Environmental product declaration

In accordance with ISO 14025 and EN 15804:2012+A2:2019 for:

Straw as insulation material- UK

Up-Straw - Straw Building UK (SBUK)

Calculation number:		EPD-NIBE-20210706-20460
EPD-registration number:	S-P-03854	S-P-03854
Generation on:		15-10-2021
Issue date:		15-10-2021
Revision date:		20/01/2025 (version 3)
Valid until:		15-10-2026
Status:		Valid

Table of content

1 General

1.1 COMPANY INFORMATION / DECLARATION OWNER

EPD owner: Straw Building UK (SBUK)

Straw Building UK (SBUK) is a membership association of practitioners, designers, academics and enthusiasts who work together to provide a voice to increase the uptake of straw-bale building across the UK, and to provide best practice information and technical resources relatign to straw construction.

Address: Memory cottage, Church lane, Ringsfield, Beccles, Suffolk, NR348JY, UK

E-mail: general@strawbuildinguk.org

SBUK Website: https://www.strawbuildinguk.org/

Website of LCA Practitioner: http://www.nweurope.eu/projects/project-search/up-straw-urban-and-public- buildings-in-straw/

Production Location: Interreg Up-Staw – UK

Other: This LCA is made based on and in cooperation with the Up-Straw: Urban and Public Buildings in Straw research programme.

1.2 EPD INFORMATION

Product name: Straw as insulation material- UK

Calculation number: EPD-NIBE-20210706-20460

Generation on: 15-10-2021

Date of issue: 15-10-2021

End of validity: 15-10-2026

Version NIBE's EPD Application: v2.0

Version Environmental Profile database: v3.04 (2021-07-06)

PCR: EN15804:2019+A2 + EN 16783:2017

1.3 EPD PUBLISHER

Programme: The International EPD® System, www.environdec.com

Programme operator: EPD International AB

EPD registration number: S-P-03854

1.4 CALCULATION BASIS

LCA Method: EN15804:2019+A2

LCA Software: Simapro 9.1.1

Characterization method: EN 15804 +A2 Method v1.0

LCA database profiles: EcoInvent version 3.6

Version database: v3.04 (2021-07-06)

1.5 PURPOSE AND TARGET GROUPS

The purpose of this LCA is to compile environmental data of materials and products used in the built environment. So that the environmental data can be used in calculations of buildings and / or civil works or an LCA of the final product.

The purpose of this report is to draw up a review dossier for the product accordance with the EN15804:2012+A2:2019. This standard defines a standardised method for a LCA in Europe, of a product used in the build environment. The review dossier is also in accordance with ISO14040 and ISO14044, as well as with other requirements as mentioned in General Programme Instructions in the International EPD® System.

The target groups of this LCA study are users of EPD's in accordance with the EN15804:2012+A2:2019, ISO14040 and ISO14044, such as B2B.

The EPD owner has the sole ownership, liability, and responsibility for the EPD.

EPDs within the same product category but from different programmes may not be comparable. EPDs of construction products may not be comparable if they do not comply with EN 15804. For further information about comparability, see EN 15804 and ISO 14025.

1 General

1.6 SCOPE OF DECLARATION

This is a cradle to grave with options EPD. The EPD is an average EPD: it is a national weighted average of the total UK national wheat and barley grain yields. It covers UK national averages of wheat and barley grain yields per hectare, with calculation of amount of straw per hectare; quantities of wheat and barley straw removed from fields and calculation of nutrients removed (as part of straw); fertiliser use by type, per hectare and per kg grain, for wheat and barley; pesticide use by type, per hectare and per kg grain, for wheat and barley; fuel use per hectare for all cereal crops (information on individual cereal types is not found). The source for this information is the UK government database, June 20.

The life cycle stages included are as shown below:
(X = included, MND = module not declared)

A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	X	X	X	MND	MND	MND	MND	X	X	X	X	X

The modules of the EN15804 contain the following:

Module A1 = Raw material supply	Module B5 = Refurbishment
Module A2 = Transport	Module B6 = Operational energy use
Module A3 = Manufacturing	Module B7 = Operational water use
Module A4 = Transport	Module C1 = De-construction / Demolition
Module A5 = Installation process	Module C2 = Transport
Module B1 = Emissions during use stage	Module C3 = Waste Processing
Module B2 = Maintenance	Module C4 = Final Disposal
Module B3 = Repair	Module D = Benefits and loads beyond the system boundaries
Module B4 = Replacement	

1.7 VERIFICATION OF THE DECLARATION

CEN standard EN 15804:2012 serves as the core PCR. PCR review was conducted by: Renuables Ltd, Andrew Norton, www.renuables.co.uk.

EPDs of construction products may not be comparable if they do not comply with NEN-EN15804 and additional PCR.

Independent third-party verification of the declaration and data, according to EN ISO 14025:2010.

☐ Internal ☒ External

1 General

1.8 STATEMENT REVISIONS

Version 2: On 10-12-2021 changes have been made in the EPD and background report relating to the biogenic carbon content. It appeared that the numbers were exchanged in the table. The following overview shows where and what changes have been made. Both the old text as well as the new is described, where in the new the changes are underlined.

Page 5 is the product description and also mentions the biogenic carbon content. The following sentence is changed "Biogenic carbon storage per kg is 0,3525 (kg C), 1,2925 (kg CO2), and per m3 is 129,25 (kg C), 35,25 (kg CO2), calculated according to the EN16449, an extended description can be found in the background report paragraph 3.6.".

It now reads "Biogenic carbon storage per kg is 0,3525 (kg C), 1,2925 (kg CO2), and per m3 is 35,25 (kg C), 129,25 (kg CO2), calculated according to the EN16449, an extended description can be found in the background report paragraph 3.6.".

Page 9 and 10 of the report state how the calculation is made.

- In the table the numbers are switched around, quantity stated 129,25 and CO_2-equivalent stated 35,25. It now states: "*Quantity 35,25 and CO_2-equivalent 129,25*".

Page numbers have changed, due to a double numbered page 4. Hence, the page numbers above in the statement revisions have been adjusted as well, from 'page 8 and 9' to 'page 9 and 10'.

The revision date on the front page is adjusted to match the new revision date, and a version is added so it is clear it is the newest version.

Eco platform has adjusted its logo and thus, this is changed as well. See front page, and page 3.

Version 3: On 20/01/2025 EPD owner updated in accordance with GPI 5 section 7.4.3, to reflect the transfer of ownership of the EPD from School of Natural Building (SnaB) to Straw Building UK (SBUK).

2 Product

2.1 PRODUCT DESCRIPTION

In this LCA, the production, including harvest, of 1 m3 of straw for the English market with a density of 100kg/m3 and a moist content of 20% is modelled. This concerns the production of grains (wheat and barley and the like) and harvest of said grains to collect straw for use as a building insulation material.

The pressed straw bales consist of wheat straw and barley and are tied with polypropylene cords. The agricultural method used for production is based on regular agriculture, i.e. the use of fertilisers and pesticides in the A1 profile for straw have been taken into account. There may therefore be a difference in the production of straw for other purposes or with other agricultural methods. The product thereby complies with the physical reality of the product as far as possible, in terms of geographical and technological coverage.

Technical information: The standard density applied is 100kg/m3. The assumed standard size of a bale is 36 x 48 x 80cm, this corresponds to 0,13824 m3 and has a weight of 13,824 kg. The standard thickness of straw when applied as insulation material is 37 cm, with a corresponding insulation value (R-value) of 7.1 Km2/ W. This results in a lambda-value of 0,052 (0,37 / 7.1 = 0,05211). This information is needed to calculated the Biogenic Carbon Content and for the Functional Unit.

Biogenic carbon storage per kg is 0,3525 (kg C), 1,2925 (kg CO2), and per m3 is 35,25 (kg C), 129,25 (kg CO2), calculated according to the EN16449, an extended description can be found in the background report paragraph 3.6.

2.2 DESCRIPTION OF THE MANUFACTURING PROCESS

Production

Straw profile (Straw, Average production UK; 67% Wheat, 33% Barley)

The data provided covers UK National averages of wheat and barley grain yields per hectare, with separate calculations of:

- the amount of straw per hectare;
- the quantities of wheat and barley straw removed from fields and a calculation of nutrients removed (as part of the straw)
- fertiliser use by type, per hectare and per kg of grain, for wheat and barley;
- fuel use per hectare for all cereal crops (information on individual cereal types is not found).

The EcoInvent profile for barley and wheat already include processes for:

- Cultivating;
- Sowing;
- Wrapping;
- Fertilisers and pesticides;
- Irrigation;
- Harvesting;

Information is not obtained for all these processes separately, where possible the information is adjusted with information provided through the national averages, otherwise the information from the EcoInvent environmental processes is used. The following process are used and modified:

1. Straw {CH}| barley production, Swiss integrated production, intensive | Cut-off, U;
2. Straw {RoW}| wheat production | Cut-off, U.

Construction

The bales are manually stacked together with a assumed standard thickness of 37 cm. Corresponding in an insulation value (R-value) of 7.1 Km2/W, lambda-value of 0,052 W/mK. After stacking the surface is flattened with an (electric) saw. Losses from the sawing are collected and put together to fill in holes between the bales. Therefore the amount of losses during construction are negligible and modelled as 0%, this deviates from the PCR as that states 2% waste during construction. The amount of energy required for the saw is expected to be very low and therefore it's assumed that it's within the cut-of-criteria of 1%.

The amount of attachment- and other installation materials, such as lath and battens, screws, plaster etc. depends on the construction technique. Due to the great variety in construction techniques it's decided to exclude these processes from the LCA. They need to be added when an EPD is made of the facade-system.

In general the following products might be added if the straw is applied in a wall or roof:

- A vapour barrier;
- Wood frame (battens and/or thicker beams);
- OSB panels or fiberboard (or the like);
- Plaster (either lime or earth plasters).

Transport to the construction stage consists the following:

Transport conveyance	Distance	Weight x distance
Lorry (Truck), unspecified (default)	0 km	0 tkm

2 Product

2.3 REFERENCE SERVICE LIFE

RSL Product

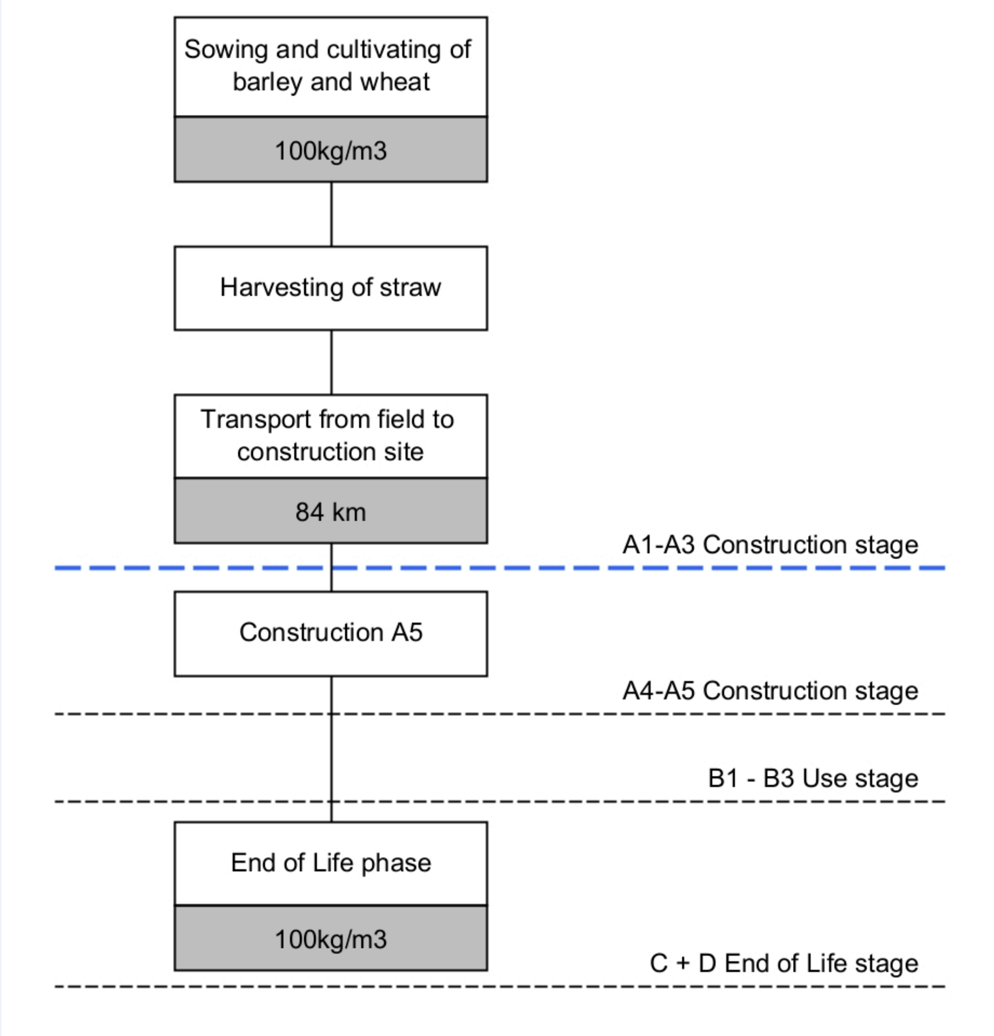
If the straw is processed dry and it is properly protected against rain and moisture, it will have a very long lifetime expectancy. There are examples of more than 100 years old strawbuildings to prove this. The UK does not have specific requirements or regulations on standardised lifetime expectancy. Based on industry experience in the UK and in historic straw buildings in other countries we would say that straw as insulation would last the lifetime of the building it is used in (potentially beyond, if re-used in a new building).

To be conservative, the lifespan for this LCA has been set at 75 years.

RSL parts

There are no separate product parts therefore a reference does not apply here

2.4 PRODUCT FLOW DIAGRAM



3 Calculation rules

3.3 FUNCTIONAL AND DECLARED UNIT

A cubic meter of straw applied as insulation material

Declared unit: cubic meter (m3)

One cubic meter of straw, corresponding to a density of 100 kg/m3, with a moist content of 20% and a lambda-value of 0,052 applied as insulation material for 75 years. Packaging material is included. Attachment- and other installation materials are excluded as they depend on the design..

3.4 ENVIRONMENTAL PROFILE AND RATINGS REPRESENTATIVE

The input data are representative for Straw as insulation material- UK, a product of the research group Up-Straw. The data are representative for the United Kingdom.

The input data is directly provided by the client or from literature of which the client has confirmed that it's representative for their product. The scenarios included are currently in use and are representative for one of the most probable alternatives.

All environment profiles are modelled using the background database EcoInvent 3.6.

This material contains no materials listed in the Candidate List of Substances of Very High Concern (SVHC) by REACH.

Appropriateness of generic data

Temporal - Very good (1): data is collected over the year 2019.

Geographical - Very good (1): data is collected specifically for the United Kingdom.

Technological - Fair (3): Data was not specified as extensively as some generic EcoInvent data. Where possible, generic data is replaced by more detailed information representative for the UK, such as the amount of N-fertilizers, for the non-specific data worst case assumptions have been made.

3.5 CUT-OFF CRITERIA

Production phase (A1-A3)

The production stage consists of the production and extraction of raw materials, including all additional steps for the growth of straw, transportation of the raw materials, processing the raw materials into materials and the production of the product. The system boundary to nature is considered and included in the Eco-Invent processes. The required energy for production, external treatments, ancillary materials, packaging material and production emissions are included.

Construction process phase (A4-A5)

This stage consists the transport of the product from production plant / agricultural site to the construction site. It also includes the loss of material during construction. The additional needed production, transport and end-of-life of the lost material during construction is included.

The end-of-life of packaging material up to the end-of-waste state or disposal of final residues is also included.

The installation of the product including manufacture, transportation and end-of-life of ancillary materials and any energy or water use required for installation or operation of the construction site are taken into account.

User phase (B1-B3)

This stage consists of the impacts arising from components of the building and construction works during their use. These stages are not considered in this LCA, as the module is not relevant for the study of this LCA.

The stage also covers the combination of all planned technical and associated administrative maintenance actions during the service life to maintain the product installed in a building, in a construction works or its parts in a state in which it can perform its required functional and technical performance, as well as preserve the aesthetic qualities of the product. This will include preventative and regular maintenance activities.

Product replacement (B4) and renovation (B5) only apply when the product is considered in a lifespan (of a building, work , etc.).

Operational water and energy use (B6-B7) are not considered.

End of life phase (C1-C4)

When the end of the life stage of the building is reached, the de-construction/demolition begins. This EPD includes de-construction/demolition (C1), the necessary transport (C2) from the demolition site to the sorting location and distance to final disposal. The end of life stage includes the final disposal to landfill (C4), incineration (C3) and needed recycling processes up to the end-of-waste point (C3). Loads and benefits of recycling, re-use and exported energy are part of module D.

The default end-of-life scenarios of the annex (November 2020) to the NMD Determination method v1.0 have been used for the various materials in the product and are described in more detail in chapter 5.

Benefits and Loads beyond the system boundary (Module D)

This stage contains the potential loads and benefits of recycling and re-use of raw materials/products. The loads contain the needed recycling processes from end-of-waste-point up to the point-of-equivalence of the substituted primary raw material and a load for secondary material that will be lost at the end-of-life stage.

The loads and benefits of recycling and reuse are included in this module. The benefits are calculated based on the primary content and the primary equivalent.

3 Calculation rules

In addition, the benefits of energy recovery are granted at this stage. The amount of avoided energy is based on the Lower Heating Values of the materials and the efficiencies of the incinerators as mentioned in the NMD Determination method v1.0 or EcoInvent 3.6 (2019).

List of excluded processes in this LCA:

- Installation materials (A5) as they depend on design;
- User-phase (module B) as the module is not relevant for the study of this LCA;
- Deconstruction processes (C1) as they depend on design.

3.3 ALLOCATION

In the case of joint co-production, where the processes cannot be sub-divided, allocation shall respect the main purpose of the processes studied, allocating all relevant products and functions appropriately. In the case of this study, straw cannot be produced without producing wheat and grains.

The EN 15 804 states that allocation shall be based on physical properties (e.g. mass or volume) when the difference in revenue from the co-products is low, in other cases allocation shall be based on economic values. Information on the yields per hectare show that the difference in revenue between straw and grain yield are high, over 25%, therefore economic allocation is applied.

Analysing the UK Government information gives a weighted average of the total UK national wheat and barley grain yields and is therefore reliable. This information represents the declared amounts in the EPD.
Analysing this information results in an allocation of 86% to grain and 14% to straw.

Barley

The profile-inputs in the EcoInvent process-card of straw are corrected with a factor of 1,48005. This is done because the allocation between the Barley grain EcoInvent profile (on which straw is based) and that of Barley-straw already contain an allocation factor (10%). But this allocation is smaller than given through the national data (15,18%). 10/15,18 = 1,48005. Information on this step can be found in the "….. In- & output.xlsx"-files.

Wheat

The profile-inputs in the EcoInvent process-card of straw are corrected with a factor of 2,35629. This is done because the allocation between the wheat-grain EcoInvent profile (on which straw is based) and that of wheat-straw already contain an allocation factor (5%). But this allocation is smaller than given through the national data (12,85%). 5/12,85 = 2,35629. Information on this step can be found in the "….. In- & output.xlsx"-files.

Reproducibility
The full calculation and the modification of the top processes is reported in the background file, which is shared separately with the verifier.

Presentation and justification

Allocations in the use of secondary materials or secondary fuels as raw materials are not performed.

Allocations in the plant (allocation between different products/production lines in a plant) is performed, "plant" is synonym for "on the field"; where wheat and grains are cultivated and harvested.

Allocation of multi-input processes (e.g. landfilling or incineration) is performed, and only calculated over the allocated input of A1-A3.

Allocation process for reuse, recycling and recovery

We assume that the process (straw) does not need to be worked up before the EOL stageis reached, meaning that the straw reaches its EOL stage directly after demolishing the real estate it is been processed in.

The EcoInvent processes quoted in chapter 6 for C3-C4 and the selected substituted processes in Module D are considered representative for this LCA, no specific data isavailable for the United Kingdom. A sensitivity analysis is performed, see chapter 9.

The calculation of net flows is based on a lower heat value of 14,67 MJ/kg, see 5.13 Benefitsand loads beyond the system boundary (D). Thereby adhering to a conservative approachfor the benefits of energy recovering by selecting "wood chips" as most representative avoided energy source.

Biogenic carbon content wheat-straw

Biogenic carbon content of the straw has been calculated according to the EN16449: Wood and wood-based products - Calculation of the biogenic carbon content of wood andconversion to carbon dioxide. The formula to calculate the carbon content: PC=Cf*((Pw*Vw)/1+(W/100))

- PC: the biogenic carbon oxidized as carbon dioxide emission form the product system into the atmosphere (e.g. energy use at the end-of-life) (expressed in kg,used amount 37 kg)
- Cf: the carbon fraction of biomass (oven dry mass), 0,423 as found in an Indian research publication (Kumar et al. 2014, table 3)
- Pw: the density of biomass of the product at that moisture content (expressed inkg/m3, used amount 100 kg/m3)
- Vw: the volume of the product at that moisture content (expressed in kg/m3, used amount 0,37 kg/m3)

3 Calculation rules

- W: the moisture content of the product (expressed in %, used amount 20%)
- Results: 37 kg stores a carbon content of 13,04 kg C and 47,82 kg CO2.

=((0,37*100)/(1+(20/100))*0,423*(44/12))

Information on biogenic carbon content

Results per functional or declared unit (m3)			
BIOGENIC CARBON CONTENT	Unit	QUANTITY	CO_2-equivalent
Biogenic carbon content in product	kg C	35,25	129,25
Biogenic carbon content in packaging	kg C	0	0

Note: 1 kg biogenic carbon is equivalent to 44/12 kg CO_2.

There is a difference between the maintained straw profile used for the LCA (-0,22784239) and the generic waste treatment profile used in the LCA (1,46065496973853) and the calculated amount of emissions released as biogenic carbon (1,2925). As a result, the quantities in phase A1 and C3 do not match, although in reality these will have to be in balance.

A correction factor is applied by adjusting the process used in A1. The process is adjusted in Simapro by adding emissions to air Carbon dioxide, biogenic. The process used already contains a negative biogenic carbon of -0,2278 kg. However, our calculation shows that is should be -1,2925 kg. Thus, an extra emission is added in the process in Simapro to correct this value: -1,2925 - -0,22784239 = -1,06465761.

Emissions to air	Value	Unit
Carbon dioxide, biogenic	-1,06466	kg/kg

A correction factor is applied by adjusting the process used in C3. The process is adjusted in Simapro by adding emissions to air Carbon dioxide, biogenic. The process used in the waste scenario accounts for the burning of wood, this is an overestimation compared to straw. The original process shows that the carbon content is 1,46 kg CO2 equivalent. Thus the process is adjusted to match our calculated value of 1,2925 kg; 1,2925 - 1,46065497 = -0,16815497.

Emissions to air	Value	Unit
Carbon dioxide, biogenic	-0,16815497	kg/kg

This way, the biogenic carbon content of the straw is corrected. However, sub-processes used in the LCA may also contain biogenic content, such as the capital goods in the waste scenario. Therefore the end-value is not 0.

3 Calculation rules

3.4 SOURCE OF BACKGROUND DATA

Description	Shortened name in application	Processes used	Source	Third-party verified	Comments
Raw material(s) **1 kg Straw as insulation - UK**					
Straw (UK)	Straw A1-A3 UK (revisie allocatie juni 2020)	UK Straw (Straw, Average production UK; 67% Wheat, 33% Barley)	NIBE/EcoInvent 3.6	no	

4 Results

4.1 DECLARED UNIT (m3)

Impact category	Unit	Total Amount
Global warming potential - Fossil (GWP-f)	kg CO2 eq.	1,03E+01
Global warming potential - Biogenic (GWP-b)	kg CO2 eq.	-2,58E+00
Global warming potential - Land use and land use change (GWP-luluc)	kg CO2 eq.	-4,88E-02
Global warming potential (GWP-total)	kg CO2 eq.	7,63E+00
Ozone depletion (ODP)	kg CFC 11 eq.	-9,17E-08
Acidification (AP)	mol H+ eq.	-4,71E-03
Eutrophication, freshwater (EP-fw)	kg PO43- eq.	ND
Eutrophication, freshwater (EP-fw)	kg P eq.	4,16E-03
Eutrophication marine (EP-m)	kg N eq.	7,60E-02
Eutrophication, terrestrial (EP-T)	mol N eq.	-1,56E-01
Photochemical ozone formation - human health (POCP)	kg NMVOC eq.	-5,89E-02
Resource use, minerals and metals (ADP-mm)	kg Sb eq.	3,32E-04
Resource use, fossils (ADP-f)	MJ	5,78E+01
Water use (WDP)	m3	7,73E+01
Potential environmental impact – additional mandatory and voluntary indicators		
Global warming potential - Fossil (GWP-f)	kg CO2 eq.	1,03E-01
Ecotoxicity, freshwater (ETP-fw)	CTUe	-1,31E+03
Particulate Matter (PM)	disease incidence	-1,14E-06
Human toxicity, cancer (HTP-c)	CTUh	2,35E-08
Human toxicity, non-cancer (HTP-nc)	CTUh	-5,05E-08
Ionising radiation, human health (IR)	kBq U235 eqv.	1,53E-01
Land use (SQP)	Pt	-5,71E+03

4 Results

Parameter	Unit	Total Amount
Use of resources		
renewable primary energy ex. raw materials	MJ	-2,73E+03
renewable primary energy used as raw materials	MJ	1,47E+03
renewable primary energy total	MJ	-1,26E+03
non-renewable primary energy ex. raw materials	MJ	6,23E+01
non-renewable primary energy used as raw materials	MJ	0,00E+00
non-renewable primary energy total	MJ	6,23E+01
use of secondary material	Kg	0,00E+00
use of renewable secondary fuels	MJ	0,00E+00
use of non-renewable secondary fuels	MJ	0,00E+00
use of net fresh water	M3	2,30E+00
Waste production and output flows	**Unit**	**Total Amount**
Waste production		
hazardous waste disposed	Kg	3,55E-05
non hazardous waste disposed	Kg	7,01E+00
radioactive waste disposed	Kg	1,74E-04
Output flows		
Components for re-use	Kg	0,00E+00
Materials for recycling	Kg	0,00E+00
Materials for energy recovery	Kg	0,00E+00
Exported Energy Thermic	MJ	4,32E+02
Exported Energy Electric	MJ	2,51E+02

4 Results

4.2 PRODUCT STAGE (A1 - 3)

- A1. raw material extraction and processing. processing of secondary material input (e.g. recycling processes
- A2. transport to the manufacturer
- A3. Manufacturing
- Environmental impacts are calculated for 1m3 of straw.

Impact category	Unit	A1	A2	A3
Global warming potential - Fossil (GWP-f)	kg CO2 eq.	1,18E+01	1,13E+00	0,0E+00
Global warming potential - Biogenic (GWP-b)	Kg CO2 eq.	-1,29E+02	5,23E-04	0,0E+00
Global warming potential - Land use and land use change (GWP-luluc)	kg CO2 eq.	1,67E-02	4,15E-04	0,0E+00
Global warming potential (GWP-total)	kg CO2 eq.	-1,17E+02	1,13E+00	0,0E+00
Ozone depletion (ODP)	kg CFC 11 eq.	7,96E-07	2,50E-07	0,0E+00
Acidification (AP)	mol H+ eq.	1,36E-01	6,57E-03	0,0E+00
Eutrophication, freshwater (EP-fw)	kg PO43- eq.	ND	ND	ND
Eutrophication, freshwater (EP-fw)	kg P eq.	4,68E-03	1,14E-05	0,0E+00
Eutrophication marine (EP-m)	kg N eq.	1,05E-01	2,32E-03	0,0E+00
Eutrophication, terrestrial (EP-T)	mol N eq.	5,25E-01	2,55E-02	0,0E+00
Photochemical ozone formation - human health (POCP)	kg NMVOC eq.	3,75E-02	7,29E-03	0,0E+00
Resource use, minerals and metals (ADP-mm)	kg Sb eq.	3,33E-04	2,87E-05	0,0E+00
Resource use, fossils (ADP-f)	MJ	7,03E+01	1,71E+01	0,0E+00
Water use (WDP)	m3	7,74E+01	6,12E-02	0,0E+00
Potential environmental impact – additional mandatory and voluntary indicators				
Global warming potential - Fossil (GWP-f)	kg CO2 eq.	1,18E-01	1,13E-02	0,0E+00
Ecotoxicity, freshwater (ETP-fw)	CTUe	4,46E+02	1,52E+01	0,0E+00
Particulate Matter (PM)	disease incidence	8,99E-07	1,02E-07	0,0E+00
Human toxicity, cancer (HTP-c)	CTUh	1,50E-08	4,94E-10	0,0E+00
Human toxicity, non-cancer (HTP-nc)	CTUh	5,74E-07	1,67E-08	0,0E+00
Ionising radiation, human health (IR)	kBq U235 eqv.	2,20E-01	7,16E-02	0,0E+00
Land use (SQP)	Pt	1,47E+03	1,48E+01	0,0E+00

4 Results

Parameter	Unit	A1	A2	A3
Use of resources				
renewable primary energy ex. raw materials	MJ	-1,21E+03	2,14E-01	0,0E+00
renewable primary energy used as raw materials	MJ	1,47E+03	0,00E+00	0,0E+00
renewable primary energy total	MJ	2,53E+02	2,14E-01	0,0E+00
non-renewable primary energy ex. raw materials	MJ	7,56E+01	1,82E+01	0,0E+00
non-renewable primary energy used as raw materials	MJ	0,00E+00	0,00E+00	0,0E+00
non-renewable primary energy total	MJ	7,56E+01	1,82E+01	0,0E+00
use of secondary material	Kg	0,00E+00	0,00E+00	0,0E+00
use of renewable secondary fuels	MJ	0,00E+00	0,00E+00	0,0E+00
use of non-renewable secondary fuels	MJ	0,00E+00	0,00E+00	0,0E+00
use of net fresh water	M3	2,27E+00	2,08E-03	0,0E+00
Waste production and output flows	**Unit**			
Waste production				
hazardous waste disposed	Kg	1,34E-04	4,33E-05	0,0E+00
non hazardous waste disposed	Kg	1,09E+00	1,08E+00	0,0E+00
radioactive waste disposed	Kg	2,79E-04	1,12E-04	0,0E+00
Output flows				
Components for re-use	Kg	0,00E+00	0,00E+00	0,0E+00
Materials for recycling	Kg	0,00E+00	0,00E+00	0,0E+00
Materials for energy recovery	Kg	0,00E+00	0,00E+00	0,0E+00
Exported Energy Thermic	MJ	0,00E+00	0,00E+00	0,0E+00
Exported Energy Electric	MJ	0,00E+00	0,00E+00	0,0E+00

4 Results

4.3 CONSTRUCTION PROCESS STAGE (A4 - 5)

- A4. transport to the building site
- A5. installation into the building

Impact category	Unit	A4	A5
Global warming potential - Fossil (GWP-f)	kg CO2 eqv.	0,00E+00	0,00E+00
Global warming potential - Biogenic (GWP-b)	kg CO2 eqv.	0,00E+00	0,00E+00
Global warming potential - Land use and land use change (GWP-luluc)	kg CO2 eqv.	0,00E+00	0,00E+00
Global warming potential (GWP-total)	kg CO2 eqv.	0,00E+00	0,00E+00
Ozone depletion (ODP)	kg CFC 11 eq.	0,00E+00	0,00E+00
Acidification (AP)	mol H+ eq.	0,00E+00	0,00E+00
Eutrophication, freshwater (EP-fw)	kg PO43- eq.	ND	ND
Eutrophication, freshwater (EP-fw)	kg P eq.	0,00E+00	0,00E+00
Eutrophication marine (EP-m)	kg N eq.	0,00E+00	0,00E+00
Eutrophication, terrestrial (EP-T)	mol N eq.	0,00E+00	0,00E+00
Photochemical ozone formation - human health (POCP)	kg NMVOC eq.	0,00E+00	0,00E+00
Resource use, minerals and metals (ADP-mm)	kg Sb eq.	0,00E+00	0,00E+00
Resource use, fossils (ADP-f)	MJ	0,00E+00	0,00E+00
Water use (WDP)	m3	0,00E+00	0,00E+00
Potential environmental impact – additional mandatory and voluntary indicators			
Global warming potential - Fossil (GWP-f)	kg CO2 eq.	0,00E+00	0,00E+00
Ecotoxicity, freshwater (ETP-fw)	CTUe	0,00E+00	0,00E+00
Particulate Matter (PM)	disease incidence	0,00E+00	0,00E+00
Human toxicity, cancer (HTP-c)	CTUh	0,00E+00	0,00E+00
Human toxicity, non-cancer (HTP-nc)	CTUh	0,00E+00	0,00E+00
Ionising radiation, human health (IR)	kBq U235 eqv.	0,00E+00	0,00E+00
Land use (SQP)	Pt	0,00E+00	0,00E+00

4 Results

Parameter	Unit	A4	A5
Use of resources			
renewable primary energy ex. raw materials	MJ	0.00E+0	0.00E+0
renewable primary energy used as raw materials	MJ	0.00E+0	0.00E+0
renewable primary energy total	MJ	0.00E+0	0.00E+0
non-renewable primary energy ex. raw materials	MJ	0.00E+0	0.00E+0
non-renewable primary energy used as raw materials	MJ	0.00E+0	0.00E+0
non-renewable primary energy total	MJ	0.00E+0	0.00E+0
use of secondary material	Kg	0.00E+0	0.00E+0
use of renewable secondary fuels	MJ	0.00E+0	0.00E+0
use of non-renewable secondary fuels	MJ	0.00E+0	0.00E+0
use of net fresh water	M3	0.00E+0	0.00E+0
Waste production and output flows	**Unit**		
Waste production			
hazardous waste disposed	Kg	0.00E+0	0.00E+0
non hazardous waste disposed	Kg	0.00E+0	0.00E+0
radioactive waste disposed	Kg	0.00E+0	0.00E+0
Output flows			
Components for re-use	Kg	0.00E+0	0.00E+0
Materials for recycling	Kg	0.00E+0	0.00E+0
Materials for energy recovery	Kg	0.00E+0	0.00E+0
Exported Energy Thermic	MJ	0.00E+0	0.00E+0
Exported Energy Electric	MJ	0.00E+0	0.00E+0

TRANSPORT TO CONSTRUCTION SITE (A4)

The average distance travelled from source to building site in the UK is 52 miles / 84 km. This is all by road, none by rail. Straw is directly transported from field to construction site, therefore transportation in A4 is left empty and transportation is modelled in phase A2. There is not an official source forthis information, it comes from the Sustainable Building Consultancy.

CONSTRUCTION STAGE (A5)

The amount of attachment- and other installation materials, such as lath and battens, screws, plaster etc. depends on the construction technique. Due to the great variety in construction techniques it's decided to exclude these processes from the LCA. No scenarios are created. They need to be added when an EPD is made of the facade-system. For full transparency, the scenarios used in the Up-Straw project have been added to the project file for informative purposes. It is thereby not said that these will be considered in reality.

Input flow(s) construction stage: There are no (significant) raw material, energy or transport inputs needed in the construction stage.

Waste flow(s) product: Waste output flows as a result of losses at the construction site is assumed to be 0%.

4 Results

A4. transport to the building site

Parameter	Unit / functional unit
Fuel type and consumption of vehicle – or – vehicle type used for transport	not available Lorry (Truck), unspecified (default)
Distance	0 km
Capacity utilisation (including empty returns)	50 % (loaded up and return empty)
Bulk density of transported products	inapplicable
Volume capacity utilisation factor	1

A5. installation of the product in the building

Parameter	Unit / functional unit
Ancillary materials, water use and energy use for installation	
Waste materials on the building site before waste processing generated by the product's installation	
Output materials as result of waste processing at the building site	0% of Straw as insulation material- UK

4 Results

4.4 USE STAGE (B1 - 7)

- B1, use or application of the installed product
- B2, maintenance
- B3, repair
- B4, replacement (m.n.d.)
- B5, refurbishment (m.n.d.)
- B6, operational energy use (m.n.d.)
- B7, operational water use (m.n.d.)

Impact category	Unit	B1	B2	B3	B4	B5	B6	B7
Global warming potential - Fossil (GWP-f)	kg CO2 eqv.	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Global warming potential - Biogenic (GWP-b)	kg CO2 eqv.	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Global warming potential - Land use and land use change (GWP-luluc)	kg CO2 eqv.	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Global warming potential (GWP-total)	kg CO2 eqv.	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Ozone depletion (ODP)	kg CFC 11 eq.	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Acidification (AP)	mol H+ eq.	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Eutrophication, freshwater (EP-fw)	kg PO43- eq.	ND	ND	ND	ND	ND	ND	ND
Eutrophication, freshwater (EP-fw)	kg P eq.	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Eutrophication marine (EP-m)	kg N eq.	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Eutrophication, terrestrial (EP-T)	mol N eq.	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Photochemical ozone formation - human health (POCP)	kg NMVOC eq.	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Resource use, minerals and metals (ADP-mm)	kg Sb eq.	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Resource use, fossils (ADP-f)	MJ	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Water use (WDP)	m3	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Potential environmental impact – additional mandatory and voluntary indicators								
Global warming potential - Fossil (GWP-f)	kg CO2 eq.	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Ecotoxicity, freshwater (ETP-fw)	CTUe	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Particulate Matter (PM)	disease incidence	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Human toxicity, cancer (HTP-c)	CTUh	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Human toxicity, non-cancer (HTP-nc)	CTUh	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Ionising radiation, human health (IR)	kBq U235 eqv.	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND
Land use (SQP)	Pt	0,00E+00	0,00E+00	0,00E+00	MND	MND	MND	MND

4 Results

Parameter	Unit	B1	B2	B3	B4	B5	B6	B7
Use of resources								
renewable primary energy ex. raw materials	MJ	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
renewable primary energy used as raw materials	MJ	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
renewable primary energy total	MJ	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
non-renewable primary energy ex. raw materials	MJ	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
non-renewable primary energy used as raw materials	MJ	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
non-renewable primary energy total	MJ	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
use of secondary material	Kg	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
use of renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
use of non-renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
use of net fresh water	M3	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
Waste production and output flows	**Unit**							
Waste production								
hazardous waste disposed	Kg	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
non hazardous waste disposed	Kg	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
radioactive waste disposed	Kg	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
Output flows								
Components for re-use	Kg	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
Materials for recycling	Kg	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
Materials for energy recovery	Kg	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
Exported Energy Thermic	MJ	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND
Exported Energy Electric	MJ	0.00E+0	0.00E+0	0.00E+0	MND	MND	MND	MND

4 Results

B2 Maintenance

Parameter	Unit / functional unit
Maintenance process and cycle	
Ancillary materials and energy input for maintenance	

B3 Repair

Parameter	Unit / functional unit
Repair process	Repair of the parts;
Repair cycle	Amount for product reference service life of 75 years:
Waste materials resulting from repair	Amount for product reference service life of 75 years:

Reference Service Life

Parameter	RSL
Product: Straw as insulation material- UK	75 years
Straw (UK) | Straw A1-A3 UK (revisie allocatie juni 2020)	75 years

4 Results

4.5 END OF LIFE STAGE (C1 - 4)

- C1. de-construction. Demolition (m.n.d.)
- C2. transport to waste processing
- C3. waste processing for reuse. recovery and/or recycling (m.n.d.)
- C4. disposal

Impact category	Unit	C1	C2	C3	C4
Global warming potential - Fossil (GWP-f)	kg CO2 eqv.	0,0E+00	1,99E+00	8,35E-01	3,00E-01
Global warming potential - Biogenic (GWP-b)	kg CO2 eqv.	0,0E+00	9,19E-04	1,23E+02	4,49E+00
Global warming potential - Land use and land use change (GWP-luluc)	kg CO2 eqv.	0,0E+00	7,29E-04	2,25E-04	9,01E-05
Global warming potential (GWP-total)	kg CO2 eqv.	0,0E+00	1,99E+00	1,24E+02	4,79E+00
Ozone depletion (ODP)	kg CFC 11 eq.	0,0E+00	4,39E-07	1,07E-07	1,80E-08
Acidification (AP)	mol H+ eq.	0,0E+00	1,15E-02	2,97E-02	8,98E-04
Eutrophication, freshwater (EP-fw)	kg PO43- eq.	ND	ND	ND	ND
Eutrophication, freshwater (EP-fw)	kg P eq.	0,0E+00	2,01E-05	1,70E-05	2,69E-05
Eutrophication marine (EP-m)	kg N eq.	0,0E+00	4,07E-03	1,38E-02	6,35E-03
Eutrophication, terrestrial (EP-T)	mol N eq.	0,0E+00	4,49E-02	1,58E-01	2,44E-03
Photochemical ozone formation - human health (POCP)	kg NMVOC eq.	0,0E+00	1,28E-02	4,14E-02	1,76E-03
Resource use, minerals and metals (ADP-mm)	kg Sb eq.	0,0E+00	5,04E-05	5,07E-06	7,46E-07
Resource use, fossils (ADP-f)	MJ	0,0E+00	3,00E+01	8,62E+00	1,70E+00
Water use (WDP)	m3	0,0E+00	1,07E-01	3,04E-01	5,92E-02
Potential environmental impact – additional mandatory and voluntary indicators					
Global warming potential - Fossil (GWP-f)	kg CO2 eq.	0,0E+00	1,99E-02	8,35E-03	3,00E-03
Ecotoxicity, freshwater (ETP-fw)	CTUe	0,0E+00	2,68E+01	2,14E+01	2,56E+01
Particulate Matter (PM)	disease incidence	0,0E+00	1,79E-07	2,39E-07	1,05E-08
Human toxicity, cancer (HTP-c)	CTUh	0,0E+00	8,68E-10	2,80E-08	1,60E-10
Human toxicity, non-cancer (HTP-nc)	CTUh	0,0E+00	2,93E-08	8,86E-08	7,75E-09
Ionising radiation, human health (IR)	kBq U235 eqv.	0,0E+00	1,26E-01	2,18E-02	6,82E-03
Land use (SQP)	Pt	0,0E+00	2,60E+01	2,78E+00	3,05E+00

4 Results

Parameter	Unit	C1	C2	C3	C4
Use of resources					
renewable primary energy ex. raw materials	MJ	0,0E+00	3,76E-01	3,84E-01	7,37E-02
renewable primary energy used as raw materials	MJ	0,0E+00	0,00E+00	0,00E+00	0,00E+00
renewable primary energy total	MJ	0,0E+00	3,76E-01	3,84E-01	7,37E-02
non-renewable primary energy ex. raw materials	MJ	0,0E+00	3,19E+01	9,28E+00	1,81E+00
non-renewable primary energy used as raw materials	MJ	0,0E+00	0,00E+00	0,00E+00	0,00E+00
non-renewable primary energy total	MJ	0,0E+00	3,19E+01	9,28E+00	1,81E+00
use of secondary material	Kg	0,0E+00	0,00E+00	0,00E+00	0,00E+00
use of renewable secondary fuels	MJ	0,0E+00	0,00E+00	0,00E+00	0,00E+00
use of non-renewable secondary fuels	MJ	0,0E+00	0,00E+00	0,00E+00	0,00E+00
use of net fresh water	M3	0,0E+00	3,66E-03	4,61E-02	1,56E-03
Waste production and output flows	**Unit**				
Waste production					
hazardous waste disposed	Kg	0,0E+00	7,61E-05	2,43E-05	5,64E-06
non hazardous waste disposed	Kg	0,0E+00	1,90E+00	6,21E-01	5,02E+00
radioactive waste disposed	Kg	0,0E+00	1,97E-04	2,61E-05	8,81E-06
Output flows					
Components for re-use	Kg	0,0E+00	0,00E+00	0,00E+00	0,00E+00
Materials for recycling	Kg	0,0E+00	0,00E+00	0,00E+00	0,00E+00
Materials for energy recovery	Kg	0,0E+00	0,00E+00	0,00E+00	0,00E+00
Exported Energy Thermic	MJ	0,0E+00	0,00E+00	0,00E+00	0,00E+00
Exported Energy Electric	MJ	0,0E+00	0,00E+00	0,00E+00	0,00E+00

DE-CONSTRUCTION, DEMOLITION (C1)
It's expected that deconstruction of the system is performed manually and therefore processes are excluded from the calculation.

No inputs are needed for the product at the de-construction / demolition phase

TRANSPORT END-OF-LIFE (C2)
The waste scenario used in the full LCA for the Up-straw study for waste from phases A3, A5 and C3-4 is the NMD waste scenario ID38: organic material, other (i.a. insulation).

4 Results

Scenario design
The NMD waste scenario ID38: organic material, other (i.a. insulation), which consists of the following disquisition: 5% landfill and 95% incineration is determined by the Dutch LCA-community in the PCR: Determination method “Environmental performance Building” Version 1.0 (July 2020) and represents the current flow of organic waste streams in the Netherlands. This standard waste-scenario includes prescribed transport-distances for every type of waste stream (landfill (100 km), incineration (150 km), recycling (50 km), re-use* (0 km) or to be left (0 km)). In this disquisition, it is assumed that in the Netherlands there will be more, but smaller recycling stations, rather than landfill sites or incineration installations. Thus, the mileage differs. The transport distances in this LCA are based on Dutch averages, as there is no data on these transport distances in the UK it's assumed that this is similar for the end-of-life scenario of straw bales in the UK.

*Re-use is assumed 0km, because the transportation needs to be included as A2 transportation in a new life-cycle analysis according to the PCR.

WASTE PROCESSING (C3)

The waste scenario used in the full LCA for the Up-straw study for waste from phases A3, A5 and C3-4 is the NMD waste scenario ID38: organic material, other (i.a. insulation).

Scenario design
The NMD waste scenario ID38: organic material, other (i.a. insulation), which consists of the following disquisition: 5% landfill and 95% incineration is determined by the Dutch LCA-community in the PCR: Determination method “Environmental performance Building” Version 1.0 (July 2020) and represents the current flow of organic waste streams in the Netherlands. The waste processing is based on the Dutch PCR as there is no data found on the waste processing in the UK. Thus, it's assumed that the distribution between landfill and incineration is the most representative information and applies to the UK as well.

However, a correction for biogenic content is applied, as the scenario assumes incineration of wood, which has a higher carbon content, see allocation for the correction factor.

This material contains no materials listed in the Candidate List of Substances of Very High Concern (SVHC) by REACH and therefore incineration may be carried out.

After demolition and transport of the waste streams to the applicable waste processing routes, the waste is processed for final disposal or recycling and/or reuse. The calculated quantities and the applicable end-of-life scenario are shown below.

FINAL DISPOSAL (C4)

The waste scenario used in the full LCA for the Up-straw study for waste from phases A3, A5 and C3-4 is the NMD waste scenario ID38: organic material, other (i.a. insulation).

Scenario design
The NMD waste scenario ID38: organic material, other (i.a. insulation), which consists of the following disquisition: 5% landfill and 95% incineration is determined by the Dutch LCA-community in the PCR: Determination method “Environmental performance Building” Version 1.0 (July 2020) and represents the current flow of organic waste streams in the Netherlands. The waste processing is based on the Dutch PCR as there is no data found on the waste processing in the UK. Thus, it's assumed that the distribution between landfill and incineration is the most representative information and applies to the UK as well. However, a correction for biogenic content is applied, as the scenario assumes incineration of wood, which has a higher carbon content, see allocation for the correction factor.

This material contains no materials listed in the Candidate List of Substances of Very High Concern (SVHC) by REACH and therefore incineration may be carried out.

4 Results

End - of - life

Processes	Unit / functional unit
Recovery system	0.00 kg for re - use 0.00 kg for recycling 0.00 kg for energy recovery
Disposal	0.00 kg of materials used in the product

4.6 BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY (D)

Impact category	Unit	D
Global warming potential - Fossil (GWP-f)	kg CO2 eqv.	-5,82E+00
Global warming potential - Biogenic (GWP-b)	kg CO2 eqv.	-6,01E-01
Global warming potential - Land use and land use change (GWP-luluc)	kg CO2 eqv.	-6,70E-02
Global warming potential (GWP-total)	kg CO2 eqv.	-6,49E+00
Ozone depletion (ODP)	kg CFC 11 eq.	-1,70E-06
Acidification (AP)	mol H+ eq.	-1,89E-01
Eutrophication, freshwater (EP-fw)	kg PO43- eq.	ND
Eutrophication, freshwater (EP-fw)	kg P eq.	-5,97E-04
Eutrophication marine (EP-m)	kg N eq.	-5,54E-02
Eutrophication, terrestrial (EP-T)	mol N eq.	-9,12E-01
Photochemical ozone formation - human health (POCP)	kg NMVOC eq.	-1,60E-01
Resource use, minerals and metals (ADP-mm)	kg Sb eq.	-8,56E-05
Resource use, fossils (ADP-f)	MJ	-7,00E+01
Water use (WDP)	m3	-6,23E-01
Potential environmental impact – additional mandatory and voluntary indicators		
Global warming potential - Fossil (GWP-f)	kg CO2 eq.	-5,82E-02
Ecotoxicity, freshwater (ETP-fw)	CTUe	-1,84E+03
Particulate Matter (PM)	disease incidence	-2,57E-06
Human toxicity, cancer (HTP-c)	CTUh	-2,11E-08
Human toxicity, non-cancer (HTP-nc)	CTUh	-7,67E-07
Ionising radiation, human health (IR)	kBq U235 eqv.	-2,93E-01

4 Results

Parameter	Unit	D
Use of resources		
renewable primary energy ex. raw materials	MJ	-1,51E+03
renewable primary energy used as raw materials	MJ	0,00E+00
renewable primary energy total	MJ	-1,51E+03
non-renewable primary energy ex. raw materials	MJ	-7,44E+01
non-renewable primary energy used as raw materials	MJ	0,00E+00
non-renewable primary energy total	MJ	-7,44E+01
use of secondary material	Kg	0,00E+00
use of renewable secondary fuels	MJ	0,00E+00
use of non-renewable secondary fuels	MJ	0,00E+00
use of net fresh water	M3	-1,86E-02
Waste production and output flows	**Unit**	
Waste production		
hazardous waste disposed	Kg	-2,48E-04
non hazardous waste disposed	Kg	-2,71E+00
radioactive waste disposed	Kg	-4,49E-04
Output flows		
Components for re-use	Kg	0,00E+00
Materials for recycling	Kg	0,00E+00
Materials for energy recovery	Kg	0,00E+00
Exported Energy Thermic	MJ	4,32E+02
Exported Energy Electric	MJ	a2,51E+02

BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY (D)

The waste scenario used in the full LCA for the Up-straw study for waste from phases A3, A5 and C3-4 is the NMD waste scenario ID38: organic material, other (i.a. insulation). Which consists of the following disquisition: 5% landfill and 95% incineration. This distribution of waste scenarios is set up by the Dutch LCA-community in the PCR: Determination method "Environmental performance Building" Version 1.0 (July 2020), and represents the current flow of organic waste streams in the Netherlands. No information is found for this particular waste stream in the UK and thus it is assumed that the distribution between landfill and incineration is the most representative information and applies to the UK as well. A sensitivity analysis is performed, see chapter 9.

Module D of this standard waste scenario is based on avoided energy from the Netherlands. No data was found regarding the representativeness of the thermal/electrical ratio from the Netherlands to the UK. It's assumed that the ratio of thermal/ electrical energy avoided is similar in the UK as that of the Netherlands, as this is the most conservative yet substantiated assumption.

A sensitivity analysis is performed, in which the Eco-Invent processes are switched for those representative for the UK, which showed that the impact did not deviate drastically.

Everything until the allocation split is included in the calculation, no costs or benefits are included in module D for the allocated co-products (A1-A3) which are not part of the end product.

When materials are recycled or reused a benefit may be taken into account in module D. According to the EN15804 the benefit may only be calculated for the net primary content that comes available for the next life cycle stage. The amount assumed for recycling and re-use are listed per input in the table below. The amount of avoided production of primary material is also shown.

5 References

ISO 14040
ISO 14040:2006-10, Environmental management - Life cycle assessment - Principles and framework; EN ISO 14040:2006

ISO 14044
ISO 14044:2006-10, Environmental management - Life cycle assessment - Requirements and guidelines; EN ISO 14040:2006

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

EN 15804+A1
EN 15804+A1: 2013: Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products
Environdec: PCR 2012:01 Construction products and construction services (EN 15804:A1) (2.33)

EN 15804+A2
EN 15804+A2: 2019: Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products
Environdec: PCR 2019:14 Construction products (EN 15804:A2) (1.11)

EN 16783
EN 16783: 2017: Thermal insulation products — Product category rules (PCR) for factory made and in-situ formed products for preparing environmental product declarations
Environdec: PCR 2019:14-c-PCR-005 c-PCR-005 Thermal Insulation products (EN 16783) (2019-12-20)

SBK-verification protocol
SBK-verification protocol – inclusion data in the Dutch environmental database, Final Version 3.0, January 2019, SBK

NMD Determination method
NMD Determination method Environmental performance Construction works v1.0 July 2020, foundation NMD

LCA German straw (2019)
EPD - ENVIRONMENTAL PRODUCT DECLARATION UMWELT-PRODUKTDEKLARATION nach ISO 14025 und EN 15804
(BAU-EPD-Fasba-2019-1-GaBi-Baustrohballen-20191010)

LCA French straw (2015)
Rapport d'étude ACV / FDES conforme aux exigences de la norme NF EN 15804
(150601_ACV_Paille_15804_vdef (002) LCA France.pdf)

United Kingdom Government database (2019)
UK Wheat, Barley and straw yields and specifications at June 2019 (data revised Decmeber 2019)
(LCA_Data_UK.Gov_stats.xlsx)

ILCD Handbook (2010)
ILCD Handbook: General guide for Life Cycle Assessment - Detailed guidance, p. 330-331.

Carbon Content straw (2014)
Kumar, Manoj & Singh, R. P. & Panigrahy, S. & Raghubanshi, Akhilesh. (2014). Carbon density and accumulation in agroecosystem of Indo-Gangetic Plains and Vindhyan highlands, India. Environmental monitoring and assessment. 186. 10.1007/s10661-014-3752-3. Table 3.