REPORT:

The climate footprint of Barista oat drink, UK Oatly

CarbonCloud

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The climate footprint of Oatly Barista oat drink

The food system directly accounts for a quarter of global anthropogenic greenhouse gas emissions responsible for climate change, through biological soil organic processes, manure management, enteric fermentation, carbon leakage from organic soils, and deforestation.[1] On top of this there are emissions from fossil fuel use in machinery, fertilizer production, transports, heating, refinement, and other gases from leakage from e.g. refrigerants used in the value chain. By far the most important greenhouse gases from food production are nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO_2).

Climate change is by no means the only negative externality associated with food production. Food production is also the main driver for antibiotic resistance, animal welfare issues, unsustainable water extraction, eutrophication, biodiversity loss from pesticide usage and habitat destruction. There are also important public health and worker-safety issues related to food production. This is not intended as a comprehensive list of food production related externalities.

Focus in this study is solely on climate change, as it is a climate footprint assessment. This focus is chosen without any ranking of the importance of climate change relative any other of the negative externalities associated with food production.

CarbonCloud has calculated the climate footprint of 1 kg of Oatly Barista Oat Drink, to be sold in the UK with the purpose to communicate the climate footprint and to identify areas for improvement in the life cycle of this product. This document is a summary of the results and how the calculations were done.

[1] IPCC, 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

Approach

An attributional approach to life cycle accounting

CarbonCloud uses the attributional approach to life cycle accounting. This means that all processes in the production are considered, and their combined climate impact is attributed to the product. The attributional approach only accounts for emissions and removals of greenhouse gases generated during a product's life cycle and not avoided emissions or actions taken to mitigate released emissions. Carbon offsetting is not taken into account. The attributional approach as described here is in line with major standards for carbon foot-printing such as ISO 14067 and GHG Protocol.

This contrasts to the consequential approach, which is used to assess the climate impact from changing the level of output of a product. The consequential approach focuses on marginal effects linked to the production of a product.

From cradle to store

CarbonCloud assesses the climate footprint of the product from *cradle to store*. In this case it means that we consider all steps of the life cycle from the production of agricultural inputs, through agriculture, transports, refinements and distribution up until the product reaches the shelf of the grocery store. Hence, the calculated climate footprint does not consider e.g. lighting and refrigeration at the grocery store, transport from grocery store to home, or cooking of product. Biogenic uptake of carbon stored in agricultural products is not taken into account since it is released again upon digestion.

Time horizon

Yield data represent the average of the period 2013-2017. Data from Oatly's production facilities represent year 2017.

Unit of analysis

The unit of analysis in this study is

- One kg of packaged food product delivered to the store.

The weighting of greenhouse gases

The total climate impact is given in carbon dioxide equivalents (CO_2e). The calculation includes emissions to the atmosphere of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O). Sulfur hexafluoride (SF_6) is indirectly included in the emission factor for the electricity mix. Perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs) emissions are included in the emissions from chilled transport.

All greenhouses gases are weighted with the latest values of GWP_{100} given by the IPCC (Edenhofer et al, 2014). For methane, nitrous oxide and sulphur hexafluoride we use a GWP of 34, 298 and 23 500 respectively.

Allocation

When a process generates more than one product, the climate impact from the process needs to be allocated between the products. As a general principle in this study, economic allocation is applied. This means that the climate impact from a process is allocated between the products in proportion to their economic value.

Material for this calculation is that rapeseed oil and rapeseed cake are produced in the same process. Their upstream emissions are allocated according details in Table 1. There are additional by-products from the oat base production. These by-product streams are used as animal feed and for biogas production. Since Oatly does not receive any financial compensation for this, they have no economic value, and no climate footprint is allocated to these by-products. That is, the upstream emissions for oat production are allocated to 100% to Oatly's products and 0% to the biogas and animal feed.

Table 1. Allocation for rapeseed[2]

Impact allocated to	Percentage impact (economic allocation)
Rapeseed oil	70%
Rapeseed cake	30%

Agricultural calculation model

Emissions from agriculture stem from a range of processes, such as energy related activities (like fuels for tractors), soil nitrogen processes, carbon leakage from organic soils, and biological processes from livestock (where applicable). The emissions correlate with yield levels in a non-linear manner.

Emissions from agriculture are calculated with ALBIO (Agricultural Land use and Biomass), a computer model that calculates all greenhouse gas (GHG) emissions related to the production of a specified food product. The model represents all major supply steps related to food production and use, from production of inputs to processing and transportation of end-use-ready food items.

For the production of oats and rapeseed oil, the model accounts for:

- Emissions of nitrous oxide (N_2O) from mineral soils
- *Indirect* emissions of nitrous oxide (N_2O) related to ammonia and nitrate emissions from soils
- Emissions of nitrous oxide (N_2O) and carbon dioxide (CO_2) from organic soils
- Carbon dioxide (CO_2) emissions from production and use of fuels (e.g. for tractors and machinery) and electricity
- Carbon dioxide (CO_2) emissions from transport of inputs to farm, from farm to dairy, and from dairy to market

[2] Flysjö et al 2008

- Emissions of carbon dioxide (CO_2) and nitrous oxide (N_2O) from production of mineral fertilizers and other inputs

The model represents the flows of nitrogen (N) through the crop and livestock systems (where applicable) on a mass balance basis. Further model descriptions can be found in Wirsenius (2000, pp. 13-54), Wirsenius (2003a-b) and Bryngelsson (2016).

What is included?

The climate footprint includes emissions from:

- **Agriculture**: The agricultural production of oats, rapeseed and other ingredients (fertilizers, pesticides, use of farm equipment)
- **Processing of Ingredients**: Electricity and gas consumption in the mill (dehulling and drying of the oats) and the rapeseed oil production facility.
- **Transport of Ingredients**: The transport of ingredients from field to factory and between factories.
- **Factory Oatly**: Electricity and gas consumption in the oatbase and oat drink production facilities.
- **Packaging:** production and transport of packaging material
- **Distribution**: The distribution of the final product from factory to market.

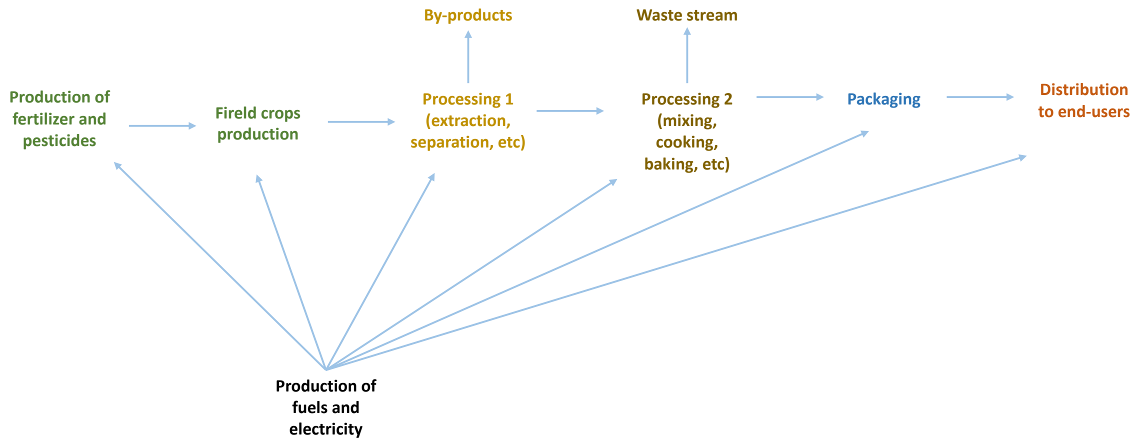

Figure 1. Climate footprint includes emissions from agriculture, processing of ingredients, transport of ingredients factory, packaging and transport

What is not included?

Most importantly the calculations omit

- Product losses after filling
- Manufacture of capital goods (e.g., machinery, trucks, infrastructure)
- Overheat operations (e.g., facility lighting, air conditioning)
- Corporate activities and services (e.g., research and development, administrative functions, company sales and marketing)
- Transport of the product user to the retail location
- Travel of employees to and from work

Inventory data

Ingredients, summary

Ingredients in Barista oat drink are water, oats, rapeseed oil, calcium carbonate, calcium phosphate, potassium phosphate, iodised salt and vitamins. The oats and rapeseed oil are sources from Sweden. These ingredients make up more than 95% of the dry mass (DM) in the oat drink. Oats and rapeseed oil are explicitly modelled and for the rest a conservative number (2 kg CO_2e/kg substance) has been used and added to the climate footprint. The climate footprints of the ingredients are shown in Table 2.

Table 2. Climate footprint of oat and rapeseed oil in the Barista drink. The crops are grown in Sweden.

		% of GHG emissions that stem from[3]			
Ingredient	Gram CO_2e/kg oat drink	Fertilizers and other inputs	Soil nitrogen process	Organic soil	Energy, including transport
Oat	94	23%	27%	38%	12%
Rapeseed oil	50	22%	32%	26%	20%

More details about agriculture, processing of ingredients and transport of ingredients are given in the following sections.

[3] Wirsenius, 2019

Agriculture

Data on inputs and energy use for the agricultural production of oats and rapeseed are given in Table 3.

Table 3. Agricultural data for oats and rapeseed, Sweden

		Oats	Rapeseed
Yield		4.1 Mg DM/ha/yr	3.3 Mg DM/ha/yr
Inputs	N fertilizer	122 kg N/ha/yr	189 kg N/ha/yr
	P fertilizer	8 kg P/ha/yr	11 kg P/ha/yr
	K fertilizer	13 kg K/ha/yr	20 kg P/ha/yr
	Pesticides	0.08 g AS/kg	0.08 g AS/kg
Energy use	Electricity	0.07 MJ/kg	0.07 MJ/kg
	Fuel	2.5 MJ LHV/kg	3.7 MJ LHV/kg

Processing of Ingredients

The ingredients are processed in Sweden. Energy consumption is listed in Table 3. For electricity an emission intensity factor representing the Nordic power mix is applied that accounts for upstream emissions and power losses. The emission intensity of the gaseous fuel is also based on a life-cycle perspective.

Table 4. Energy consumption for the processing of ingredients, allocated to the ingredients

Process	Energy use	kg CO_2e/MJ[4]	Total kg CO_2e
Mill	0.86 MJ electricity/kg hulled oats	0.035	0.0301/kg hulled oats
Rapeseed oil	0.1 MJ electricity/kg	0.035	0.0035/kg DM
Rapeseed oil	1.7 MJ gaseous fuel /kg	0.089	0.055/kg DM

[4] Energimyndigheten 2018

Transport of Ingredients

Table 5 below specifies transport mode, load factor, fuel type and emission intensity for the transport chain of ingredients.

Table 3. Transport of ingredients for Barista oat drink

Transport	Mode	Load factor (volume)	Fuel type	kg CO_2e/MJ[5]	km	Fuel use MJ/ton/km
Oat field to mill	Truck	0.5	Diesel	0.089	100	0.8
Rapeseed field to factory	Truck	0.5	Diesel	0.089	80	0.8
Rapeseed oil to oat base production	Truck	0.5	Diesel	0.089	153	0.8
Oat mill to oat base production	Truck	0.9	Diesel	0.089	530	0.4
Oat base production to oat drink production	Truck (chilled)	0.9	Diesel	0.089	830	0.7

Factory Oatly

Energy consumption for the production of Barista is listed in Table 6. The drink is produced in factories in Sweden and Germany. For electricity emission intensity factors representing the Nordic power mix and the German power mix, respectively, that accounts for upstream emissions and power losses are applied. In Sweden biogas is used as gaseous fuel. Leakage from production is not included in the emission factor.

Table 4. Energy consumption in factories

	Energy use MJ/kg product	Emission factor, Sweden kg CO_2e/MJ	Emission factor, Germany kg CO_2e/MJ
Electricity	0.56	0.035	0.118
Gaseous fuel	1.1	0.0	0.065

[5] Edwards et al, 2014

Packaging

The climate impact of packaging depends on the material used, processes in manufacturing of the material, and its ability to be recycled. This study uses average numbers for the recycling of materials. In Table 5 assumptions for packaging are listed.

Table 5. Packaging for Barista oat drink

Type	Material/kg product	Emission factor kg CO2e/kg material[6]	Total g CO2e/kg product
Primary packaging	Cardboard: 22.45 g	1	22.45
	Polyethylene: 7.79 g	2.5	19.5
	Aluminium: 0.141 g	10	1.41
Secondary packaging	Cardboard: 17.5 g	1	17.5
Tertiary packaging	Polyethylene: 0.54 g	2.5	1.35

Distribution

Table 9 below specifies transport mode, load factor, fuel type and emission intensity for the transports in the distribution chain. When no primary data was available, conservative assumptions were made based on transport modes typical for the region.

Table 9. Distribution transports for Barista oat drink, UK

Transport	Mode	Load factor (volume)	Fuel type	kg CO_2e/MJ[7]	km	Fuel use MJ/ton/km	Total kg CO_2e/kg product
Oat drink production facility to warehouse	Truck	0.9	Diesel	0.089	830	0.5	0.039
Warehouse to wholesaler	Truck	0.9	Diesel	0.089	1330	0.5	0.063
Wholesaler to grocery store	Truck	0.5	Diesel	0.089	50	2.9	0.013

[6] Hillman et al, 2016

[7] Edwards et al, 2014

Results

The climate footprint for the Barista oat drink is 0.44 kg CO_2e per kg product. The climate footprint separated into main process steps is depicted in Figure 2. The agricultural stage has the largest climate impact followed by distribution, factory and packaging.

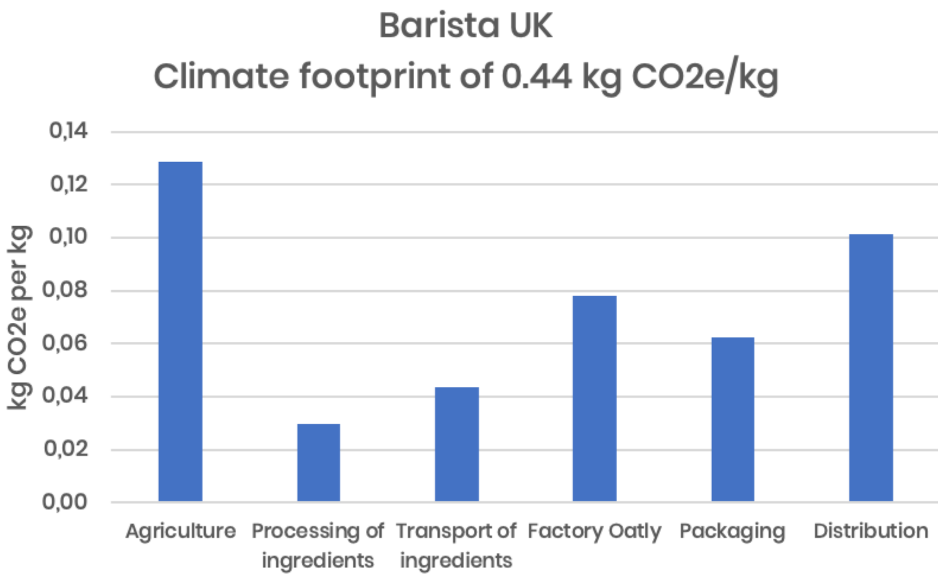

Figure 2. Climate footprint separated into main process steps

Table 10. Greenhouse gas emissions (climate footprint) per major process for Barista oat drink, UK. All emissions are expressed in the unit kg CO2e per kg product.

	kg CO2e/kg product
Agriculture	0.13
Processing of Ingredients	0.03
Transport of ingredients	0.04
Factory Oatly	0.08
Packaging	0.06
Distribution	0.10
Total	0.44

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