REPORT:

The climate footprint of Barista oat drink, UK Oatly

CarbonCloud

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CarbonCloud AB
Stena Center
412 92 Göteborg
Sweden

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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, processing, 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 considered since it is released again upon digestion.

Time horizon

Data of energy consumption at Oatly's production facilities represents year 2020.

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 greenhouse gases are weighted with the latest values of GWP_{100} including climate-carbon feedback effects 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 to 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
- Emissions of carbon dioxide (CO_2) and nitrous oxide (N_2O) from production of mineral fertilizers and other inputs

[2] Flysjö et al 2008

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.

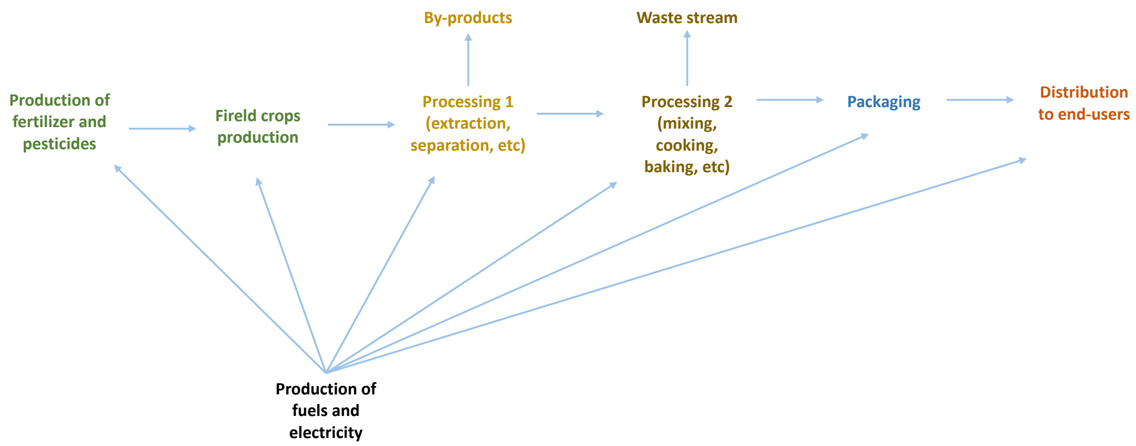

Figure 1. Climate footprint includes emissions from agriculture, processing of ingredients, transport of ingredients, factory, packaging, and distribution

What is not included?

Most importantly the calculations omit

- Product losses after filling
- Manufacture of capital goods (e.g., machinery, trucks, infrastructure)
- Corporate activities and services (e.g., research and development, administrative functions, company sales and marketing)
- Travel of employees to and from work

Inventory data

Agriculture

We have modelled the climate footprint of rapeseed (SWE) and oats (SWE, FIN and EST). Data used for the agricultural modelling is given in Table 2.

Table 2. Agricultural data for oats and rapeseed

	Rape-seed	Oats, SWE	Oats, FIN	Oats, EST	Sources:
Yield [t/ha/yr]	3.14	4.17	3.50	2.44	FAOStat, accessed 2021. Average for years 2015-2019
Crop residues [kg N/ha/yr]	27.4	50.9	42.7	29.8	Model estimates based on IPCC guidelines IPCC. 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Edited by E. Calvo Buendia, K. Tanabe, A. Kranjc, J. Baasansuren, M. Fukuda, S. Ngarize, A. Osako, Y. Pyrozhenko, P. Shermanau, and S. Federici. Switzerland: IPCC, 2019. https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html.
Organic fertilizer [kg N/ha/yr]	25.8	14.7	14.6	8.5	Model estimates based on IFA data Heffer, P., A. Gruère, and T. Roberts. "Assessment of Fertilizer Use by Crop at the Global Level 2014-15." International Fertilizer Association & International Plant Nutrition Institute, 2017. https://api.ifastat.org/reports/download/12246.
Synthetic fertilizer [kg N/ha/yr]	117.5	67.1	54.1	39.5	
Phosphorus [kg P2O5/ha/yr]	24.9	12.1	10.2	7.1	
Potassium [kg K2O/ha/yr]	30.0	13.0	11.0	7.6	
Pesticides [kg AS/ha/yr]	0.83	0.66	0.88	0.67	Production adjusted estimate based on: Peltonen-Sainio (1994), Flysjö, A., Cederberg, C., & Strid, I. (2008). Peltonen-Sainio, P., & Järvinen, P. (1994). Garthwaite, D. G., Thomas, M. R., Anderson, H., & Stoddart, H. (2005). Kemi & SCB (2018) Williams, A. G., Audsley, E., & Sandars, D. L. (2010). Bernesson, S. (2004).
Machinery diesel [liter/ha/yr]	87.3	99.8	83.8	58.5	Production adjusted estimate based on: Baky, A., Sundberg, M., & Brown, N. (2010). Anna Flysjö, Christel Cederberg, Ingrid Strid (2008) McDevitt, J. E., & Milà i Canals, L. (2011). Dartt, B., & Schwab, G. D. (2001). Schmidt, J. H. (2007). Elsgaard, L., Olesen, J. E., Hermansen, J. E., Kristensen, I. T., & Børgesen, C. D. (2013). Dalgaard, R., Schmidt, J., Halberg, N., Christensen, P., Thrane, M., & Pengue, W. A. (2008). Bernesson (2004)
Organic soil [ha/ha]	4.9%	4.9%	10.6%	2.8%	National Inventory Reports submitted to UNFCCC 2021. Data for year 2019

Processing of Ingredients

Energy consumption for the mill and the rapeseed factory is listed in Table 3. For the mill we assume that its heat demand is met by combustion of oat residues. (I.e. we only specify the electricity consumption in the table below.) For electricity and natural gas, emission intensity factors are applied that are based on a life cycle perspective and include upstream emissions and power losses.

Table 3. Energy consumption for the processing of ingredients, allocated to the ingredients

Process	Energy use	Emission factor [kg CO_2e/MJ]	Source of emission factor:
Mill	0.86 MJ electricity/kg hulled oats (Residual electricity, Belgium)	0.07	Association of Issuing Bodies, 2019
Rapeseed oil	0.1 MJ electricity/kg (Swedish residual mix)	0.0536	Association of Issuing Bodies, 2019
	1.7 MJ natural gas/kg	0.073	Cradle-to-gate: Skone, 2015. Combustion: Naturvårdsverket, 2020

Transport of Ingredients

The transport chains for oats and rapeseed, up until the Barista factory, are the following:

- Oats from field to mill. Oats from Sweden, Finland and Estonia are used. The oats are processed at a mill in Belgium.
- Hulled and dried oats from mill to factory.
- Rapeseed from field to rapeseed oil factory
- Rapeseed oil to Barista factories

Table 4 below specifies the details of the transports

Table 4. Transport of ingredients for Barista oat drink

	Mode	Fuel type	kg CO_2e/MJ[3]	km	Fuel use MJ/ton/km
Oat field (SWE) to mill	Truck	Diesel B7, Sweden	0.077	400	0.75
	Ship	Heavy fuel oil	0.101	1154	0.39
	Truck	Diesel B7, EU average	0.091	50	0.75
Oat field (FIN) to mill	Truck	Diesel B7, EU average	0.091	200	0.75
	Ship	Heavy fuel oil	0.101	2215	0.39
	Truck	Diesel B7, EU average	0.091	50	0.75
Oat field (EST) to mill	Truck	Diesel B7, EU average	0.091	300	0.75
	Ship	Heavy fuel oil	0.101	2180	0.39
	Truck	Diesel B7, EU average	0.091	50	0.75
Mill to oat drink factory	Truck	Diesel B7, EU average	0.091	130	0.75
Rapeseed field to oil refinery	Truck	Diesel B7, Sweden	0.077	80	0.75
Rapeseed oil to oat drink factory	Truck	Diesel B7, EU average	0.091	1244	0.75

Factories Oatly

Oatly produces an oat base that is used as ingredient for the Barista Oat drink. The energy consumption to produce the oat base is given in Table 5. Energy consumption to produce Barista is listed in Table 6. For each type of electricity and gaseous fuel, emission intensity factors are applied that are based on a life cycle perspective.

Table 5. Energy consumption for oat drink production

	Energy use MJ/kg oat base	Type	Emission factor [kg CO2e/MJ]	Source of emission factor:
Gaseous fuel	0.11	Natural gas	0.073	Cradle-to-gate: Skone, 2015. Combustion: Naturvårdsverket, 2020
Electricity	0.158	Hydropower	0.0105	EDP of Electricity from Vattenfall's Nordic Hydropower. Registration number: S-P 00088.

[3] Energimyndigheten (2020)

Table 2. Energy consumption for oat drink production

	Energy use MJ/kg barista	Type	Emission factor [kg CO2e/MJ]	Source of emission factor:
Gaseous fuel	1.1	Natural gas	0.073	Cradle-to-gate: Skone, 2015. Combustion: Naturvårdsverket, 2020
Electricity	0.56	Hydropower	0.0105	EDP of Electricity from Vattenfall's Nordic Hydropower. Registration number: S-P 00088.

Packaging

In Table 7 assumptions for packaging are listed.

Table 7. Packaging for Barista

Type	Material/kg product	Emission factor kg CO_2e /kg material
Primary packaging	Paperboard[4]: 22.45 g	0.54
	LDPE[5]: 6.46 g	1.9
	Aluminum[6]: 1.41 g	6.3
Secondary packaging	Cardboard[7]: 16.5 g	0.54

Distribution

The Barista Oat drinks is transported to a warehouse in the UK, before being further distributed to the market. The distribution transports are specified in Table 8.

Table 8. Distribution transports

Transport	Mode	Fuel type	Emission factor[8] [kg CO_2e/MJ]	km	Fuel use MJ/ton/km
Factory to warehouse	Truck	Diesel B7, EU average	0.091	733	0.75
Warehouse to grocery store	Truck	Diesel B7, EU average	0.091	50	3.6

[4] FEFCO. European database for corrugated board life cycle studies.

[5] Hammond, G., Jones, C., 2008

[6] Hillman et al, 2016

[7] FEFCO. European database for corrugated board life cycle studies.

[8] Energimyndigheten, 2020

Results

The climate footprint for the Barista oat drink is 0.51 kg CO_2e per kg product. The climate footprint separated into main process steps is depicted in Figure 2, and Table 9. The agricultural stage has the largest climate impact followed by processing, and distribution.

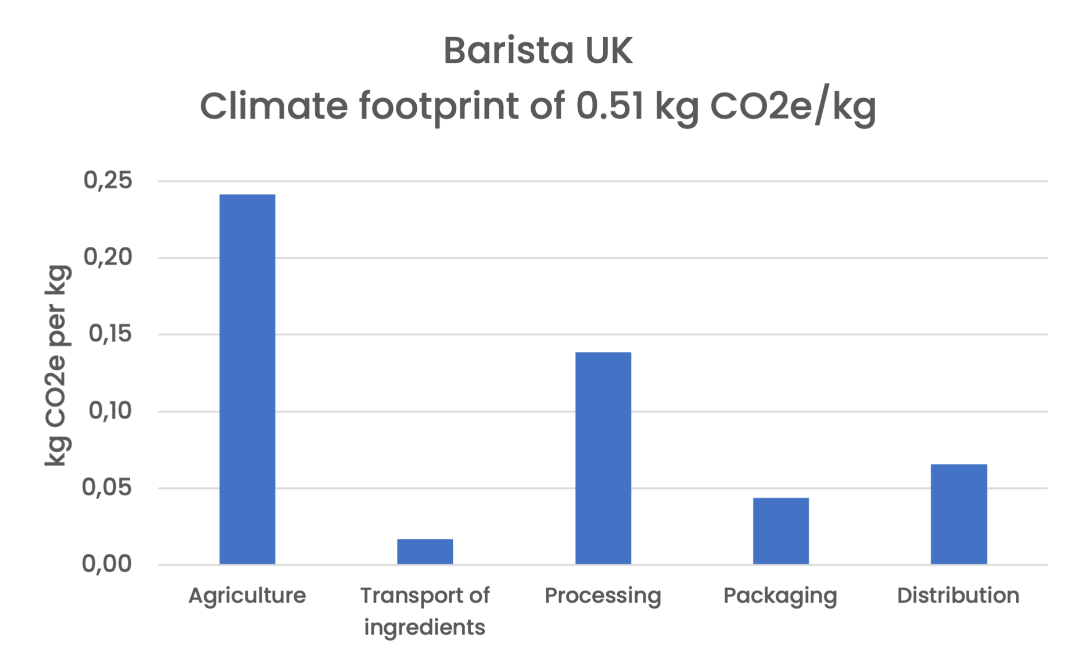

Figure 2. Climate footprint separated into main process steps

Table 9. 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	Share of total
Agriculture	0.24	48%
Transport of ingredients	0.02	3%
Processing	0.14	27%
Packaging	0.04	9%
Distribution	0.07	13%
Total	0.51	100%

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