BIOECONOMY AND HEALTH
AGRIFOOD AND BIOSCIENCE

Carbon footprint report on Arla’s Arla Ko® Eko brand of organic dairy products on the Swedish market 2019 - Public

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Content

Abbreviations

AR4 & AR5	Assessment report 4 respective 5 (IPCC)
C	Carbon
CO2e	Carbon dioxide equivalents
CH_4	Methane
DEFRA	Department for Environment Food & Rural Affairs
EF	Emission factor
EDA	the European Dairy Association
EPD	Environmental Product Declaration
ESG	Environmental, social and corporate governance
FAO	Food and Agriculture Organization of the United Nations
FPCM	Fat and Protein Corrected Milk
GWP	Global Warming Potential
GHG	Greenhouse gas
GHGP	Greenhouse gas protocol
HFC	Hydro Fluoro Carbon compounds
IDF	International Dairy Federation
ISO	ISO - International Organization for Standardization
KRAV	Swedish organization that develops rules for organic farming and animal husbandry, breeding and services, as well as rules for certification of these
LCA	Life cycle assessment
LEAP	Livestock environmental assessment and performance partnership
LU	Land-use
LUC	Land-use change
MS	Milk solids
N	Nitrogen
N_2O	Dinitrogen oxide
NIR	National Inventory Report
PCR	Product Category Rule
PEF	Product Environmental Footprint
SF	Sequestration factor
UNFCCC	United Nations Framework Convention on Climate Change

1 Summary

Introduction

Arla Foods amba commissioned RISE Research Institutes of Sweden, to assess the carbon footprint of Arla Foods organic brand Arla Ko® Eko product assortment provided the Swedish market in 2019.

An overview of project details is given in Summary table 1

Summary table 1. Summary of project details.

Project details	
Client company	Arla Foods amba
Performing company	RISE Agriculture and Food
Goal	Assessing the carbon footprint of Arla's Arla Ko® Eko products in 2019.
Scope	The complete value chain of Arla's Arla Ko® Eko products provided to the Swedish market.
Standard for calculation	ISO 14067 Carbon footprint of products, Greenhouse Gas Protocol Corporate Standard, IDF guide to standard life cycle assessment methodology
Base year	Production year 2019 from 1st January to 31st of December.
Type of control	Operational control approach (Arla has full authority to introduce and implement its operating policies to any process)
Revision of data and Validation	A Limited Assurance engagement has been undertaken by EY Godkendt Revisionspartnerselskab in accordance with ISAE 3410 assessing the greenhouse gas inventory and reporting, as well as the use of the Greenhouse Gas Protocol's Corporate Standard as reporting framework including the Scope 2 Guidance and the Corporate Value Chain (Scope 3) Standard. See pages 42-43 for EY Godkendt Revisionspartnerselskab Independent practitioner's review report.

Methodology in assessment

The assessed product carbon footprints are in accordance with ISO 14067:2018 Carbon footprint of products (ISO,2019). As a complement to the generic ISO standard the methodology in the International Dairy Federation (IDF) guide to standard life cycle assessment methodology for carbon footprint of dairy products has been applied (IDF, 2015). The methodology recommended in the IDF guide is also to a large part adopted to the Product Environmental Footprint Category Rules for dairy products (EDA, 2018).

The calculations and reporting also follow the Greenhouse Gas (GHG) Protocol Corporate Standard and Greenhouse Gas Protocol Value Chain (Scope 3) Reporting and Accounting (Greenhouse Gas protocol, 2011).

Goal and scope of assessment

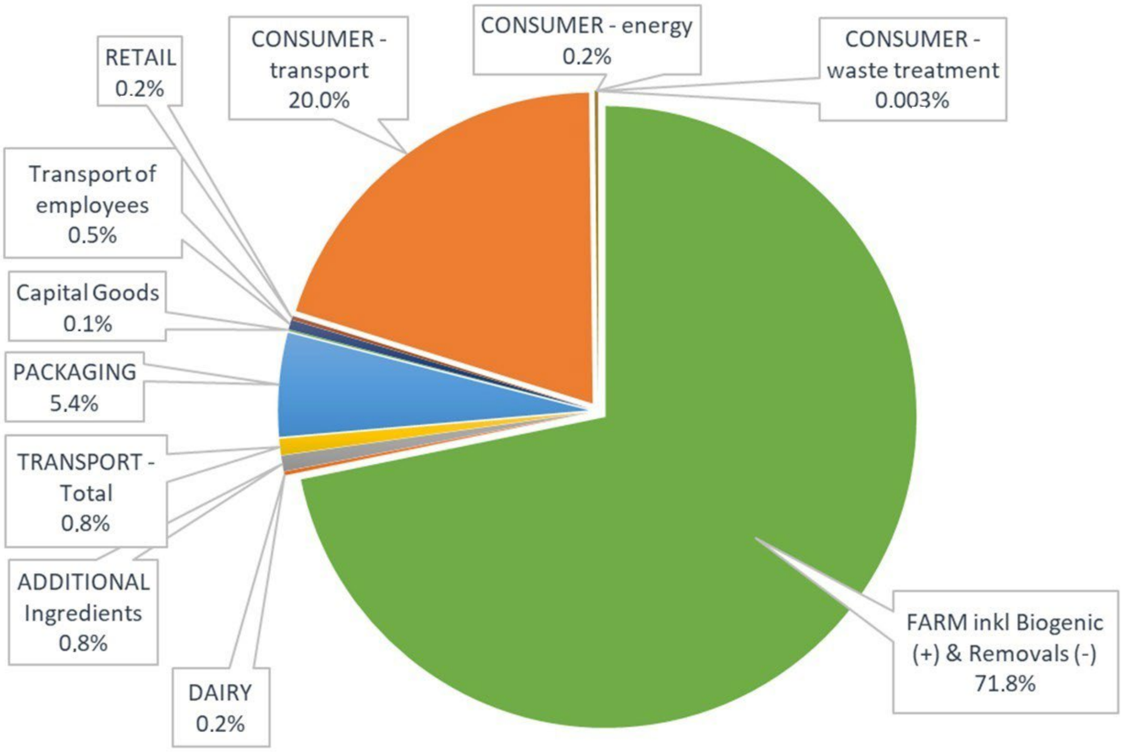
The results in the report will be used for making carbon-neutral claims[1] and represent best-available data for the production system 2019. The concept carbon neutral as defined in ISO14021, meaning that the focus is to set ambitious targets, reduce emission and climate compensate for remaining emissions using carbon credits.

The scope of the assessment is cradle-to-grave i.e., the assessment includes all activities in the dairy product value chain starting with the dairy farm and ending after consumption and end-of-life of waste and packaging at household. The calculations are based on specific data representing the production of the Arla Ko® Eko products in Sweden in 2019, supplied by Arla. The base year for the assessment starts 1st of January and ends 31st of December 2019. Furthermore, information has been collected from suppliers, official statistics in combination with generic data and emission factors.

Result

The total climate impact of Arla Ko Eko product assortment has been estimated to 164068 tonnes of CO2e. The farm step (including contribution from land use, peat soil and sequestration) stand for 71.8% of the total contribution, Summary Figure 1. Contribution from Arla's own activities (dairies, transports, capital goods, business travel and commuting) account for 1.6 % of total climate impact. Packaging contributes with 5.4 % and additional ingredients and retail together account forone percentage. The consumer steps accounts for 20.2% of total carbon footprint, where the consumers transport between retail and household accounts for the dominant part, 20%. Detailed information can be seen in Table 16.

[1] The term "netto noll klimatavtryck" (net-zero) is used by Arla for the carbon neutral claims on organic dairy products in Sweden, and the concept is to be understood as equivalent to the concept carbon neutral as defined in ISO 14021.



Summary Figure 1. Contribution, in shares of total, from the different life cycle steps to total CO2e of Arla Ko® Eko product assortment in SE 2019.

In the assessment the contribution from sequestration is included but reported separately in result. No consensus methodology in how to account for sequestration in the carbon footprint assessment is yet agreed upon. RISE use carbon sequestration numbers correlated to specific soil types provided by peer reviewed references, described, and discussed below in report, page 16. Therefore, the carbon footprint result of the different product groups is given both with and without contribution of sequestration.

The product category Milk accounts for 72.1 % of total climate impact of the Arla Ko® Eko product assortment and is also the largest by volume product group. The average product carbon footprint for milk is 1.44 kg CO2e/kg when including sequestration and 1.64 kg CO2e/kg without. The average product carbon footprint for all Arla Ko® Eko products is 1.58 kgCO2e/kg including sequestration and 1.81 kg CO2e/kg without.

The GHG calculations per se are subject to inherent uncertainties due to made assumptions and immature scientific knowledge. But since the method for GHG calculation in this assessment follows both GHG Protocol Corporate Standard and Value Chain (Scope 3) as well as the ISO standard 14067:2018 Carbon footprint of products together with transparent reporting of assumptions and methodological choices the result carbon footprint is considered representative for the Arla Ko® Eko product assortment of 2019.

2 Introduction

The assessed product carbon footprints are in accordance with ISO 14067:2018 Carbon footprint of products (ISO,20198. As a complement to the generic ISO standard the methodology in the International Dairy Federation (IDF) guide to standard life cycle assessment methodology for carbon footprint of dairy products has been applied (IDF, 2015). The methodology recommended in the IDF guide is also to a large part adopted to the Product Environmental Footprint Category Rules for dairy products (EDA, 2018).

The calculations and reporting also follow the Greenhouse Gas (GHG) Protocol Corporate Standard and Greenhouse Gas Protocol Value Chain (Scope 3) Reporting and Accounting (Greenhouse Gas protocol, 2011).

The calculations are based on specific data representing the production of the Arla Ko® Eko products in Sweden in 2019 supplied by Arla. Furthermore, information has been collected from suppliers, in combination with generic data and emission factors from recognized life cycle assessment databases, scientific articles and other published studies.

3 Scope of the assessment

The carbon footprint of Arla Ko® Eko products provided to the Swedish market in 2019 have been assessed. The product assortment includes milk, yoghurt, sour milk, cream, sour cream, and cheese. The scope of the assessment includes contribution from the complete value chain: from field for feed production, resource use at farm and dairy, packaging, transports, retail and up to consumer at final day of shelf life for the products and waste handling (of food waste and packaging). Specific information on production, packaging and transportation have been gathered for all products in the Arla Ko® Eko assortment and the product carbon footprint has been assessed according to the standard ISO 14067. The product carbon footprints together with total production volumes in 2019 were used to assess the carbon footprint of the total Arla Ko® Eko product assortment and is reported according to the GHG protocol corporate standard and Value Chain (Scope 3). System boundaries of the assessed system are given in Figure 1, with indication on data included in each step. Upper part of the figure shows the scope from a product perspective (according to ISO 14067). Upper together with lower part of Figure 1, describe the system included in the assessment of the Arla Ko® Eko product assortment according to GHG protocol (GHGP, 2011).

Green boxes indicate data provided by Arla and orange boxes data gathered by RISE. The assessment applies the operational control approach since Arla has full authority to introduce and implement its operating policies to any process.

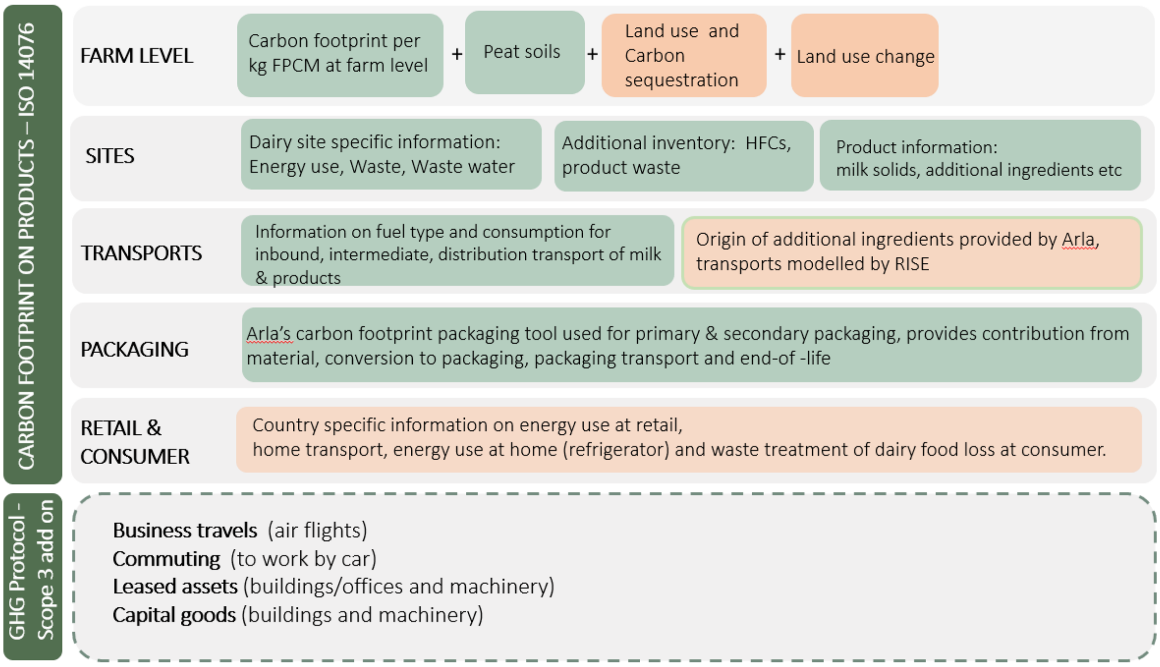


Figure 1. System boundaries for the assessment of carbon footprint of Arla Ko® Eko products and product assortment in Sweden.

3.1 Methodology

The assessment of carbon footprint of the Arla Ko® Eko products and product assortment follows the ISO 14067 standard for carbon footprint of products (ISO, 2018), the GHG Protocols standards for Corporate and for Scope 3 (GHG protocol, 2011) as well as the IDF guide to standard life cycle assessment methodology (IDF, 2015). The characterisation method for GHGs used as default is AR5 (IPCC 2013), with feedback loops. Attributional LCA methodology was applied in the assessment.

3.2 Aim of the study

The aim of the study has been to quantify the carbon footprint of the total Arla Ko® Eko product assortment provided the Swedish market in 2019.

3.3 Arla Ko® Eko brand

Arla Ko® Eko is an Arla brand for KRAV-certified organic products produced from Swedish milk. In 2019 the brand included 67 products sold on the Swedish market. The calculation has been carried out based on specific information on every product and production sites.

3.4 Functional unit

The functional unit from a product assortment perspective is 103794 tonnes of products at the point of distribution inclusive packaging, downstream transports, storage during complete shelf life and waste treatment of packaging and potential food waste.

The functional unit from a product perspective is 1 kg of dairy product at the point of distribution (according to ISO 14067). Packaging correlated to 1 kg of product is also included in the functional unit.

3.5 Reference flow

The reference flow is 99385568 kg of fat and protein corrected milk, FPCM, from farm to production of the Arla Ko® Eko products of the year 2019. This equal 12075347 kg milk solids, MS, referring to the content of fat, protein, and lactose in milk. The FPCM contain 12,15% MS per kg. All milk used in the products is milk from Sweden.

3.6 System description

The defined Arla Ko® Eko product system is based on a product perspective which follows the methodology in the product carbon footprint ISO 14067 standard and is reported with a business perspective according to Greenhouse Gas Protocol, Scope 3 Reporting, Figure 1.

From a product perspective (ISO 14067) the processes included in the product system, Figure 2, are divided in:

- Upstream processes, mainly farm activities (cradle-to-gate),
- Core processes, activities at Arla´s sites and facilities (gate-to-gate),
- Downstream processes, activities in the value chain between dairy and consumer (gate-to-grave).

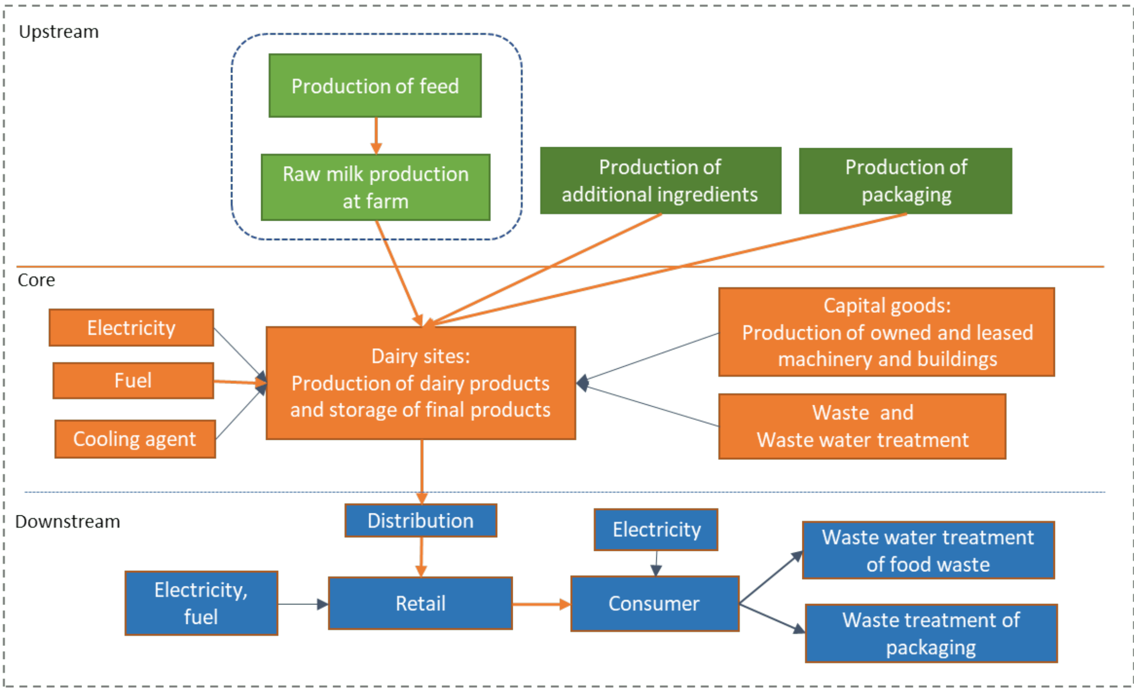


Figure 2. Simplified flowchart of the Arla Ko® Eko product system, orange arrows indicate transports.

From a business perspective (Greenhouse Gas Protocol) all relevant scope 3 categories are covered and the emissions are reported in relevant scopes and categories. Emissions of cooling agents and emissions from combustion of fuels in Arla owned assets are reported in scope 1 and emissions from production of purchased energy (electricity and district heating) used in Arla owned or leased facilities are reported in scope 2. The remaining emissions are reported in scope 3.

3.6.1 Included processes

All processes included in the assessment are listed in Table 2.

Table 1. Processes representing the Arla Ko® Eko products included in the assessment. Indication is given from where in the value chain and what scope the emissions are allocated to.

Category	**Emissions to Scope**	**Processes**
Upstream processes	3	All farm activities (on and off farm): - Methane emissions from cow enteric fermentation - Manure handling, storage and spreading - Feed cultivation, production, and consumption, on farm and imported - Inbound transports of feed and inputs to farm - Production and use of electricity and heat at farm - Emissions from peat soils at farm - Sequestration and emissions from land use
	3	Milk collection of Arla milk, external transports, from farms to dairies
	3	Production of and inbound transports of ingredients and packaging
Core processes	3	Extraction and distribution of energy to Arla sites
	1	Combustion of fuels at Arla dairy sites to production of the final product (e.g., skimming, homogenization, pasteurization, packing, cooling)
	2	Emissions from the generation of purchased electricity used at Arla dairy sites
	3	Waste management of all waste fractions and wastewater treatment of wastewater from Arla dairy sites
	3	Intermediate transport (external) between Arla dairies
	3	Production of capital goods and leased assets at Arla sites.
	3	Business travels and commuting (Arla employees)
Downstream processes	1	Distribution transport (internal) from dairy or warehouse to retail
	3	Distribution transport (external) from dairy or warehouse to retail
	3	Retail: Energy and electricity use
	3	Consumer: transport from household to retail, return trip

	3	Consumer: energy use due to cold storage
	3	Consumer: waste treatment of dairy food loss in households
	3	End-of -life treatment (incineration) of packaging

The defined production system is also based on the Greenhouse Gas Protocol Value Chain Scope 3 Reporting Standard. Table 3 gives information on how the different life cycle stages correlate to scopes and categories according to the GHG Scope 3 standard, and whether they are included or not in the assessment.

Table 2. Correlation of life cycle stages to Scope and Categories of GHG Protocol with comments whether included or excluded in the carbon footprint assessment of the Arla Ko® Eko product assortment.

Scope	**Categories**	**Included/excluded and life cycle stage**
Scope 1	Direct emissions	Included in Dairy sites: emissions from fuel combustion at sites, emission from internal transports and emission of refrigerants
Scope 2	Indirect emissions from purchased energy	Included in Dairy sites: purchased electricity and district heating
Scope 3	**Categories for scope 3 as defined in GHG Protocol**	
Scope 3 - Upstream	1. Purchased goods and services	Included in Farm, Additional Ingredients and Packaging
	2. Capital goods	Arla's buildings and machinery (forklifts and filling machines) are included, as well as capital goods in transport, remaining capital goods are excluded
	3. Fuel-and energy-related activities (not included in scope 1 or scope 2)	Included in stages: -Transport; well-to-tank in internal Distribution - Dairy; use of electricity and district heating (scope 3)
	4. Upstream transportation and distribution	External transports (well-to-wheel) included in stages: -Transports; Inbound +Intermediate + Distribution from external transports of dairy based products. -Packaging; Incoming transports of packaging material - Ingredients; Incoming transports ingredients to Arla sites
	5. Waste generated in operations	Included in Dairy and in Packaging

Scope	Categories	Included/excluded and life cycle stage
	6. Business travel	Air flights are included in Business travel, business travels with other transport modes are excluded
	7. Employee commuting	Included as Commuting, car commuting by Arla employees
	8. Upstream leased assets	Leased forklifts and filling machines at Arla dairies are included
Scope 3 - Downstream	9. Downstream transportation and distribution	Included in Consumer: Consumer transport from retail to home
	10. Processing of sold products	Included in Retail
	11. Use of sold products	Included in Consumer energy
	12. End-of-life treatment of sold product	Included in Consumer waste treatment and in Packaging
	13. Downstream leased assets	n/a, see 3.9
	14. Franchises	n/a, see 3.9
	15. Investments	Excluded, see 3.9
Out of Scope		Biogenic carbon emissions from the combustion of renewable fuels, reported separately

3.7 Time and geographical representativeness

The assessment represents the production of the Arla Ko® Eko product assortment in 2019 at seven dairies and one cheese packaging site in Sweden. All raw milk used is produced at Arla's owner milk farms in Sweden.

3.8 Allocation

The emissions at farm level (also including emissions from peat soils and sequestration at farmland) are allocated between milk and meat (from slaughtered dairy cows and surplus calves) based on the feed energy, as recommended in the methodology by IDF (IDF 2015). The allocations of the contribution from both farm level and dairy site to the different dairy products and product assortment are done based on the content of milk solids (MS; fat, protein and lactose) in the final product and product assortment (IDF, 2015). The above-mentioned allocation methods are also proposed in the product-category rules for dairy products in the European work on Product Environmental Footprint (PEF), (EDA,2018). Allocation of the contribution from transports and cold storage is based on mass.

3.9 Exclusions and delimitations

Contribution from all major impacting steps in the dairy product value chain is included in the assessment, in alignment with ISO 14067. Three (listed below) of the fifteen activities in Scope 3 GHGP standard have been excluded in the assessment since they are of no relevance for the Arla Ko® Eko product assortment, according to the Greenhouse Gas Protocol Value Chain Scope 3 Reporting Standard (Greenhouse Gas Protocol, 2011):

13. Downstream leased assets. Contributions of Downstream leased assets have been left out since Arla have no downstream leased assets.

14. Franchise. Contributions of franchise have been left out since Arla have no franchise organisation.

15. Investments. Investments are not relevant for Arla since Arla Foods is a cooperative and all excess of money returns to the farmers as an extra payment to them. In a GHGP assessment done in 2019 on the Arla Ko® Eko product assortment for the Swedish market the contribution from investments (represented by pension funds to Arla employees) was shown to be 0.2% of total climate impact (U&We, 2019).

In the two Scope 3 categories below, the following delimitations were done:

11. Use of sold product. Contribution from the activity Use of sold product is represented by the refrigerator storage at home. No other energy use is related to consumption of Arla's products.

12. End of life for sold products. Contribution of the activity End of life for sold products is represented by waste treatment of packaging and wastewater treatment from household (dairy product waste at household in Sweden).

4 Inventory

4.1 Arla organic dairy milk farms in Sweden

Information of all relevant activities on farm related to milk production has been collected by Arla and provided to RISE. RISE has then adjusted these numbers to comply with ISO 14067 (i.e., using GWP factors including climate-carbon feedback loops). In addition, emissions, and uptakes of carbon in relation to land use has been added by RISE (see 4.1.3).

The carbon footprint of milk at farm level has been calculated using the Arla carbon footprint farm tool (climate check tool). Arla has invested in a tool, developed by 2.0-LCA consultants, to calculate the carbon footprint of milk at farm level. The climate check tool is based on the methodology developed by the IDF (IDF, 2015) and the methodology was later also to large part adopted by Livestock Environmental Assessment and Performance Partnership, LEAP, (FAO, 2016) and PEF (EDA, 2018). The methodology is also in accordance with ISO 14044 (2006) and also, to a large extend, ISO 14067 (2018). However, in the climate check tool Arla do not use GWP_{100} including feedback loops which is required by ISO 14067, so this has been adjusted for, hence the GWP_{100} including feedback loops is used in the present study. Currently, the tool does not account for carbon emissions and removals (carbon sequestration) from land use, although this has been assessed and added by RISE in the study. The tool was developed several years ago and has gone through several updates which are documented in a number of papers and reports (Dalgaard et al., 2014; Dalgaard et al., 2016; Schmidt and Dalgaard 2012).

The Arla tool includes all relevant emissions both on farm and off farm: methane (CH_4) emissions on farm level from enteric fermentation from animals (cows and heifers), CH_4 and nitrous oxide (N_2O) emissions related to manure handling and storage, both direct and indirect N_2O emissions from feed cultivation, and fossil CO_2 emissions from diesel and other energy use on farm, as well as emissions from production of imported feed, transportation, and other inputs. The tool also includes emissions (N_2O and CO_2) from peat soils.

In 2019 Arla had 389 organic farmer owners in Sweden. The CF of the milk in the present study is based on 351[2] carbon assessments of the Arla owners conducted in 2020 based on 2019 data [or 2018/2019].

During 2020, the Arla climate check tool has gone through a major update and has been rolled out to all Arla farmer owners. The data used for the carbon footprint calculations are farm-specific and verified by an external agricultural advisor, who also conducts a visit[3] at the farm. The climate check consists of four steps:

1. data input by the farmer
2. validation and completion of the data by an external advisor during the advisory visit
3. evaluation of the results by an external advisor to help the farmer interpret the results and understand strengths and areas of improvement for the farm.
4. statistical process by Arla where outliers have been identified and gone through an extra check by the external advisor.

Based on the 351 farms, the average annual milk yield per cow was 8303 kg FPCM and the average heard size was 97 cows per farm. The average share of peat soils on the Swedish Arla organic milk farms were 3.0% and 4.4% for permanent pastures and crops in rotation, respectively (see section 4.1.2). Information on land use is found in section 4.1.3. Based on the assessment the average carbon footprint is 1.39 kgCO2e per kg FPCM (using GWP100 including feedback loops and emissions from peat soils but excluding carbon emissions and carbon sequestration related to land use).

4.1.1 Contribution from land use change

The Swedish soy dialogue (Svenska Sojadialogen, 2021) is an initiative where the member companies through voluntary responsibility contributes to the development of and an increased demand for more responsibly produced soy. The initiative approves organic soy as sustainably produced where one of the criteria is that it should not cause deforestation & conversion. The market leaders for feed sales in Sweden) are members of the Swedish soy dialogue and have signed the commitment to sell soy that meets the criteria stated by the Soy dialogue. Based on a dialogue with feed industry experts, palm

[2] All organic farmers have conducted a carbon assessment in 2020, but due to various steps in validation of the data, only 351 of the assessments are used in the present study.

[3] Physical visits were curtailed due to Covid-19. Many farm visits were conducted online.

oil products are not used in organic feed for dairy cows in Sweden. Therefore, no contribution from land use change is included in the assessment

Contribution from organic soils (peat soils)

The share of peat soils of the permanent grassland and the rotational cropland (including rotational grassland) in the Arla organic farms in Sweden are 3.0% and 4.4 % respectively according to Arla. Information was provided by Arla and represent a milk volume weighted average of all organic farms (Arla SE). The average organic dairy farm uses 244.5 ha and 8.2 ha of cropland (including grassland in rotation) and 1.6 ha of permanent grassland is peat soil. The contribution from peat soil cultivation is included in the information from Arla farm tool and specified as being 0.1795 kg CO2/kg FPCM and 0.155 g N2O/kg FPCM (UNFCCC, 2018)

4.1.2 Contribution from sequestration

Carbon sequestration is when CO_2 from the atmosphere is stored in soil and plants. Carbon sequestration can be both above ground (e.g., trees, hedges) and below ground (i.e., in the soil). In the present study, a conservative approach is taken and only carbon sequestration in soil is included.

According to professor, Thomas Kätterer at the Swedish University of Agricultural Sciences (Kätterer, pers. Comm., 2020), there are currently too few studies to make it possible to distinguish between sequestration in different countries, so the carbon uptake/release figures from land use applied in the assessment for Sweden, may also be used for other markets. Hence the focus is on the different types of land used at Arla organic dairy farms in this assessment.

The effect of manure has not been accounted for as a separate sequestration impact but assumed to be included and considered in the carbon uptake/release-figures in Table 4.

Grassland is a natural part of dairy farms, for pasture, hay and silage production. Grasslands have proven to sequester carbon from the atmosphere to the soil, due to its extensive root system, were both fresh and decayed roots contribute to the soil carbon pool. The sequestration has been measured in several long-term field trials, and although the reported amount of carbon varies in the scientific literature, there is strong agreement that there is a net sequestration (Bolinder et al., 2017). A few exceptions can be seen on soils with very high initial carbon content, were grassland as well as cropland loose carbon, however grassland in a much lesser extent than annual crops.

One important aspect that greatly affects the sequestration figures is which reference use of land has been considered. The reference use of land varies in literature, in some field trials, the sequestration in grassland is compared to a reference plot where annual crops are grown, in other experiments the actual sequestration in the same grassland plot is measured each year.

In this study, the change in carbon soil is reflected in comparison to land with annual crop cultivation. The reasoning here, is to consider what the land would be used for if Arla did not use it for organic dairy production. A likely scenario is that the land would be used for annual crops, and therefore this is chosen as the "reference" land use. The assumption is however that annual crops are in steady state i.e., there is no net carbon sequestration. This means that the grassland carbon sequestration is the same as the actual sequestered carbon in the grassland (the reference is zero). This is a conservative assumption, as e.g., intensive crop rotations with annual crops risk eroding soil carbon rather than maintaining or building it.

There are several important aspects that have been focused on in order to account for carbon sequestration; the reasoning for each type of land is summarised below:

Annual crops, in rotation and no rotation. Since this have been chosen as the reference there is no net carbon soil change for this land type. Further, this is in line with figures reported for ley in literature, which is often compared to annual crops. There are no published studies on sequestration for annual crops with no rotation of crops but Kätterer (pers. comm., 2020) argues that it is reasonable to expect similar uptake as for annual crops in rotation; this is assumed in the assessment.

Grass and clover/lucerne in rotation. There is large variation in carbon sequestration for this type of crop in literature. Soussana et al (2007) states 310 kg C, Kätterer et al (2013) states 500 kg C, and Bolinder 645 kg C per ha and year. Kätterer is currently conducting a study which gives preliminary findings of 570 kg C per ha and year. Furthermore, according to Kätterer, it is reasonable to expect little difference between a 2-year crop and a multi-year crop, since in the 2-year crop there will be a large carbon supply when the crop is ploughed down into the field. Still, the lower figure is used, in order to be conservative and not overestimate the sequestration.

Permanent grass (>5y). There is one study from north European countries that states sequestration of 500 kg C per ha and year (Kätterer et al, 2013), with annual crops as reference state. This value is used in the assessment.

Permanent grassland with high nature value. For this type of land there is one study, based on Swedish conditions, and the variations are expected to be large between different countries. However, due to lack of other data, the value 30 kg C/ha and year taken from the reference (Karltun et al, 2010), is used in this assessment.

Table 4 shows the share of different types of land on organic dairy farms in Sweden providing milk to production of Arla Ko® Eko products. For each type of land, a carbon uptake (sequestration), or release, has been considered in the assessment, summarised in the second column in Table 4.

Table 3. Area (ha) of different types of land at the Arla organic dairy farms in Sweden in 2019, and factors used to account for sequestration for each type of land. A negative sequestration factor indicates carbon emission instead of sequestration.

	Land use in ha Arla organic farms 2019	**Kg C /ha/yr**	**Reference**	**Comment**
Annual crops, in rotation and no rotation	26133 (31%)	0	Steady state has been assumed.	Chosen as reference state so no net carbon soil change.
Grass and clover/lucerne in rotation	39033 (46%)	310	Soussana et al, 2007	Based on 2-year test for different types of ley in different European countries, both forage and pasture, and fertilised and non-fertilised.
Permanent gras s (>5y)	4377 (5%)	500	Kätterer et al, 2013	Compared to annual crop, average value from different north European countries.
Extensive pastures	14923 (18%)	30	Karltun et al, 2010	Based on study from the Swedish board of agriculture, C/N method, valid for Swedish natural grassland, but no other study available, so used also for SE.

4.2 Carbon footprint of milk at farmgate in Sweden

Summary of contribution to carbon footprint of 1 kg FPCM from farm level in the Sweden is given in Table 5.

Table 4. The carbon footprint of 1 kg FPCM at farm level in Sweden, IPCC 2013, with feedback loops. Cell in green is used in calculation.

Country	Total **without** contribution from peat soil and sequestration (kgCO2e/kg FPCM)	Contribution from sequestration (kgCO2e/kg FPCM)	Contribution from peat soil (kgCO2e/kg FPCM)	Total **inclusive** sequestration and peat soil (kgCO2e/kg FPCM)
Sweden	1.16	-0.20	0.23	1.18

4.3 Products included in Arla Ko® Eko product assortment in 2019

The total production volume of Arla Ko® Eko products during 2019 was 103794 tonnes containing 67 different products. Some products only differ in packaging size, but have the same product content, still defined here as a separate product. The 67 products can be divided in 5 different product categories of consumer products, Table 6.

Table 5. Number of Arla Ko® Eko products in each product group and production sites.

Product group	Number of products	Dairy sites
Milk	27	Jönköping, Linköping, Stockholm, Sundsvall and Visby
Cream& soured cream (gräddfil)	7	Jönköping, Stockholm, Linköping, and Sundsvall
Yoghurt	16	Linköping
Sour milk (filmjölk)	4	Linköping and Stockholm
Cheese	13	Götene and Kalmar

4.4 Dairy sites

Seven dairy sites in Sweden are manufacturing the Arla Ko® Eko products: Götene, Jönköping, Kalmar, Linköping, Stockholm, Sundsvall, and Visby dairy sites. The cheese, produced at Götene and Kalmar dairies, is cut into pieces and packed at a packaging site Alexander situated in Götene. The electricity, fuels, and refrigerant use as well as waste generated at each dairy are allocated to the Arla Ko® Eko product assortment according to the content of MS in each organic product in relation to the total amount of MS handled at the dairy. All by-products e.g., whey in the cheese production, are used in other products for human consumption. The final products are distributed with an intermediate transport to a distribution centre, prior distribution to retail.

4.4.1 Food losses at dairy

Specific information on food waste at the different dairy sites and for different products was provided by Arla. This information was used in the calculation so that the amount of input milk from farm was increased with the waste percentage specific for each product and dairy.

4.4.2 Resource use at dairy

The total amount of MS in the final Arla Ko® Eko product assortment is 11469 tonnes. With the specific food waste percentage in dairy for each product, milk volumes needed to the final product have been calculated and used as the contribution to the carbon footprint from farm level. The total amount of MS in the in-put milk to Arla Ko® Eko product assortment is 12075 tonnes.

The use of energy and electricity resources at the dairies is given in Table 7.

Table 6. Energy use at the dairies producing Arla Ko® Eko products, 2019.

2019	Energy use at dairy, allocated to Arla Ko® Eko product assortment	Unit
Gas oil	45	MWh
Fuel oil	23	MWh
Biogas	82	MWh
Biomass	1741	MWh
District heating (Renewable)	4008	MWh
District heating	494	MWh
Electricity	11036	MWh

The emission factor used to characterise the climate impact of natural gas is given in Table 18 in Appendix. Emission factor for SE electricity, both location and market based, is provided by Sphera.

4.4.3 Waste and HFC emission generated at dairy

Contribution of incineration of waste and hazardous waste is included in the assessment together with contribution of wastewater treatment (regarding COD content in wastewater to external treatment) and emission of cooling media, Table 8.

Table 7. Waste and HCFC emission at the dairies producing Arla Ko® Eko product assortment.

2019	Waste and HFC emission generated at the dairy, allocated to Arla Ko® Eko product assortment	Unit
Waste for incineration	22	tonnes
Hazardous waste for incineration	48	tonnes
COD in wastewater to external treatment	102	tonnes
Emission of cooling media (HFC-gas)	4	kg

Waste that goes to recycling or biogas production is not included in the assessment since a cut-off have been used on all materials entering another production life cycle. The emission factors used to characterise the climate impact of waste treatment and leakage of refrigerants are given in Table 19 and Table 20 in Appendix.

4.4.4 Ingredients in products

In most of the 67 Arla Ko® Eko products the dairy-based content was >98%. Six products contain also non-dairy based ingredients e.g., fruit and sugar. Arla provided information on amount and the origin of the ingredients.

Ingredients used in the products are listed in Table 9. Climate impact from the non-dairy ingredients is taken from the RISE Climate database for food, version 1.7, from the Ecoinvent database 3.6 and from industry data. The origin of the non-dairy ingredients was provided by Arla and the incoming transports of the ingredients are included in the assessment.

Table 8. Ingredients used in the products.

Ingredients	Reference to climate impact information
Strawberry	RISE Climate database for food 1.7
Pear	RISE Climate database for food 1.7
Milk protein	RISE Climate database for food 1.7
Enzyme	Ecoinvent database 3.6
Bacteria culture	Industry data
Starch	Ecoinvent database 3.6
Sugar	RISE Climate database for food 1.7
Salt	RISE Climate database for food 1.7
Vanilla	World Food LCA Database
Pectin	Industry data
Lemon juice	RISE Climate database for food 1.7

The total amount of all added non-dairy based ingredients was 346 tonnes (0.32 % of total Arla Ko® Eko product volume). The total impact of the additional ingredients to carbon footprint of the Arla Ko® Eko product assortment was 1340 tonnes CO2e.

4.4.5 Capital goods at dairies

Regarding capital goods, the contribution from filling machines, forklifts as well as the buildings at the seven dairies were included, Table 10. Capital goods is included in the datasets used from Ecoinvent database but not in other parts of the value chain capital goods have not been considered.

The contribution was modelled based on provided numbers of machines and forklifts at the dairies and building areas of the different Arla sites. Then the data for climate impact contribution used in the calculation was taken from databases and literature to best match the systems. This results in larger uncertainties in the assessment of contribution from capital goods than from other parts of the assessment. Contribution from capital goods is however known to have a minor contribution to the climate impact of a product or a product assortment (U&We,2019). Below follows information on assumptions and models used.

For **filling machines,** the carbon footprint data of two environmental product declarations (EPD) from TetraPak of filling machines were used as the basis representing a filling machine in the dairy sector. The EPDs give the impact from the manufacturing stage related to the filling of 1000 litres of packed liquid foods, based on 1-litre packs. The life span of the filling machines in the EDPs is 30 000 hours of active use. Arla estimated a life span of their filling machines to 20 years. In relation to the life span Tetra Pak used this would correlate to 1500 hours of use per year at Arla hence the contribution of the filling machines is on the conservative side. Then calculating the resulting total impact of Arla's filling machines can be done in two ways. The carbon footprint from the EPDs (using an average the two EPD figures) can be multiplied with either the volume of Arla organic products or by multiplying with the number of Arla products (then assuming every filling of product is the same for all products independently of product type or size). The volume of products gives the highest figure and is thereby used to be conservative. For more information see Appendix 8.2.1.

For **forklifts,** information on carbon footprint from the manufacture of two tractors have been used as a basis, due to lack of data on forklift production, see Table 22 in Appendix. Production of tractors have probably a higher climate impact than production of forklifts but used here as a conservative choice to represent forklifts. A six-year life span of the forklifts was given by Arla. Arla has supplied information about the number of forklifts used at each dairy and since these forklifts are used for the total production at the dairies, allocation based on MS content in the organic products is used to allocate the share to these products. For more information see Appendix 8.2.2

For **buildings**, information about the carbon footprint from the production of a block of flats, was used as a proxy for data on production of a dairy/storage/office building. A 60-year life span of the buildings has been assumed. Arla has supplied information about the area of buildings they use. As for forklifts, these buildings are used for the total production at the dairies, hence, allocation based on MS content in the organic products is used to allocate the share to these products. For more information see Appendix 8.2.3

Table 9. Contribution from capital goods, number in green cell used in assessment.

	Filling machines	Forklifts	Buildings	Total contribution from capital goods
t CO2e	14	39	81	134

4.5 Shelf life of products at dairy, retail and consumer

Information on shelf life of the products was provided by Arla. Shelf life is defined as the date of the production to best-before-date printed on the packaging. The complete shelf-life time is considered in the assessment. This is a conservative choice since products possibly will be consumed before the last day of best-before-date. The share of the shelf life (storage) allocated to dairy was given by Arla and RISE divided the remaining days equally between storage at retail and storage at the consumer.

All products need refrigerated storage during shelf life.

4.6 Packaging

Information regarding packaging (material types and weights) for primary and secondary packaging for all products was provided by Arla and included in the assessment. Tertiary packaging, roll containers and pallets, are reused for several years and the contribution to carbon footprint per kg dairy product and route will be insignificant. The climate impact of the packaging was calculated by Arla using the Arla Packaging Calculator, which is a GaBi Envision tool developed by Sphera and designed to determine the environmental impacts of product packaging. The tool is based on a fully parameterised LCA model, and the methodology is verified by an independent 3rd party LCA expert. Contribution from production of packaging material, transport of packaging material, conversion of material into packaging and waste treatment at end of life of packaging are included. Since a conservative approach is applied in the assessment emissions from the part of packaging that goes to incineration are included while the energy produced at incineration is excluded i.e., it is not giving any benefit to the assessed system from the produced energy[4]. The part of the packaging that goes to recycling is also excluded. This cut-off gives the advantages of recycled material to the user of the recycled material. The characterized CO_2e contribution is given divided in CO_2e from fossil, biogenic and land use change sources.

Six different primary packaging was used for the Arla Ko® Eko products, Table 11.

Table 10. Primary packaging used for the Arla Ko® Eko products.

Type of primary packaging	Packaging size (L or kg)
Liquid board, (Tetra Top)	0.3L & 1.0L
Liquid board, white or brown board (Gable Top)	0.3L, 0.5L, 1L & 1.5L
Liquid board, (Tetra Brik)	0.3L
Plastic bucket	5.8 kg
Bag-in-Box	10L & 20L
Top and Bottom Laminated plastic packaging	0.135kg to 5kg

The secondary packaging used for the products are carton (corrugated board, single use) and a plastic crate (multiple use; H-box). Contribution from the multiple use secondary crates is not included in assessment. Information was provided by Arla on amount of carton used per primary packaging.

[4] This is in alignment to the GHG protocols requirement

4.7 Transports

4.7.1 Transports within Arla

The transport of milk and dairy products until retail Arla can be divided in inbound, intermediate and distribution transports, Figure 3. The arrows in the figure indicate transports. The information on type and amount of fuel use for all transports was provided by Arla. All inbound and intermediate transports are run by external transport services. In the distribution transports there are both Arla owned and external transport services in operation, 40% of the fuel use in distribution is used in Arla owned trucks.

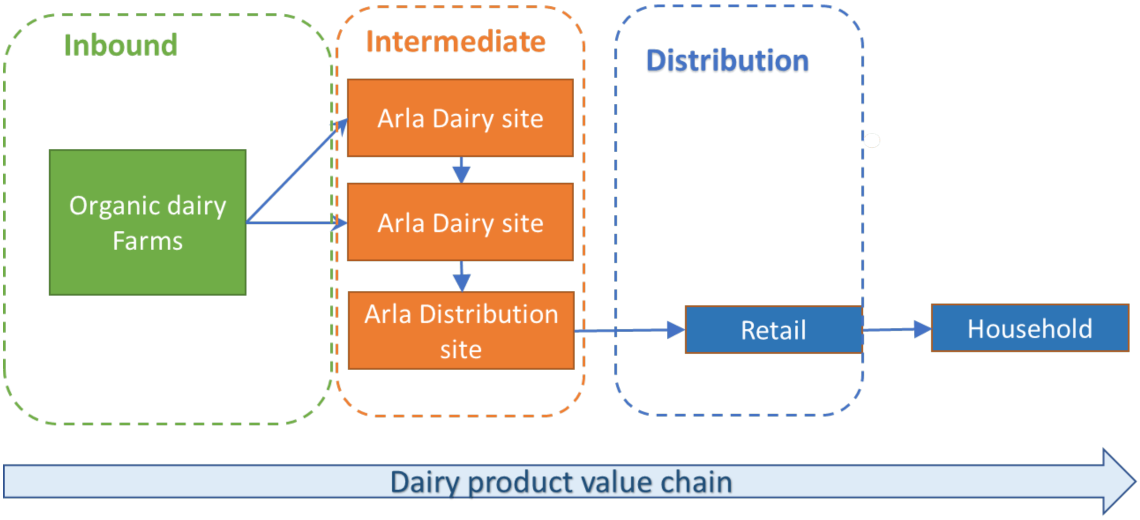


Figure 3. Simplified transport flow of milk products from farm to household. Arrows indicate transports.

Information on fuel used in milk collection was provided by Arla. 100% of the fuel used in the **inbound** transports is renewable (HVO and RME). The contribution from the inbound (milk collection) transport is allocated regarding the content of MS in final product.

Intermediate transports of cheese between cheese dairy and cheese packaging site are included here as well as products transported from Linköping dairy to distribution centrals. The cheese products are then transported to an Arla distribution site before being distributed to retail. Specific information on fuel use in the intermediate transports was provided by Arla. In the intermediate transports 65% of the fuel used is renewable. Allocation of the intermediate transport was done by mass.

The **distribution** of dairy products from Arla sites to retail is included in the assessment. Information on fuel used in distribution was provided by Arla. 97% of the fuel used in distribution transports is renewable. Allocation of the distribution transport was done by mass.

The intermediate and distribution transports are refrigerated transports. The estimated contribution from leakage of refrigerants from truck cooling systems is included. The information on the amount of refrigerant losses was provided by Arla. The inbound milk collection transports are not refrigerated. A contribution from infrastructure of transports (construction and maintenance of trucks and roads) was taken from corresponding transport processes in the Eco invent data base and added.

The last transport along dairy product value chain is the consumer transport from retail to household. For consumer transport see section 4.9.1.

The contribution from all transports of Arla Ko® Eko products is 1384 tonnes CO_2e. The biogenic carbon from combustion of renewable fuels, considered Out of Scope, is 4174 tonnes CO_2e.

4.7.2 Transports of non-dairy based ingredients

The transports of all additional non-dairy based ingredients to the production sites were modelled by RISE using the information of origin (country) of the ingredients given by Arla. The specific transport distances were defined as from the capital of the origin country to Stockholm. The land-based distances were estimated using Google maps.

The truck type used in the calculations is a rigid truck 14-20 t, Euro5, Diesel B7EU with a 90% load factor and container ship, dwt 100000, load factor 90% (NTM, 2020).

4.8 Retail

Information on the energy use at retail is taken from a report on energy use in retail premises (Swedish Energy Agency, 2010). Food retail stores are the type of stores that had the highest energy consumption of all stores investigated. 399 kWh/m2 and year is the weighted national average energy use in food retail stores. Refrigeration accounts for about 50% of the energy use, 145 kWh/m2 and year. Even though the energy for cooling was specified the total energy use was used in the assessment. Since 2010 energy efficiency for refrigeration in the retail sector has increased as well as replacing old refrigerators and freezers to comply with EU directive on cooling agents, meaning that the numbers used are the best available data and likely conservative.

In order to still not underestimate the energy use at retail an extra energy use for refrigeration was added as well. Electricity consumption of retail refrigeration was taken from literature (Axell, 2001).

From the information of energy use per square meter and year RISE made the following assumption expressing energy use per kg instead of per m2 in store:

Starting from the most common packaging type the 1 litre milk packed in a gable top packaging (size: 7*7*23 cm) one square meter give space to 204 gable top packaging and a cubic meter may store 887 litres. Goods at retail is displayed from floor up to 1,8 meter in height, results in that one m2 holds 1.8*887 ~1600kg of product. The products are stored with some space in between assuming 50% of the volume is product and 50% is air. Then the actual weight per m2 is 1600*0,5 ~800 kg. Swedish average electricity mix (location based) has been used in the assessment of climate impact from storage at retail.

From this information the contribution of energy use per kg and day at retail was calculated, Table 12.

Table 11. Energy use in the food retail sector in the Sweden (Swedish energy agency, 2010). The electricity for refrigeration was taken from Axell, 2001. Green cell used in assessment.

Energy source	kWh/m2*y	kWh/kg*d	kg CO2e / kg and day
District heat	56.6		
Fuel oil	5.2		
Wood pellets	14.4		
Electricity	322.2		
District cooling	0.7		
Electricity (refrigeration)		8.6E-03	5.7E-04

The total contribution from retail is 335 tonnes CO2e.

4.9 Consumer

The contribution from the consumer phase included in the carbon footprint of the Arla Ko® Eko dairy products are:

- the transport of product from retail to home
- the refrigerated storage of product at home
- the treatment of wastewater from the dairy products wasted in the sink.

Waste handling of packaging is included in the section of packaging, 4.7

4.9.1 Home transport

According to a report on availability of retails in Sweden (Trafikanalys, 2021) the average distance in Sweden between household and retail is 4.8 km. In the assessment 9.6 km was selected as the total distance for food purchase: 4.8 km x 2. 61 % of the shopping and service errands was done by car (Trafikverket, 2019) and an assumption done that 5 kg of food was bought at every retail trip. The emission factors used for the personal car is taken from NTM; Car, vehicle operation, Petrol E5, Euro 5. Contribution from infrastructure (from production and maintenance of car and roads) is included.

The contribution in kg CO2e allocated to 1 kg of purchased food by car is 0.32 kg CO2e.

The total contribution from transport of Arla Ko® Eko dairy product from retail to household is 32811 tonnes CO2e.

4.9.2 Refrigerated storage

Energy consumption data for consumer refrigerator was taken from the site SparEnergy.dk (Spar.Energy.dk, 2020). There is no reason to believe that the energy consumption of consumer refrigerators varies in different western European countries, so this source was used also for Swedish households. A 200-litre fridge size was chosen, with an electricity consumption of 196 kWh per year (average between energy class A and class B fridges, 200 l) to represent the consumer cold storage of Arla Ko® Eko products. A 25% average load factor of fridge was used as a conservative approach. Swedish average electricity mix (location based) have been used in the assessment of climate impact from refrigeration storage at household.

The contribution from cold storage of one litre (kg) product one day is 0.0005 kg CO2e.

The total contribution from cold storage of Arla Ko® Eko dairy product in household is 306 tonnes CO2e.

4.9.3 Treatment of dairy based waste

According to a report from the Swedish EPA 25 % of the liquid food wasted at household in Sweden 2014 was dairy based products (Sörme et al, 2014). That equals to 55000 tonnes of dairy based products rinsed out in the zinc in 2014. In relation to the consumed volumes of liquid dairy-based products in 2015 (Jordbruksverkets statistics, 2020) the waste percentage will be 4,6%. In a report on global food loss (FAO, 2012) the food loss of dairy products at consumer in Europe was given as 7%. According to the conservative approach in this assessment the 7 % dairy-based food waste at household is used. Almost all products in this report (99,2% of the produced volume) is liquid dairy products and thereby wasted in the sink. An assumption is made that 1 litre of water is used to every litre of dairy product wasted. The contribution of wastewater treatment from households is then added. The Ecoinvent database process "Wastewater, from residence {CH}| treatment of capacity 1.1E10l/year | Cut-off," is used but modified so that Swedish electricity, instead of Swiss, is used. (Ecoinvent v 3.6, 2019).

The contribution from one litre wastewater treatment from residence in the Sweden is 0.00006 kg CO2e.

The total contribution from wastewater treatment connected to Arla Ko® Eko dairy product wastewater handling in household is 6 tonnes CO2e.

4.10 Business travel

Contribution from all major sources of climate impact shall be included in the assessment according to the ISO standard 14 067 (ISO, 2018). Air flights account for the most important contribution from business travels and therefore the air business trips Arla personnel did during 2019 was considered. The total mileage and corresponding GHG emissions were provided by the travel agency that Arla uses. The travel agency has used emission factors for plane travels from GHGP. Depending on the type of air flights radiation factors were considered, and emission factors specific for Arla flights was calculated, representing different mileage trips (short, medium and long) and also distinguishes between cabin type (economy, business, other). The information provided by the travel agency represents air flights for the entire Arla corporate group global, and an allocation based on economic revenue has been used to derive the share of greenhouse gases for the Arla Ko® Eko assortment. The total GHG emissions caused by Arla air business trips allocated to the Arla Ko® Eko product assortment is 34.1 tonnes CO2e.

Contribution from company cars and business trips made with other modes of transport than air travel has not been considered. In a previous assessment of the Arla Ko® Eko assortment on the Swedish market, for 2018 (U&W, 2019), these had only a minor impact (less than 0.02%), therefore they have been excluded here.

4.11 Commuting

For commuting we have taken into account the travels that Arla personnel does by car. All other modes of transport have been assumed to have minor contribution to the GHG emissions, i.e., from using public transport and/or a bicycle. Table 13 shows the data that has been used to derive the average distance travelled by car for people commuting to dairy sites in the SE. The number of Arla personnel that works with the Arla Ko® Eko assortment was allocated from total number of employees at Arla in Sweden, based on the share of the economic revenue of the Arla Ko® Eko products out of the total revenue of Arla Sweden. The GHG emissions from the car is based on data from NTM (2020) for "car, vehicle operation, petrol E5, euro 5".

Table 12. Data on commuting and the corresponding GHG emissions

Commuting data	Value	Unit	Source
Total commuting distance by car per person and day	62	km	Based on Table 3," Total distance travelled (in kilometres) per person and day with 95% confidence interval (±) by classification of municipality and mode of travel year 2019" in the Swedish travel habit investigation 2019.resvanor i Sverige 2019 https://www.trafa.se/kommunikationsvanor/RVU-Sverige/ 29km +/-2 choosing 31 km
Working days 2019 in SE	225	days/ year	Estimation of working days 2019: 250 (https://antal.arbetsdag.se/#) minus 25 days of vacation =225
Total distance travelled by car for commuting allocated to the Arla Ko® Eko assortment, per year	2941618	km/ year	Calculated by RISE
GHGs for commuting allocated to the Arla Ko® Eko assortment in 2019	793	t CO2e	Calculated by RISE

5 Results

The carbon footprint of the Arla Ko® Eko assortment in Sweden for the period 1st of January to 31st of December 2019 is 164068 tonnes CO2e. Table 14 shows the results divided by scope for both location- and market-based according to GHG Protocol Scope 2 Guidance.

Table 13 Results per scope and approach, to be in line with Greenhouse Gas Protocol Scope 2 Guidance.

Scope	Method	Climate impact (tCO2e)
Scope 1		107
Scope 2	Location based	498
	Market based	49
Scope 3		184240
Out-of-scope		5132
Removals		-20328
Total (market based)		**164068**

The largest share of the climate impact comes from Scope 3 activities, where the milk raw material is included. The market-based method is considering market-based instruments for electricity (e.g., certificates of origin) that can prove you have purchased electricity with a lower carbon footprint than average. Location-based is the reference scenario and used if there is no such market for instruments. In the results for Arla Ko® Eko product assortment below, we have chosen to report the results with market-based electricity, since Arla acts in Sweden where there is a market for electricity instruments. The reason for a lower climate impact with marked based electricity is because all Arla's dairies use renewable electricity.

The contribution to climate impact from specific GHG emissions is given in Table 15. Methane, from cow enteric fermentation, is the major dominating GHG-emission to the carbon footprint, 43.7% of total climate impact, Table 15. The sequestration (the removal) removes 20328 tonnes of CO2e and the contribution from peat soils is 22430 tonnes of CO2e. The sum of land use (sequestration + peat soils) ends at a small contribution of 2102 tonnes of CO2e or 1.3 % of total carbon footprint during 2019.

Table 14. Total greenhouse gas emissions and climate impact for Arla Ko® Eko product assortment divided in specific greenhouse gasses. "Unspecified" is the climate impact for processes where information on emissions distributed per gas is missing.

GHG	**Emissions (tonnes)**	**Removals (tonnes)**	**Climate impact (tCO_2e)**	**Relative contribution (%)**
CO_2 fossil	55261		55261	33.7%
CO_2 biogenic	18579	-20328	-1749	-1.1%
CH_4	2111		71777	43.7%
N_2O	115		34147	20.8%
Unspecified			4631	2.8%
SUM			**164068**	**100%**

The climate impact contribution from the activities on the farm (farm and land use) dominates the contribution to carbon footprint of the Arla Ko® Eko dairy product assortment (71.8 %), Table 16 and Figure 4.

The contribution from dairy production and product packaging together makes up 5.6% of the total carbon footprint. Capital goods, additional ingredients, and Arla transports (inclusive transports of employees) account for 2.2%. The consumer contribution (transport from retail, refrigeration storage and wastewater treatment) account for 20.2 %. The energy consumption at retail contributes with 0.2%.

Table 15 Climate impact divided on the different life cycle stages for Arla Ko® Eko product assortment, contribution from sequestration is included.

Life cycle stage	Climate impact (tCO2e)	Relative contribution (%)
FARM	115 665	70.5%
*Biogenic (+)	22 430	13.7%
*Removals (-)	-20 328	-12.4%
FARM incl Biogenic (+) & Removals (-)	117 767	71.8%
DAIRY	317	0.2%
ADDITIONAL Ingredients	1 340	0.8%
TRANSPORT - TOTAL	1 384	0.8%
PACKAGING	8 841	5.4%
Capital Goods	134	0.1%
Transport of employees	827	0.5%
RETAIL	335	0.2%
CONSUMER - transport	32 811	20.0%
CONSUMER – energy	306	0.2%
CONSUMER – waste treatment	6	0.0%
TOTAL	**164 068**	**100%**

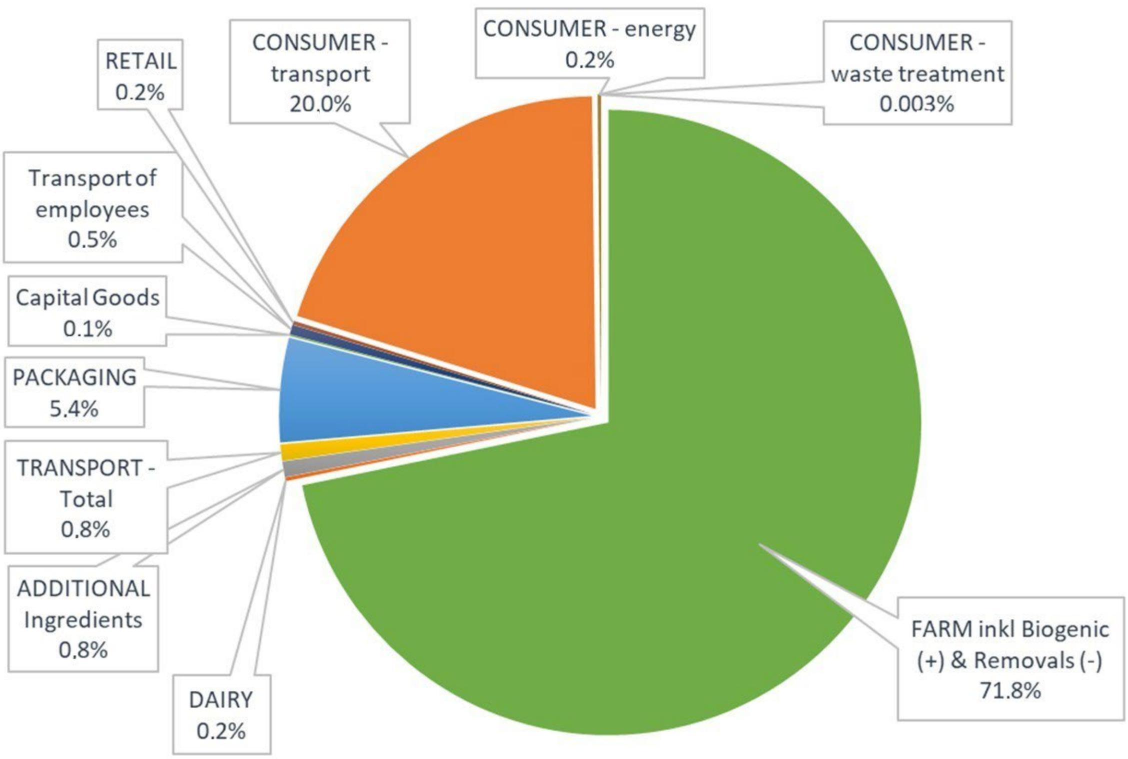


Figure 4. Contribution from the different life cycle steps to total CO2e of Arla Ko® Eko product assortment in SE 2019.

The average product carbon footprint for milk is 1.44 kg CO2e/kg including sequestration and 1.64 kg CO2e/kg without. The average product carbon footprint for all products is 1.58 kgCO2e/kg including sequestration and 1.81 kg CO2e/kg without.

Table 16. Average carbon footprint of each product category is given in the column to the right.

Dairy product category	**Average carbon footprint including SEQUESTRATION kg CO2e per kg**	**Average carbon footprint excluding SEQUESTRATION kg CO2e per kg**
Milk	1.44	1.64
Cream& soured cream (gräddfil)	4.36	5.09
Yoghurt	1.58	1.80
Sour milk (filmjölk)	1.37	1.56
Cheese	6.33	7.43
Average all products	**1.58**	**1.81**

6 Uncertainties and data quality

The absolute major contribution to climate impact of the Arla Ko® Eko product assortment origins from farm activities. The inventory data for the farm systems are provided by Arla and the data are collected from a large number of Arla's organic milk farms in Sweden. These data are therefore considered to be of good quality. The contribution both from sequestration and land use (emission from peat soils) are based on best available methods provided by scientific organisations and researchers in the field, but still there are uncertainties in the methods that probably would influence the result. How to include these biogenic carbon contributions in carbon footprint assessments are still not commonly agreed up on. The GHGP has an ongoing project, aiming for an agreed consensus methodology how to include biogenic carbon in carbon footprint assessment. This work is said to be finish in 2021. Arla foods has also together with a number of companies and organisations started a project to develop a method and seek consensus on how to quantify carbon sequestration for dairy and the method is currently being pilot tested. In the present assessment of the Arla Ko® Eko assortment the results are given both with the contribution of sequestration and without, according to the methods described in the report.

In Sweden the Arla organic milk farms have a low share of peat soil land but still it contributes to the final carbon footprint. The share of permanent- and rotational grassland, on the other hand, is relatively high. The effect of sequestration on the carbon footprint, based on calculation methods used in this assessment, levels out the contribution from peat soils i.e the contribution from biogenic carbon neither increase nor decrease the final carbon footprint of the Arla Ko® Eko product assortment.

The inventory data used in the assessment for dairy activities and packaging are specific data from each of the Arla dairies and each of the packaging, data provided from the Arla's ESG system. EY performed limited assurance on ESG data in Arla's annual report for 2019. The ESG data contains Scope 1, 2 and 3 carbon emissions for Arla Foods amba

The quality of the data is therefore considered good.

For contribution from downstream activities (retailer, consumer) some assumptions have been made based on information from reports and statistics. In every assumption a conservative approach was selected so that the impact from that activity is not underestimated.

The assumption that the consumer brings home 5 kg of food on average every retail trip by car is off course also influencing the final result. No official statistic was found on average amount of food bought per trip to retail. It is reasonable to believe that when the consumer takes the car to retail the amount of food is not less than 5 kg. In a Swedish travel habit survey from 2019 it says that each person uses the car 0,12 times per day for shopping (Trafikanalys, 2019). This means that the car is used almost 44 times during a year for shopping. In case 5 kg is bought each time it results in 220 kg food which is well below the approximately 800 kg food per person and year that the consumption statistics says (including consumption in restaurants and public kitchens as well) (Jordbruksverket, 2020). The assumption used of 5 kg food being transported per car trip is a conservative choice. In case the average amount instead was 10 kg per shopping trip the contribution from consumer transport would be 50% lower than reported here in the assessment.

The GHG calculations per se are subject to inherent uncertainties due to made assumptions and immature scientific knowledge. But since the method for GHG calculation in this assessment follows both GHG Protocol Corporate Standard and Value Chain (Scope 3) as well as the ISO standard 14067:2018 Carbon footprint of products together with transparent reporting of assumptions and methodological choices the result carbon footprint is considered representative for the Arla Ko® Eko product assortment of 2019.

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8 Appendix

8.1 Emission factors

Table 17. Emission factors for energy, with references.

Energy Source	Scope 1				Scope 2	Scope 3	"Outside of Scopes"	Total of all Scopes		
	CO2e (kg)	CO2 (kg)	CH4 (g)	N2O (g)	CO2e (kg)	CO2e (kg)	CO2e (kg)	CO2 (CO2e)	Unit	Source
Natural gas	183,9	183,5	7,1	0,3		23,9		207,8	mass unit/MWh	DEFRA (2019)
Fuel oil	267,8	266,8	10,3	2,2		50,8		318,6	mass unit/MWh	DEFRA (2019)
Gas oil	256,8	253,6	7,9	9,7		58,9		315,6	mass unit/MWh	DEFRA (2019)
Petrol (average biofuel blend)	233,7	232,4	21,2	2,2		63,2		296,9	mass unit/MWh	DEFRA (2019)
Biogas						24,1	0,2	24,1	mass unit/MWh	DEFRA (2019)
Biomass e.g. woodchips						7,9	15,6	7,9	mass unit/MWh	DEFRA (2019)
District heating based on renewable sources					10,9			10,9	mass unit/MWh	Ecoinvent 3.6: Heat, district or industrial, other than natural gas {SE}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | APOS, S
District heating					93,1			93,1	mass unit/MWh	Ecoinvent 3.6: Heat, district or industrial, other than natural gas {SE}| heat, from municipal waste incineration to generic market for heat district or industrial, other than natural gas | APOS, S
District cooling SV								50,0	mass unit/MWh	https://www.tekniskaverken.se/miljo/miljorapporter-och-statistik/miljovarden/fjarrkyla/

Table 18. Emission factors and electricity use for waste treatment.

Waste management	EF CO2e	Unit	Reference
1 kg Hazardous waste, for incineration {Europe without Switzerland}| treatment of hazardous waste, hazardous waste incineration | Cut-off, S (of project Ecoinvent 3 - allocation, cut-off by classification - system)	2.52	kg CO2e/ kg waste	Ecoinvent 3.6
1 kg Municipal solid waste {GB}| treatment of, incineration | Cut-off, S (of project Ecoinvent 3 - allocation, cut-off by classification - system)	0.52	kg CO2e/ kg waste	Ecoinvent 3.6
COD to external treatment	0.55	kWh/ kg COD	EnviDan, (2014)

Table 19. Emission factor for cooling media - refrigerants

Cooling media	GWP100 (kg CO2/kg media)	Reference
R404A	3 922	Swedish EPA, https://www.naturvardsverket.se/upload/stod-i-miljoarbetet/vagledning/kemikalier/koldmedieforteckning-augusti-2019.pdf (2019)
R407A	2 107	Swedish EPA, https://www.naturvardsverket.se/upload/stod-i-miljoarbetet/vagledning/kemikalier/koldmedieforteckning-augusti-2019.pdf (2019)
R410A	2 088	Swedish EPA, https://www.naturvardsverket.se/upload/stod-i-miljoarbetet/vagledning/kemikalier/koldmedieforteckning-augusti-2019.pdf (2019)
R452A	2 140	Swedish EPA, https://www.naturvardsverket.se/upload/stod-i-miljoarbetet/vagledning/kemikalier/koldmedieforteckning-augusti-2019.pdf (2019)

8.2 Contribution from capital goods

8.2.1 Filling machines

Table 20. GHG emissions from production of filling machines

Filling machine data	Filling machine 1	Filling machine 2	Average of the two machines
Machine	Tetra Pak A3/Speed filling machine	Tetra Pak A3/Speed filling machine	
Source	EPD: Tetra Pak A3/Speed, filling machine, Environmental Product Declaration Rev.0, 20-10-2005, Certification S-P-00100 (page 6)	EPD: Tetra Pak A3/Flex, filling machine, Environmental Product Declaration R ev.0, 20-10-2005 Certification S -P-00101	
Comment	The EPDs are quite old, but discussed with TetraPak who states that the environmental burden from machine use has most likely decreased since 2005, so it is a conservative measure to use these figures.		
Functional unit (FU)	1,000 packed litres of liquid food provided by Tetra Pak A3/Speed during a standard production cycle.	1,000 packed litres of liquid food provided by Tetra Pak A3/Flex during a standard production cycle.	
g CO2e/FU, manufacturing stage	67.72	190.76	129.24
kg CO2e/packed litre	0.00006772	0.00019076	0.00012924

8.2.2 Contribution from forklifts

Table 21. GHG emissions from forklifts used in assessment

Fork lift data	Tractor 1	Tractor 2	Average of the two tractors
Type of vehicle	Tractor	Tractor	
Source	Ecoinvent 2 database: "Tractor, production /CH/ I S"	Agri-footprint database: "Tractor, production, at plant /RER economic"	
Comment	Includes production, maintenance, repair and disposal. No data for production of forklift was found, we use a tractor as proxy, and assume a forklift weighs ca 2000 kg.	Includes production. No data for production of forklift was found, we use a tractor as proxy, and assume a forklift weighs ca 2000 kg. The tractor in agri-footprint weight about 5000 kg.	
Functional unit (FU) in database process	kg tractor	one tractor	
kg CO2e/FU	6.13	39 200	
kg CO2e/machine, manufacturing stage	12 260	15 680	13 970
kg CO2e/machine&year, assuming 10 year life span	1226	1568	1397

8.2.3 Contribution from buildings

Table 22. GHG emissions used in assessment for establishment of buildings

Building data	
Type of building	House of flats
Source	Larsson et al (2016)
Comment	Includes production of materials, transport to building site, building including preparation of the ground. The data is for a building of flats, and not a dairy building, but has been used due to lack of other data.
Functional unit (FU) in data source	m2
kg CO2e/FU	289
kg CO2e/m2&year, assuming 60 year life span	4.8

8.2.4 Transport vehicles and emission factors for transports, Table 23.

Table 24. Emissions from vehicle transport

	SCOPE 1 (tank to wheel)						SCOPE 3 (well to tank)						TOTAL						
Type of truck	CO2 total [kg]	CO2 fossil [kg]	CO2 biogen [kg]	CO2e [kg]	CH4 [g]	N2O [g]	CO2 total [kg]	CO2 fossil [kg]	CO2 biogen [kg]	CO2e [kg]	CH4 [g]	N2O [g]	CO2 total [kg]	CO2 fossil [kg]	CO2 biogen [kg]	CO2e [kg]	CH4 [g]	N2O [g]	Unit
Rigid truck 14-20 t, Diesel B7EU, Euro5, load factor 90%	0,0833	0,0777	0,0056	0,0791	0,0001	0,0046	0,0087	0,0087	0,0000	0,0122	0,0827	0,0022	0,0920	0,0864	0,0056	0,0912	0,0827	0,0068	per tkm
Rigid truck 14-20 t, Diesel B7EU, Euro5, load factor 90% + cooling transport	0,0803	0,0749	0,0054	0,0762	0,0001	0,0045	0,0097	0,0097	0,0000	0,0135	0,0916	0,0024	0,0900	0,0957	0,0062	0,1011	0,0917	0,0075	per tkm
Type of ship																			
Container ship, dwt 100000, load factor 90%	0,0135	0,0135	0,0000	0,0137	0,0001	0,0007	0,0012	0,0012	0,0000	0,0015	0,0130	0,0000	0,0146	0,0146	0,0000	0,0152	0,0131	0,0007	per tkm
Type of car																			
Car, Vechicle Operation - Distance, Petrol E5, Euro 5	0,2393	0,2313	0,0079	0,2315	0,0007	0,0004	0,0303	0,0303	0,0000	0,0364	0,1676	0,0063	0,2695	0,2617	0,0079	0,2694	0,1682	0,0067	per km
Source	NTMCalc Advanced 4.0 Environmental Performance Calculator, (NTM 2021)																		
Factor of cooling transport	1,15																		

Table 25. Infrastructure contribution

	Type of truck	kg CO2 eq/kg	Addition al-%	Source:
Infrastructure contribution to transport	Rigid truck 14-20 t, Diesel B7EU, Euro5, load factor 90%	0,025	139%	Infrastructure contribution (building and maintanace of roads and truck) is obtained from the Ecoinvent 3.3 dataset; Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32
	Rigid truck 14-20 t, Diesel B7EU, Euro5, load factor 90% + cooling transport	0,025	134%	Infrastructure contribution (building and maintanace of roads and truck) is obtained from the Ecoinvent 3.3 dataset; Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5
	Container ship, dwt 100000, load factor 90%	0,000	103%	Infrastructure contribution (building and maintanace of roads and truck) is obtained from the Ecoinvent 3.3 dataset: Transport, freight, sea, container ship {GLO}| transport, freight, sea, container ship
	Car, Vehicle Operation , Petrol E5, Euro 5	0,100	159%	Infrastructure contribution (building and maintanace of roads and car) is taken from Ecoinvent 3.3: Transport, passenger car, medium size, diesel, EURO 5 {RoW}| transport, passenger car, medium size, diesel, EURO 5

Table 26. Emission from combustion of different fuels

		SCOPE 1 (tank to wheel)	SCOPE 3 (well to tank)	TOTALT	"Outside of Scopes"	
With infrastructure transport, assuming all trucks to be: Rigid truck 14-20 t, Diesel B7EU, Euro5, load factor 90% + cooling	**Fuel consumption**	CO2e [kg]	CO2e (kg)	CO2e [kg]	CO2e (kg)	Unit
	Bioethanol	0,10	0,85	0,95	1,52	1 litre fuel
	Biodiesel	0,09	0,52	0,61	2,49	1 litre fuel
	Biomethane	0,10	0,89	1,00	2,71	1 litre fuel
	Diesel (100% mineral diesel)	3,16	1,89	5,05	0,00	1 litre diesel
	Preem Evolution Diesel (80% Vanlig Diesel/20% Biodiesel)	2,54	1,62	4,16	0,50	1 litre diesel
	Miles Diesel (58% Vanlig Diesel/42% Biodiesel)	1,87	1,32	3,19	1,05	1 litre diesel
	Bio+: Diesel-HVO-RME (73%-20%-7%)	2,33	1,52	3,85	0,67	1 litre diesel
Source	Defra 2019 https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019					

9 Validation report

Independent practitioner's assurance report

To the shareholders of Arla Foods Amba

Scope

We have been engaged by Arla Foods Amba (hereafter 'Arla) to perform a 'limited assurance engagement,' as defined by International Standards on Assurance Engagements, here after referred to as the engagement, to report on the Carbon Footprint report on Arla Foods' Ko® Eko brand of organic dairy products on the Swedish market (the "Subject Matter") for the period from 1st of January 2019 to 31st of December 2019.

Criteria applied by Arla

In preparing the climate accounting, Arla applied the accounting practice described on pages 6-14.

Arla's responsibilities

Arla's management is responsible for selecting the Criteria, and for presenting the climate accounting in accordance with that Criteria, in all material respects. This responsibility includes establishing and maintaining internal controls, maintaining adequate records and making estimates that are relevant to the preparation of the GHG statement, such that it is free from material misstatement, whether due to fraud or error.

EY's responsibilities

Our responsibility is to express a conclusion on the presentation of the Subject Matter based on our procedures and the evidence we have obtained.

We conducted our engagement in accordance with the *International Standard for Assurance Engagements on Greenhouse Gas Statements* ('ISAE 3410') and additional requirements under Danish audit legislation. Those standards require that we plan and perform our engagement to obtain limited assurance about whether, in all material respects, the Subject Matter is presented in accordance with the Criteria, and to issue a report. The nature, timing, and extent of the procedures selected depend on our judgment, including an assessment of the risk of material misstatement, whether due to fraud or error.

Our Independence and Quality Control

We have maintained our independence and confirm that we have met the requirements of the ethical standards under FSR - Danish Auditors' Code of Ethics for Professional Accountants, which rely on general principles regarding integrity, objectivity, professional competence and due care, confidentiality and professional conduct], and have the required competencies and experience to conduct this assurance engagement.

EY Godkendt Revisionspartnerselskab also applies International Standard on Quality Control *1,* and accordingly maintains a comprehensive system of quality control including documented policies and procedures regarding compliance with ethical requirements, professional standards and applicable legal and regulatory requirements.

Description of procedures performed

Procedures performed in a limited assurance engagement vary in nature and timing from and are less in extent than for a reasonable assurance engagement. Consequently, the level of assurance obtained in a limited assurance engagement is substantially lower than the assurance that would have been obtained had a reasonable assurance engagement been performed. Our procedures were designed to obtain a limited level of assurance on which to base our conclusion and do not provide all the evidence that would be required to provide a reasonable level of assurance.

Although we considered the effectiveness of management's internal controls when determining the nature and extent of our procedures, our assurance engagement was not designed to provide assurance on internal controls. Our procedures did not include testing controls or performing procedures relating to checking aggregation or calculation of data within IT systems.

The Green House Gas quantification process is subject to scientific uncertainty, which arises because of incomplete scientific knowledge about the measurement of GHGs. Additionally, GHG procedures are subject to estimation (or measurement) uncertainty resulting from the measurement and calculation processes used to quantify emissions within the bounds of existing scientific knowledge.

A limited assurance engagement consists of making enquiries, primarily of persons responsible for preparing the climate accounting and related information and applying analytical and other appropriate procedures.

Our procedures included:

- Conducted interviews with personnel to understand the business and reporting process
- Conducted interviews with key personnel and third-party consultants to understand the process for collecting, collating and reporting the subject matter during the reporting period
- Checked that the calculation criteria have been correctly applied in accordance with the methodologies outlined in the Criteria
- Undertook analytical review procedures to support the reasonableness of the data
- Evaluation of the appropriateness of accounting policies used and the reasonableness of accounting estimates made by Management
- Tested, on a sample basis, underlying source information to check the accuracy of the data

We also performed such other procedures as we considered necessary in the circumstances.

Conclusion

Based on our procedures and the evidence obtained, we are not aware of any material modifications that should be made to the climate accounting for the period from 1st of January 2019 to 31st of December 2019, in order for it to be in accordance with the Criteria described on pages 6-14.

Frederiksberg, 17th of September 2021
EY Godkendt Revisionspartnerselskab
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