozone depletion potential value of approx. 1.96E-05 / 1.07E-05 kg R11 equivalent for the overall system.

Production (39% / 37%) and transportation (36% / 29%) are the main contributors to the **acidification potential.** 1.78 / 9.25E-01 kg SO_2 equivalent are emitted during the production phase per m³ of DHF / DFF. The emissions from combustion are a bit lower than the emission credits due to energy utilisation of the DHF at its end of life. This results in an acidification potential of approx. 1.59 / 9.19E-01 kg SO_2 equivalent for the overall system under consideration.

For the **eutrophication potential** due to manufacturing, transportation (27% / 22%), raw materials (32% / 39%) and production (40% / 37%) are the most significant contributing factors. For manufacturing, the eutrophication potential is 2.22E-01 / 1.25E-01 kg phosphate equivalent. The EoL increases the eutrophication potential again to between 1.87E-01 / 1.27E-01 kg phosphate equivalent under consideration of the substitution effects.

Provisioning of raw materials (approx. 33% / 38%), production (50% / 48%) and transportation (16% / 12%) contribute to the **photochemical oxidant crea tion poten tial (ground-level ozone formation)**. Overall the POFP within the factory gate system boundary is 2.49E-01 / 0.143 kg ethylene equivalent. The EoL reduces the POFP to 0.2 / 0.124 kg ethylene equivalent through energy substitution.

8 Evidence and verifications

8.1 Formaldehyde

Testing institute: WKI Fraunhofer Wilhelm-Klauditz-Institute

Testing, monitoring, and certification site, Brunswick, Germany

Test report, date: B1572/08 DHF boards from 15/05/2008
B2762/06 DFF boards from 22/11/2006

Result: The testing of the formaldehyde content was performed according to the perforator method according to EN 120. The results, similar as those from PMDI gluing, correspond to the emissions expected from wood in its natural state.

- 0.3 mg HCHO/100g according to EN 120 for DHF, 15 mm
- 0.8 mg HCHO/100g according to EN 120 for DFF, 30 mm

8.2 MDI

Testing institute: Wessling – Beratende Ingenieure GmbH, Altenberge

Test report: Project-No.: IAL-08-0437

Result: The testing of the PUR bonded DHF boards was performed according to the RAL UZ 76 test procedures.

The emissions of MDI and other isocyanates were below the detection limit for the analysis method for both board types.

This fulfils the RAL-UZ 76 requirements for MDI emissions.

8.3 Eluate analysis

Testing institute: MFPA Leipzig GmbH, Division I – Construction Materials

Accredited testing laboratory, Leipzig Institute for Materials Research and Testing, Leipzig, Germany

Test report, date:

UB 1.1 / 08 – 162 DHF boards from 15/08/2008

Result: Determination of elutable heavy metals was performed according to EN 71-3. The following values were determined [mg/kg]: Antimony <1, Arsenic <0.5, Barium 16, Cadmium 0.19, Chrome <0.2, Lead <0.5, Mercury <0.01, Selenium <1.

8.4 Toxicity of fire gases

Testing institute: MFPA Leipzig GmbH, Division I – Construction Materials

Accredited testing laboratory, Leipzig Institute for Materials Research and Testing for the construction industry, Leipzig, Germany

Test report, date: UB 1.1 / 08 – 162 for DHF boards from 15/08/2008

Result: The determination of toxic fire gases was performed according to DIN 4102 part 1 – class A at 400° C. The results show that after 30 minutes, 7200 ppm of carbon monoxide was measured in the inhalation space, while all other chemical compounds were not detectable within this timeframe. After 60 minutes, the following concentrations were found in the inhalation space: Carbon monoxide 20 000 ppm (hence calculated >50% COHb), carbon dioxide 12 000 ppm, ammonia not detectable (n.d.), and hydrocarbons (styrol) 300 ppm. Hydrogen chloride was not detectable (n.d.). The relative weight reduction at a test temperature of 400° C was 63.9 %.

At the end of the test, dense yellow smoke was present in the inhalation space.

The hydrogen cyanide concentration (HCN detection limit of 2 ppm) corresponds to the concentration which is also emitted from wood under the same test conditions.

The gaseous emissions released under the selected test conditions largely correspond to the emissions released from wood under the same test conditions.

8.5 EOX (extractable organic halogen compounds)

Testing institute: MFPA Leipzig GmbH, Division I – Construction Materials

Accredited testing laboratory, Leipzig Institute for Materials Research and Testing for the construction industry, Leipzig, Germany

Test report, date:

UB 1.1 / 08 – 162 for DHF boards from 15/08/2008

Result: Determination of the extractable organic compounds (EOX) was performed according to DIN 38414-S17 and resulted in a measured value <2 mg/kg.

8.6 PCP / Lindane

Testing institute: WKI Fraunhofer Wilhelm-Klauditz-Institute

Testing, monitoring, and certification site, Brunswick, Germany

Test report, date:

B1639/08 external monitoring of the PCP and lindane content from 16/05/2008

Result: PA-C-12:2006-02 "Determining the pentachlorophenol (PCP) and γ-Hexachlorocyclohexane (lindane) in wood and wood-based materials": After extraction of the contained substances, the solutions were separated, processed, and then analysed using gas chromatography.

The values for PCP and lindane are below the detection limit of 0.1 mg/kg.

9 PCR Document and Verification

The declaration is based on the PCR document "Wood-based materials", year 2008.

Review of the PCR document by the expert committee. Chairman of the expert committee: Prof. Dr.-Ing. Hans-Wolf Reinhardt (University of Stuttgart, IWB (Institute for Materials in Construction))
Independent verification of the declaration according to ISO 14025: ☐ internal ☒ external
Validation of the declaration: Dr. Frank Werner

10 References

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For further literature see the PCR document

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