



Sheep Inc.

Product Carbon Footprint:
Life Cycle Assessment Report for
Sheep Inc's
Medium Knit, V-neck, Light Knit, Cardigan,
Beanie & Hoodie

21st May 2021

Executive Summary

This report provides an analysis of the greenhouse gas (GHG) emissions associated with **Sheep Inc.'s Medium Knit, V-neck, Light Knit, Cardigan, Beanie & Hoodie and associated packaging**. The assessment includes the full lifecycle of the products; from the embodied raw materials, and transportation of these materials; the manufacture and distribution of the finished product; as well as the usage and disposal.

All of Sheep Inc.'s products are made from wool; produced by sheep in New Zealand, cleaned in China and sent to Italy to be spun into yarn. The yarn is then sent to Portugal where the products are made, and then transported to the UK for packaging and distribution. Usage has been modelled on a 5-year life expectancy (hand washed twice a year). The products (and associated packaging) can be composted at the end of life.

Total **cradle to grave** product carbon emissions for each of Sheep Inc.'s products are shown in the following table and chart; split by lifecycle stage. The majority of emissions are associated with the product distribution but overall, all the products have a negative carbon footprint due to the wool.

Lifecycle Stage	GHG Emissions (kgCO ₂ e)				
	Cardigan	Hoodie	Medium knit & V-neck	Light knit	Beanie
Raw materials – embodied	18.16	13.19	12.53	6.44	3.33
Raw materials transport	1.03	0.73	0.81	0.34	0.17
Manufacture	0.78	0.55	0.42	0.24	0.13
Product distribution	2.92	2.31	2.23	1.48	0.75
Usage	0.05	0.05	0.05	0.05	0.05
Disposal	0.01	0.01	0.01	0.01	0.01
Total Gross Emissions	22.94	16.84	16.03	8.55	4.44

Lifecycle Stage	GHG Emissions (kgCO ₂ e)				
	Cardigan	Hoodie	Medium knit & V-neck	Light knit	Beanie
Raw materials (embodied) – including sequestration at sheep farms ¹	-15.41	-10.50	-9.85	-3.85	-2.04
Raw materials transport	1.03	0.73	0.81	0.34	0.17
Manufacture	0.78	0.55	0.42	0.24	0.13
Product distribution	2.92	2.31	2.23	1.48	0.75
Usage	0.05	0.05	0.05	0.05	0.05
Disposal	0.01	0.01	0.01	0.01	0.01
Total Net Emissions – including sequestration	-10.62	-6.84	-6.34	-1.74	-0.93

¹ Relates to carbon sequestration through woody vegetation on the farmland based on a GWP of 100 years.

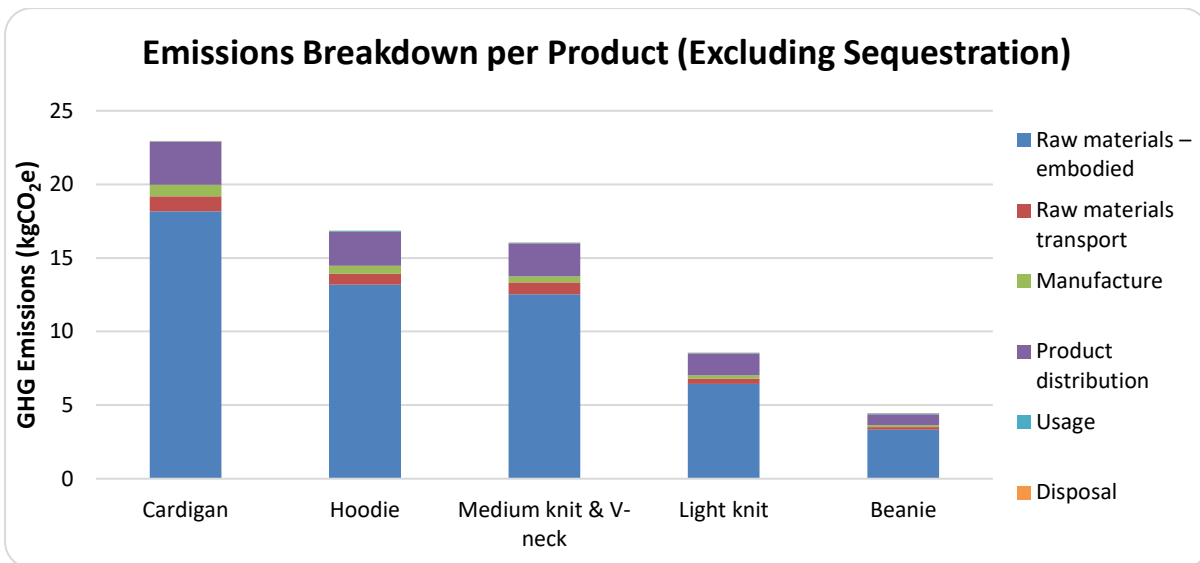


Table of Contents

1. Introduction.....	4
2. Product overview.....	6
3. Accuracy of the Product Carbon Footprint Calculation.....	7
4. Product Carbon Footprint Results	8
5. Carbon Footprint Standard.....	13
6. References	14
Annex 1: Emission Factors	15

Quality Control

Report issue number: 1.2
Date: 13 September 2021

Calculations completed by: Grace Parker
Calculations reviewed by: Katie Elmer

Report produced by: Grace Parker
Report reviewed by: Katie Elmer

Director: John Buckley

1. Introduction

1.1 Scope of this Assessment

As a sustainable fashion brand, the aim of this assessment is to demonstrate the environmental credentials of Sheep Inc.'s product. This will help to demonstrate Sheep Inc.'s commitment to monitoring its impact to its consumers, as well as providing consumers with an eco-alternative fashion brand.

Carbon emissions for the product assessed in this report include those derived from:

- the raw materials (wool from sheep in New Zealand)
- the transport of the raw materials to various factories for processing
- the manufacturing of materials to finished product
- modelled global distribution of products to consumers
- modelled usage of product
- disposal of the product

1.2 What is a Product Carbon Footprint Assessment?

This assesses the green-house gas impacts of a product or service during its life cycle. It incorporates the analysis of raw materials, manufacture, transport, usage and disposal.

The product carbon footprint detailed in this report is for *Cradle-to-Grave* carbon impact.

1.3 How is the product carbon footprint calculated?

The product carbon footprint is derived from a combination of activity data provided by Sheep Inc. and its suppliers, and emission factors extracted from internationally recognised metrics. Greenhouse gas (GHG) activity data is then multiplied by GHG emission factors to produce carbon metrics.

To guarantee transparency and reproducibility, the emission factors used in this report are shown in Annex 1 detailing the exact name of the emission factor as it appears on its respective database. All material emissions factors are sourced either from EcoInvent's database (v3.7.1) or the UK Government (BEIS, 2020). The emissions factors for the wool were taken from Wood'search Marketing Limited 2021 valuation report of OverseerFM's calculation of Lake Hawea Station's GHG emissions. EcoInvent factors account for all processes during the production of raw materials and all processes (including transport). When an exact material emissions factor was not available for some raw materials, a suitable alternative was researched and used instead.

China electricity generation and transmission and distribution factors are sourced from Climate Transparency Report (2019) and Defra/BEIS factors; published in June 2017 (v1.0)

1.4 Abbreviations

CO ₂	Carbon Dioxide
CO ₂ e	Carbon Dioxide Equivalent
BEIS	Department for Business, Energy and Industrial Strategy
Defra	Department of Environment, Food and Rural Affairs
g	Grammes
GHG	Greenhouse Gas
GLO	Global
HGV	Heavy Goods Vehicle
kg	Kilogrammes
km	Kilometres
kWh	Kilowatt Hours
LCA	Life Cycle Assessment

2. Product overview

Sheep Inc. produce all their products from wool from 3 regenerative Sheep farms in New Zealand. The dirty fleece is shipped to a factory in China for cleaning (since the beginning of 2021, Sheep Inc. has been doing this cleaning process in Italy with a B-Corp certified partner). Clean wool is transported by ship to Italy to be spun into yarn, before being sent onto Portugal for manufacture into the final product. These products are sent to a warehouse in UK for packaging and distribution.

Sheep Inc. make the wool into several different products including; a cardigan, hoodie, medium knit jumper, V-neck jumper, light knit jumper and a beanie. The medium knit jumper and V-neck jumper are the same weight of wool styled differently and so have been treated as one product in this assessment. The products are packaged in a recycled cardboard box and recycled cotton bag with a bio-plastic tag.

Table 1 details the individual materials which make up the product.

Table 1: Overview of all raw material mass

Component	Material	Material mass in final product (kg)				
		Cardigan	Hoodie	Medium knit & V-neck	Light knit	Beanie
Product						
Product	Wool	0.75	0.53	0.50	0.23	0.12
Subtotal		0.75	0.53	0.50	0.23	0.12
Packaging						
Box	Cardboard	0.20	0.20	0.20	0.20	0.10
Bag	Cotton	0.10	0.10	0.10	0.10	0.05
Tag	Bio-Plastic	0.002	0.002	0.002	0.002	0.002
Subtotal		0.30	0.30	0.30	0.30	0.15
Total Mass (kg)		1.05	0.83	0.80	0.53	0.27

3. Accuracy of the Product Carbon Footprint Calculation

The accuracy of the overall carbon footprint calculation (Table 2) is considered very good. The primary raw material data was submitted by various 3rd parties involved in Sheep Inc.'s supply chain. Usage and disposal were modelled by Carbon Footprint based on assumptions discussed with Sheep Inc.

Table 2: Source data and calculation accuracy

Dataset	Source of data and comments	Accuracy
Raw materials (Products) Embodied emissions	Product specifications (materials and weight (kg)) supplied by Sheep Inc. The emission factor for wool (raising of the sheep) was provided by the New Zealand farm. These calculations were not verified as part of this assessment; however, the methodology was discussed with the author of the valuation report and deemed appropriate.	Very Good
Raw materials (Packaging) Embodied emissions	Product specifications (materials and weight (kg)) supplied by Sheep Inc. Emissions factor for cotton production were taken from Ecoinvent v3.7.1, for cardboard from BEIS, 2020, and for tag from a proxy bio-plastic life cycle assessment.	Excellent
Raw materials Transport	Accurate destinations and shipping method provided for each leg of the journey. Shipping distances were calculated based on data extracted from www.sea-distances.org .	Excellent
Manufacturing Products	Annual energy consumption data was provided by China and Italy, which was then apportioned to the weight of product produced. Portugal provided an electricity usage per product unit for the final product manufacture. <i>Note: Italy and Portugal have a 100% green electricity tariff (evidence provided) and this was considered within the calculations.</i>	Excellent
Product distribution	The delivery footprint has been modelled based on sales split per country for quarter 4 of 2020. This was then averaged to provide a per product figure. Airbox (Sheep Inc's fulfilment centre provider & distributor) will be offsetting all warehouse and distribution emissions. <i>See Section 4.3.2 for further details.</i>	Good
Usage	Usage has been modelled based on an estimated life expectancy of 5 years and the assumption that each product is washed twice a year. The recommendation is for hand wash only, therefore only the carbon impact of water required for each wash was considered (this was estimated at 5 litres per wash).	Good
Disposal	All materials are compostable.	Good

4. Product Carbon Footprint Results

4.1 Summary of results

This report provides an analysis of the greenhouse gas (GHG) emissions associated with a Medium Knit, V-neck and Light Knit Jumper, Cardigan, Beanie and Hoodie and associated packaging. The assessment focuses on the embodied raw materials, and transportation of these materials, the manufacture and distribution of the products, as well as the usage and disposal.

Total **cradle to grave** product carbon emissions for each product are presented below. A breakdown of the carbon emissions for each product is shown below (Table 3, 4 and Figure 2); split by lifecycle stage. The majority of emissions (81%) are associated with the embodied emissions of the wool. The majority of emissions are associated with the product distribution but overall, all the products have a negative carbon footprint due to the wool.

Table 3: Breakdown of the product footprint by lifecycle stage (excluding sequestration)

Lifecycle Stage	GHG Emissions (kgCO ₂ e)				
	Cardigan	Hoodie	Medium knit & V-neck	Light knit	Beanie
Raw materials – embodied	18.16	13.19	12.53	6.44	3.33
Raw materials transport	1.03	0.73	0.81	0.34	0.17
Manufacture	0.78	0.55	0.42	0.24	0.13
Product distribution	2.92	2.31	2.23	1.48	0.75
Usage	0.05	0.05	0.05	0.05	0.05
Disposal	0.01	0.01	0.01	0.01	0.01
Total Gross Emissions	22.94	16.84	16.03	8.55	4.44

Table 4: Breakdown of the product footprint by lifecycle stage (including sequestration)

Lifecycle Stage	GHG Emissions (kgCO ₂ e)				
	Cardigan	Hoodie	Medium knit & V-neck	Light knit	Beanie
Raw materials (embodied) – including sequestration at sheep farms ²	-15.41	-10.50	-9.85	-3.85	-2.04
Raw materials transport	1.03	0.73	0.81	0.34	0.17
Manufacture	0.78	0.55	0.42	0.24	0.13
Product distribution	2.92	2.31	2.23	1.48	0.75
Usage	0.05	0.05	0.05	0.05	0.05
Disposal	0.01	0.01	0.01	0.01	0.01
Total Net Emissions – including sequestration	-10.62	-6.84	-6.34	-1.74	-0.93

² Relates to carbon sequestration through woody vegetation on the farmland based on a GWP of 100 years.

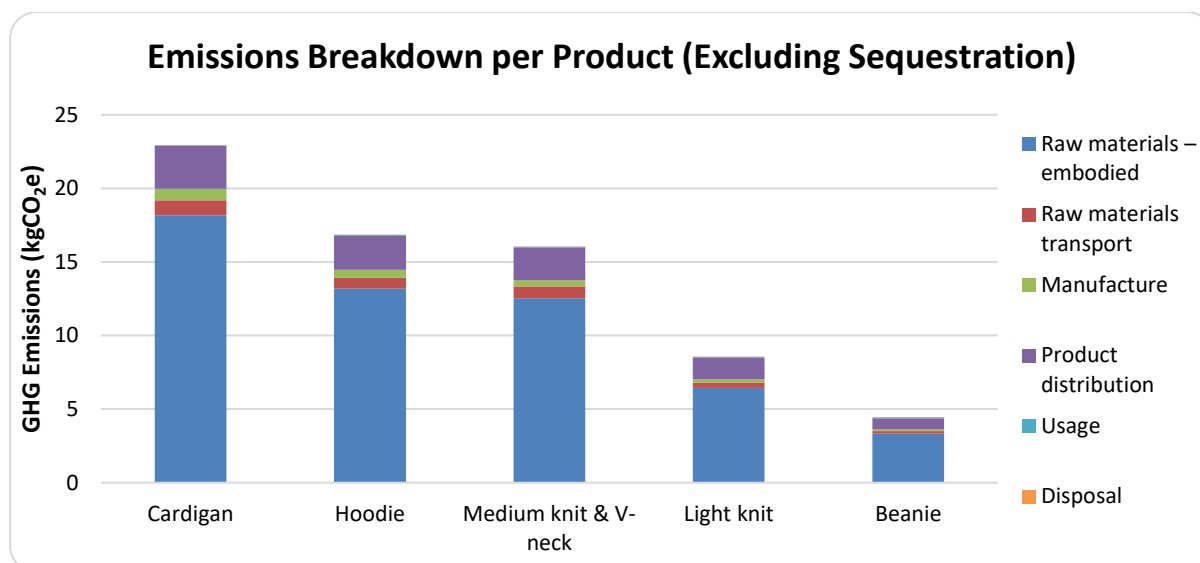


Figure 1: Breakdown of product footprint by lifecycle stage (excluding sequestration)

4.2 Embodied emissions from raw materials

Table 4 provides a breakdown of embodied emissions. It shows that the wool has the greatest impact, with the emissions accounting for the majority of the embodied emissions (80-93% of the total excluding sequestration).

One of the regenerative sheep farms from which Sheep Inc sources its wool (Lake Hawea Station) completed an independent assessment of the farms carbon emissions and sequestration. Sheep Inc.'s other farms (Middlehurst and Omarama) are in the process of performing the same analysis to confirm their net negative emission profile. The Lake Hawea Station assessment incorporated the carbon sequestration associated with the woody vegetation on the farm (with a GWP of 100 years). The embodied emissions for the wool from Lake Hawea Station were calculated to be 14.20 kgCO₂e per 1kg of greasy wool. The amount of carbon sequestered was apportioned to the amount of product produced on the farm, giving 28.2 kgCO₂e of carbon sequestration per 1kg of greasy wool. These calculations were not verified as part of this assessment; the methodology was discussed with the Dr Angus J McPherson (author of the 2020 valuation report for Lake Hawea Station).

Table 4: Embodied emissions from raw materials

Element	Raw Material Emissions (kgCO ₂ e)				
	Cardigan	Hoodie	Medium knit & V-neck	Light knit	Beanie
Wool – emissions	16.91	11.93	11.27	5.18	2.71
Cardboard Box	0.15	0.15	0.15	0.15	0.08
Cotton Bag	1.11	1.11	1.11	1.11	0.56
Bio-Plastic Tag	-0.002	-0.002	-0.002	-0.002	-0.002
Total – Embodied only	18.16	13.19	12.53	6.44	3.33
Carbon sequestered at sheep farm	-33.57	-23.69	-22.38	-10.30	-5.37
Total - Combined	-15.41	-10.50	-9.85	-3.85	-2.04

4.3 Emissions from Manufacturing

The wool goes through three stages of manufacture;

- The dirty fleece is cleaned in a factory in China³
- Fleece is spun into yarn in a factory in Italy
- Yarn is made into the final products in a factory in Portugal

Each factory provided production energy consumption which was apportioned to a single product and multiplied by the appropriate emission factor for each energy type. The factory in Italy and Portugal use 100% renewable electricity (certificate provided in evidence) and therefore the emissions for this element of the manufacturing emissions were considered as zero.

A summary of manufacturing emissions is provided in Table 5 below. It can be seen spinning the fleece into yarn (Italy factory) is the most energy intensive stage of the manufacturing process. The emissions associated with the Italy factory (Suedwolle) are caused by the use of natural gas.

Table 5: Production Emissions

Factory Location	Manufacturing emissions (gCO ₂ e)				
	Cardigan	Hoodie	Medium knit & V-neck	Light knit	Beanie
Italy	633.26	448.35	422.17	194.20	101.32
China	150.65	106.30	0.49	46.20	24.10
Portugal	0.00	0.00	0.00	0.00	0.00
Total	783.90	554.64	422.66	240.40	125.42

4.4 Emissions from Transport (Raw material and Distribution)

The emissions associated with transport reflect the mass of materials, the mode of transport and the distance travelled.

4.3.1 Raw materials transport

Sheep Inc. provided the locations and distances between the New Zealand Sheep Farms and three factories (China, Italy and Portugal) for the production of the yarn and final products. Materials are transported by a combination of truck and container ship.

The recycled cardboard box (packaging) is made in Essex, UK and transported directly to the Airbox fulfilment centre.

The recycled cotton bag (packaging) is made in New Delhi. Transport details were not provided but were assumed to be shipped to London and then transported by truck to the Airbox fulfilment centre.

This tag is made out of bio-based plastic called EcoPaXX (out of castor beans), and produced into the tag by an injection moulding company in Spain. The tags are then transported from Spain to the UK by truck.

³ Note: LCA does not include the water consumption from fleece cleaning.

Table 6 shows the raw material transport emissions. As expected, the majority of transport emissions are associated with the products themselves, as materials are processed in four different countries before being transported to the Airbox fulfilment centre.

Table 6: Total Raw material transport emissions per product

Product Element	Raw material transport emissions (gCO ₂ e)				
	Cardigan	Hoodie	Medium knit & V-neck	Light knit	Beanie
Product	992.61	699.80	772.44	306.10	157.66
Packaging	34.05	34.05	34.05	34.05	17.16
Total	1,026.67	733.86	806.49	340.15	174.81

4.3.2 Product distribution

The product distribution emissions have been calculated based on the distribution of 8,414 products across the world over a given time period, using the following assumptions:

- Sale distribution: provided for specific countries. Capital cities used as proxy.
- Europe distribution by truck.
- United States and Australia distribution by long-haul freight, plus 'last mile' transportation by truck, assumed at an average of 500 miles based on previous assessment.
- Average short/long-haul air freight and average laden HGV emission factors used (BEIS).

The total modelled emissions (for 8,414 products) was then apportioned to an individual product.

Table 7 shows the average carbon emissions associated with product distribution for the top 99% of emissions. The majority of emissions are associated with distribution to the US, which is to be expected as it accounts for the largest proportion of distribution. However, it should be noted that the UK account for almost the same amount of distribution and yet has considerably less emission associated with it, due to the significantly shorter distance required to travel and as there is no need for air freight. Similarly, distribution to Australia accounts for 14% of distribution emissions, despite only accounting for 2% of distribution, due to the distance travelled.

Table 7: Modelled product distribution emissions for top 99% of emissions

Destination	% of products	Product distribution emissions (gCO ₂ e)				
		Cardigan	Hoodie	Medium knit & V-neck	Light knit	Beanie
US	32%	2,302.59	1,820.95	1,755.27	1,164.46	594.94
Australia	2%	401.29	317.35	305.91	202.89	103.69
New Zealand	1%	177.72	93.09	89.74	59.52	30.42
Austria	2%	48.19	38.11	36.74	24.37	12.45
UK	32%	11.64	9.21	8.87	5.89	3.01
Sub total	70%	2,881.44	2,278.71	2,196.52	1,456.81	744.50
Total	100%	2,919.15	2,308.54	2,225.27	1,475.88	754.25

Note: Sheep Inc's distribution suppliers have confirmed their intention to offset all freight and warehouse emissions.

4.3.3 Usage

Emissions associated with usage of the product have been modelled on the following assumptions; the products have a 5-year life expectancy and is estimated to be washed twice annually (using 5 litres of water per wash). As the products are recommended as hand wash only, the sole factor contributing to usage emissions is water consumption.

Table 8 highlights the emissions associated with this water consumption. The emissions are the same for all the products.

Table 8: Usage Emissions

Usage Element	Usage emissions (gCO ₂ e)
Water supply & treatment	52.60

4.3.4 Disposal

The products and packaging are regarded as compostable materials at the end of life. Table 9 shows emissions from the disposal of the product and the packaging.

Table 9: Disposal Emissions

Product Element	Disposal emissions (gCO ₂ e)				
	Cardigan	Hoodie	Medium knit & V-neck	Light knit	Beanie
Product	7.65	5.41	5.10	2.35	1.22
Packaging	3.08	3.08	3.08	3.08	1.55
Total	10.73	8.49	8.18	5.43	2.77

5. Carbon Footprint Standard

Sheep Inc in conjunction with Carbon Footprint Ltd, has assessed the *cradle to grave* carbon emissions associated with its **Sheep Inc.'s Medium Knit, V-neck and Light Knit Jumper, Cardigan, Beanie, and Hoodie and associated packaging**. By achieving this, Sheep Inc. has qualified to use the Carbon Footprint Standard branding. This can be used on all marketing materials, including web site and customer tender documents, to demonstrate your carbon management achievements.



The Carbon Footprint Standard is in recognition of your organisations commitment to managing your products' carbon emissions. The text to the right-hand side of the logo demonstrates what level you have achieved in line with international best practice.

6. References

1. Association of Issuing Bodies (AIB) 2019
2. Braskem – 'I'm green™ PE Life Cycle Assessment' - <http://plasticoverde.braskem.com.br/Portal/Principal/Arquivos/ModuloHTML/Documentos/1191/Life-Cycle-Assessment-v02.pdf>
3. Climate Transparency (2019 Report)
4. Ecoinvent database v3.5 2018 (<http://www.Ecoinvent.org/>)
5. Guidelines to Defra's Greenhouse Gas (GHG) Conversion Factors for Company Reporting – annexes (June 2013)
6. Bernie Thomas, Matt Fishwick, James Joyce and Anton van Santen (2012). *The Waste and Resources Action Programme (WRAP)*, A Carbon Footprint for UK Clothing and Opportunities for Savings
7. UK Government GHG Conversion Factors for Company Reporting (2017)
8. UK Government GHG Conversion Factors for Company Reporting (v1.0 June 2020)

Annex 1: Emission Factors

The following table shows the emission factors used for the calculations contained in this report.

Table 10: Emissions factors used in this assessment

Element	Emissions factor	Comments	Unit	Database
Raw Materials (embodied)				
Wool	14.2 emissions and -28.2 sequestration		kgCO ₂ e per kg	Wood'ssearch Marketing Limited 2021
Cardboard	0.75026			UK Government 2020
Cotton	See below	Market for textile, woven cotton, GLO	Tonne of CO ₂ per kg of material	Ecoinvent v3.7.1
Bio-Plastic	-0.97		kg CO ₂ per kg of material	Braskem 'I'm green™ PE Life Cycle Assessment'
Production				
Electricity	0.6036	China	kgCO ₂ e per kWh	Climate Transparency (2019 Report) (generation) and Defra 2017 (transmission and distribution)
Natural Gas	2.02266		Tonne of CO ₂ e per m ³	UK Government 2020
Transport				
All HGV's (average)	0.1065		kg CO ₂ e per tonne.km	UK Government 2020
Rigid >3.5-7.5t	0.52043			
Rigid >7.5-17t	0.36825			
General Cargo	0.013232			
Ro-Ro Ferry	0.051659			
Short-haul Freight	2.20946			
Long-haul Freight	1.13382			
Usage				
Water supply	344		kg CO ₂ e per million litres	UK Government 2020
Water treatment	708			
Disposal				
Composting	10.204		kg CO ₂ e per tonne	UK Government 2020

Please note – In accordance with Ecoinvent's End User Licence Agreement (EULA) emissions factors cannot be presented in the report. A full emissions factor reference has been provided which will allow users with an active Ecoinvent account to search for the emissions factor. Please see <http://www.Ecoinvent.org/> for further details and to search for factors.