UBC Social Ecological Economic Development Studies (SEEDS) Student Report

UBC Food Security Project

GHG Emission Inventory: Non-Milk Dairy Products

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Scenario 2- Group 3

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Executive Summary

Greenhouse gas audits of the University of British Columbia (UBC) Vancouver campus are a component of UBC's Climate Action Plan and the intercollegiate Sustainability Tracking Assessment and Rating System (STARS) yet, to date, UBC has not performed a food system specific emission audit. The food system at UBC is an intricate system heavily dependent on outside inputs from provincial, national, and global distributors. To effectively estimate the greenhouse gas (GHG) emissions associated with the UBC food system the sector was broken into three components: meat products, vegetable products, and dairy products. This report will focus on non-milk dairy products purchased by UBC in 2011: soy products, yogurt, cream cheese, other cheeses, and goat cheese.

The ideal and most widely used quantification of GHG emissions is in kilograms of carbon dioxide equivalents (CO_2e) per kilogram of product. To calculate GHG emissions the relevant emission factors must be identified and multiplied against known, often weight-based, data. These are regarded as "tier I.5" emission calculations on the scale of increasing calculation and data complexity ranging from 1 – 3.

The data regarding the dairy products of interest for this report was compiled throughout the purchasing year and provided by UBC in the 2011 Velocity report (University of British Columbia, 2011). This list has been modified to show relevant information and included in Appen-

dix I. Data regarding greenhouse gas emission factors was collected through a review of government documents and relevant literature. Emission factors used in this report are included in Appendix II.

The results indicate that the majority (70.6%) of the non-milk dairy product greenhouse gases arise from transportation while the remainder arises from production (17.0%) and processing (12.5%). Product-wise, soy products are responsible for the majority of the emissions (32.3%) followed by semi-hard cheeses (18.6%). The total emissions for non-milk dairy product emissions are: **299,219.41** kg CO_2e as summarized in the below table:

Product Category	GHG Emissions (kg CO_2e)	Percentage of Total
Soy	96,709.32	32.3 %
Yogurt	41,022.1	13.7 %
Cream Cheese	44,434.3	14.9 %
Soft Cheese	10,576.71	3.5%
Semi-Soft Cheese	40,569.7	13.6%
Semi-Hard Cheese	55,551.6	18.6 %
Hard Cheese	8,451.2	2.8 %
Goat Cheese	1,904.5	0.64%
Total	**299,219.41**	**100%**

In determining the GHG emissions of the non-milk dairy products, some important assumptions were made that may have influenced the accuracy of the results. Due to the lack of availability of transparency of dairy processors in Canada regarding sourcing of raw milk, distance traveled by dairy products was estimated from the distribution center to the Student Union Building, as a general reference point on the Vancouver campus. Assumptions were also made regarding method of travel for several of the products: domestic and in-province cheeses were assumed transported by land, whereas out-of-province and international cheeses were assumed transported by air. Processing and packaging methods were also generalized in emissions calculations due to lack of available data, time restrictions and in order to increase simplicity of results.

Due to a lack of availability of sufficient data for calculations, the results are likely to be an underestimate of the actual GHG emissions associated with non-milk dairy products of the UBC Food System. It is also important to note that greenhouse gas emissions may not be the best indicators of sustainability and the likely inappropriateness of the carbon calculators available online to the public (Kim & Neff, 2009; Padgett, Steinemann, Clarke, & Vandenberghe, 2008).

Some general recommendations that can be made to reduce GHG emissions are: reduce or phase out the purchasing of drinkable yogurts from Quebec and opt for more local products; engage in carbon mitigation programs to achieve the goal of zero net emissions by 2050; and purchase as many bulk items as possible and establish an “Eco-to-go” program to reduce waste where possible.

Introduction

Project Overview

The University of British Columbia's Climate Action Plan has been working to estimate the greenhouse gas emissions of the campus since 2006 and has previously excluded emissions related to food consumption, production and waste on campus (UBC Sustainability, 2012). Due to the high levels of impact associated with food production globally, it is important to measure the emissions associated with the UBC Food System. The purpose of this report is to inventory the greenhouse gas emissions associated with non-milk dairy products, and provide quantitative measures of sustainability as part of UBC's Climate Action Plan (UBC Sustainability, 2012). The estimation of GHG contributions from UBC's non-milk dairy product consumption will provide a baseline measurement from which improvement goals can be set for future years. Overall we hope to address the question: where can improvements be made to UBC's dairy product choices in regards to source, packaging, and waste?

The goals of this report include to:

1. Compile useful baseline data regarding the source and abundance of dairy product-related GHG emissions
2. Provide attainable recommendations for emission and waste reduction

Context

As levels and public awareness of the effects of greenhouse gases in Earth's atmosphere rises, it becomes ever more important to investigate the sources of these increases and develop feasible ways in which to mitigate these effects. Food production contributes substantially to this climate change, with agriculture producing 10 to 12% of total anthropogenic greenhouse gas emissions globally (Eckard *et al.*, 2010).

In line with the UBC Climate Action Plan, UBC Supply Management collaborates with suppliers to implement sustainable procurement of goods and services from sourcing, to production, transport, packaging, and disposal, thus helping staff, students, and faculty members make more sustainable purchasing decisions (UBC Sustainable Purchasing Guide, 2010). Additionally, participation in the self-reporting Sustainability Tracking Assessment and Rating System (STARS) program helps to provide a framework for understanding sustainability in all sectors of higher education in relation to other colleges and universities in Canada and the United States (Advancement of Sustainability in Higher Education, 2011). UBC has also partnered with the University Neighbourhoods Association to participate in Metro Vancouver's "Zero Waste Challenge" (UBC Waste Management, 2011). This partnership will assess the existing campus solid waste system and identify opportunities and steps to achieve the "Zero Waste Challenge" of 70% reductions by 2015 (UBC Waste Management, 2011).

Background Information

Agriculture accounts for approximately 8.00% of Canada's greenhouse gas emissions in kilotons of CO_2 equivalents (Environment Canada, 2011). Emissions from the livestock agriculture sector have been decreasing since 2005 but leave significant room for improvement. The dairy sector, the focus of this report, accounts for comparatively little of Canada's livestock agricultural emissions; the bulk of the emissions arise from intensive beef and pork production (Environment Canada, 2011). Theoretically this amount will increase or decrease with consumer demand for dairy products as it is federally regulated by a quota system. The GHG emissions on a dairy farm are primarily associated with enteric fermentation of the animals, as well as manure storage and management. Due to the increased fermentation required to digest feed that contains higher amounts of roughage as opposed to concentrated feed cows in an organic system will produce more between 10-15% more methane than cows in a conventional system (Cederberg & Mattsson, 2000). Organic production does have other benefits though, as the reduction in chemical fertilizers and pesticides can have a significant beneficial impact. There are also indirect GHG reductions involved in organic production in terms of reducing emissions associated with chemical production, transportation and application. As a consumer, UBC Food Services can select dairy products that are sourced from low GHG emission farms. The majority of dairy sector GHG emissions arise from bovine metabolism and waste products (Canadian Dairy Information Centre, 2009). The necessity of refrigeration during the transportation processes makes the transport of dairy products a significant contributor to the sector's carbon dioxide emissions (CDIC, 2009). The other influences on the GHG impact of a dairy product include the processing of the milk into various products and the packaging process(es) (Phetteplace *et al*., 2001; FAOUN, 2010).

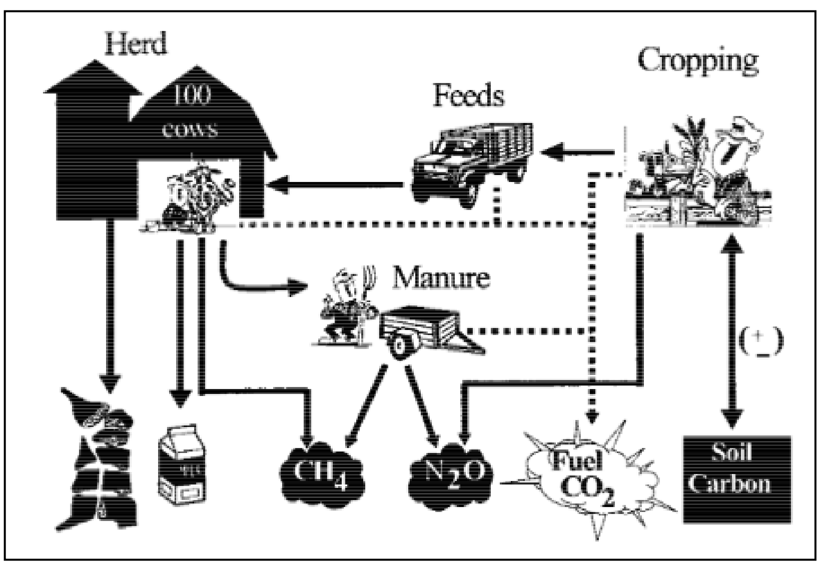

Figure 1: The energy cycles and GHG sources and sink of cattle farms (Taken from Phetteplace, Johnson, and Seidl (2001).

Milk

Milk production in Canada is regulated by the Canadian Dairy Commission, which supports the industry through the implementation of national policies for milk production, assessing changes in the demand and the production of milk, as well as overseeing the revenue and market-sharing systems of the dairy system (CDIC, 2011). The dairy processing sector is concentrated, with the three largest processors in Canada (Saputo, Agropur, and Parmalat) "processing close to 80% of the total raw milk produced" in the country (CDIC, 2011). The processing of milk involves centrifugation, separation and clarification, followed by pasteurization to kill harmful microorganisms (Goff, 2011). The pasteurized milk is then homogenized and undergoes ultra-high temperature in order to sterilize it before packaging it in pre-sterilized containers (Goff, 2011). Globally, the average GHG emissions for milk production are 2.4 kg CO_2 equivalents per kilogram of milk after processing and transport (FAOUN, 2010) and the Canadian average is estimated at 1.0 kg CO_2 equivalent per kilogram of milk (Vergé *et al*., 2007). In Canada, packaging may be in cans, paperboard/plastic/foil/plastic laminates, flexible pouches, thermoformed plastic containers, flow molded containers, bag-in-box, or bulk totes, depending on the size and quantity desired by the consumer (Goff, 2011).

Yogurt

Yogurt production follows the steps of milk processing until the appropriate milk fat percentage is attained. Once at this stage, starter bacteria cultures are added to the milk in sealed hygienic vats and allowed to ferment until lactic acid concentrations reach a pre-determined, and not widely published, amount, at which point the yogurt production process is finished (Watson

Dairy Consulting, 2012).

Some processors allow the fermentation to continue to take place in the container the yogurt during shipping, producing a creamier yogurt. Several yogurt varieties contain fruit or fruit syrups. These are added into the container where it either rests on the bottom of the container or is stirred in (Goff, 1995). In certain drinkable yogurts – including the sole yogurt product in this study – the fermentation vessels are aggressively agitated to prevent the yogurt from getting too thick.

Most yogurts in Canada are packaged in #5 plastic tubs of various sizes, which are accepted at recycling facilities in Vancouver. Smaller tubs may be sealed with a thin sheet of plastic, which is non-recyclable, or with an aluminum sheet, which can be recycled, while larger tubs often have sealed lids of the same plastic composition.

Cheese

Canada produces a total of 667 different varieties of cheese, most of which are produced in Ontario and Quebec, using less than 60% of the total fluid milk produced in Canada (CDIC, 2011). Cheese is produced from heated processed whole milk with the addition of a bacterial culture, additives, and, occasionally, herbs (Fellows, 2008) and colour. Hard cheeses require more cooking and ripening time than soft cheeses, thus requiring more energy inputs (Fellows, 2008). Cheddars and other hard cheeses are often packaged using “vacuum gas flush” of plastic laminate made from a variety of plastics, making it non-recyclable (Hill, 2009). Soft cheeses can be purchased in larger, recyclable tubs made from polypropylene and #5 plastics (Berry, 2009). Goat cheese is produced in a similar manner to cow cheeses, but the supply for this product is more specialized. British Columbia accounts for 13.5% of the goat farms in Canada (Agriculture and Agri-Food Canada, 2006).

UBC primarily purchases semi-soft and semi-hard cheeses (eg. mozzarellas and cheddars) and also purchases soy and goat cheeses to accommodate dietary requirements of students (**Figure 2**). The categories of cheeses will be described in greater detail in the Methodology and listed in Appendix I.

Cream Cheese

Canada produces the majority of the cream cheese consumed nationally and the quantity of cream cheese imported has decreased by 45.4% from 2010 to 206,149 kg in 2011 (CDIC, 2012). Cream cheese is produced from 11-20% milk fat cream and the resulting product contains at least 55% moisture content with varying fat content from 30% to none (Hill, 2009). The production of cream cheese is similar production of other cheeses; requiring heating, cooling, removing whey, and the addition of a bacterial culture as well as any desired flavoring (Hill, 2009). Cream cheese is also poured into a mold and is refrigerated (Hill, 2009). Cheeses that have higher moisture content, such as cream cheese, have lower overall greenhouse gas emissions than harder cheeses due to reduced processing and ripening (Aguirre-Villegas et al., 2011). Cream cheese is often packaged similarly to yogurt, using type 5 plastics, but can also be packaged in a non-recyclable metal sheet. As shown in Appendix I, UBC purchases three styles of cream cheese packaging: large plastic tubs, smaller metal-wrapped blocks, and small individual serving packages.

Soy

Soybeans (*Glycine max.*) are a leguminous species that are a common alternative protein source for people with allergies, lactose intolerance, or cultural dietary restrictions. UBC purchases soymilk and soy cheeses to accommodate these dietary restrictions (Appendix I). Soy is primarily grown in the United States, South America, and China; 1.3% of the world's total soy grown in Canada (Masuda and Goldsmith, 2009). The lack of domestic production necessitates that the majority of the soy products consumed by Canadians must be imported. To produce soy products, the soybeans are steam cooked, ground into a powder, and the liquid and insoluble portions are separated. The resulting liquid is fortified and homogenized in a manner similar to milk. Soymilk is packaged using aseptic technology, a process that requires sterile conditions, high heat levels, plastics and cardboard (Mans, 1999).

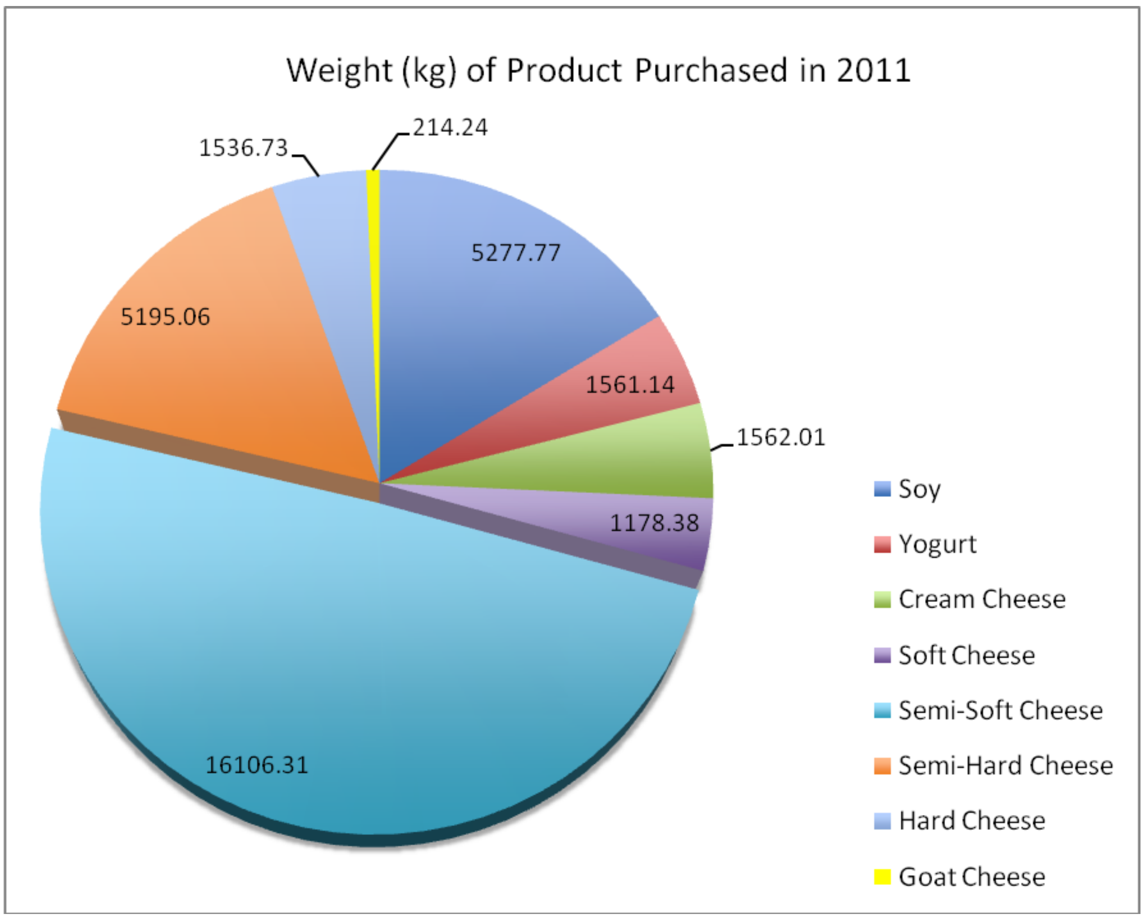

Figure 2 UBC Food Services' year-to-date dairy purchases (kg). The most purchased cheeses are semi-soft and semi-hard – the categories that contain the most cheese products (n= 17 and n =21, respectively) and include mozzarellas and cheddars. Only one yogurt product was

listed in the data provided by UBC. Interestingly, cream cheeses have the third most products purchased (n= 11) but significantly less quantity by mass.

Methodology

Our Approach

As a group we devised the following formula for calculating the greenhouse gas emissions of dairy products:

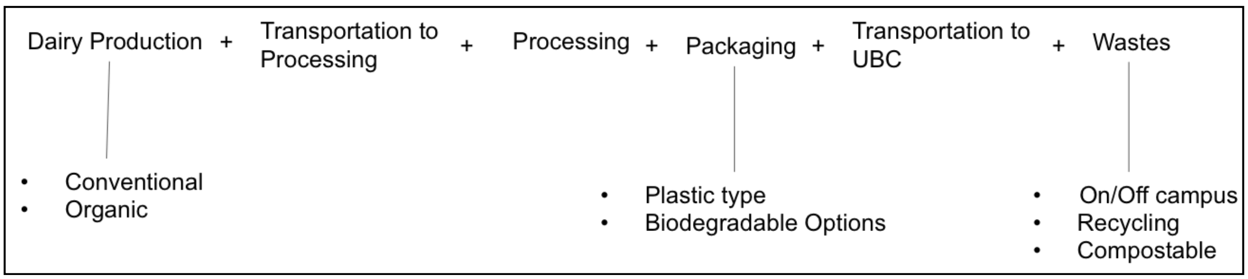

Figure 3 Our groups' formula for dairy product greenhouse gas emissions (formula 1)

This formula allowed us to break the GHG emissions into zones of origin and allowed us to visualize the accumulation of emissions from origin to consumption.

"Dairy production" emissions involved the feeding of the cows and the manure management of the farm. Given the regulations behind the dairy sector in Canada, the main variable we considered in this phase were whether the source was organic or conventional. The "transportation to processing" proved to be inaccessible given our resources and the lack of transparency of the large dairy distributors. The "processing" stage of dairy production varies from product to product. To assess each product's processing was outside of the time scope for this project; to accommodate this we generalized production for the eight categories of dairy products. "Packaging" emissions were estimated based on the type of material(s) used to package the product; in this case plastics for cheese products and cartons for soymilks.

To estimate the "transportation to UBC" element we determined the closest distribution center and used GoogleMaps® to calculated the distance to the UBC Student Union Building (as a general reference point on the UBC Vancouver campus). The "waste" element was a measure of on-campus and off-campus wastes: solid, recyclable, and compostable waste. This report will not cover this element in the greenhouse gas calculations, as this is an extremely complex issue that is discussed in the *UBC Waste Audit* (2009) in detail. This report will make recommendations that will lower the levels of waste produced.

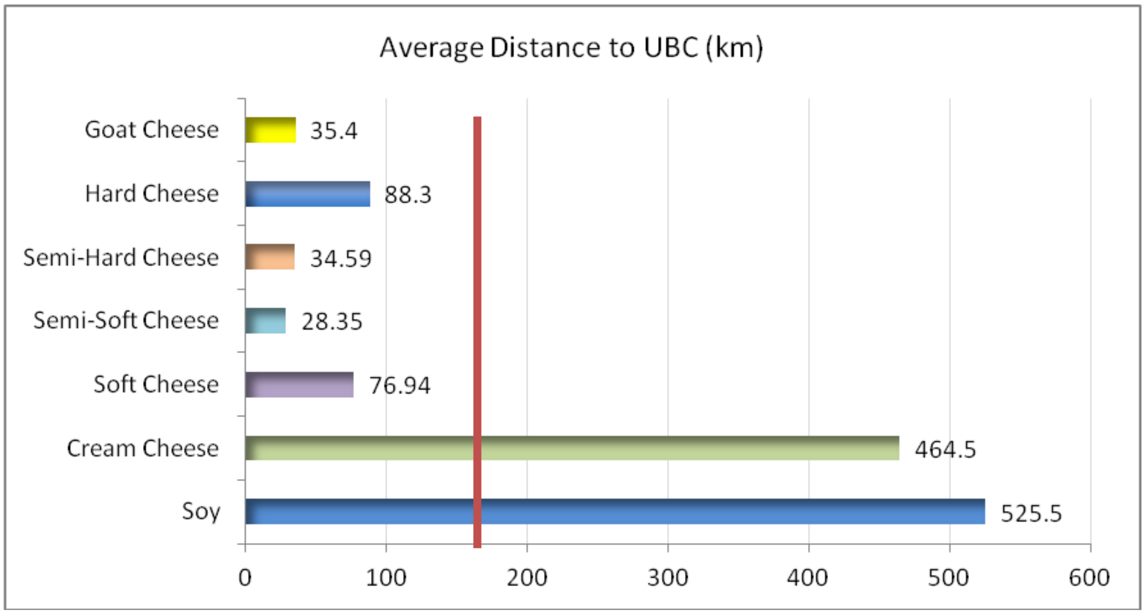

Figure 4: The average distance traveled from the nearest distribution center to the UBC Vancouver campus Student Union Building. Not included in this graph is the Yogurt group (n =1) with a distance of 4837 km. The average distance (indicated by the red line) for these products is 179.1 km. The average distance traveled, including yogurt, is 761.4 km.

A similar mental formula is appropriate for soy cheeses and milk alternative products, involving "soy production" in place of "dairy production" (**Figure 3**). The processing, transportation, and waste elements will be approached similar to the milk products.

Emission Factors

Emission factors were used in greenhouse gas calculations to convert available data into carbon equivalents as per the following formula (Environment Canada, 2010):

Emission = (Activity Data) x (Emission Factor)

These calculations will result in a comparable value in the unit kilograms of carbon per unit activity. In the case of dairy products, this will be **kg Carbon/kg product**. This will factor in the discussed elements of our devised formulae for dairy and soy products.

There are three tiers of increasing specificity regarding available emission factors (**Table 1**). An appropriate tier is determined based on technical information available and the number of emission factors considered (Environment Canada, 2005). Most calculations regarding green-house gas emissions in the agricultural sector are tier I or tier II calculations (Environment Canada, 2005), involving emission factors from production and transportation. Our report is catego-rized as "tier I.5" as it includes mass-based, sector-specific calculations with moderate expertise levels.

Table 1: Emission factor tier descriptions (adapted from Environment Canada, 2005)

Tier	Description
I	Simple, less detail & expertise required Mass-based
II	Calculations include source types, sector of industry/economy
III	Most complex GHG measuring methods Detailed data, thorough understanding of technologies Source-specific, used only for small number of "principal emission sources"

The primary source for emission factor data was International Panel on Climate Change publications, however these proved to be far more specific than the scope of this project. Therefore we extended our literature review to attain simplified emission factors. A study performed by the American Environmental Working Group produced a report with information that was be used to calculate the carbon equivalents and greenhouse gas emissions of common food-stuffs (Environmental Working Group, 2011). The EWG report provided several emission factors for the dairy sector production and processing, as well as air, ground, and sea transportation factors used in this report (Appendix II).

Assumptions

The table in Appendix I contains notes on any assumptions that were made for particular products. Much of these assumptions are related to the distances traveled throughout the production and processing. Due to a lack of firsthand data from the producers we were unable to guarantee the province or country of milk origin and location of processing plants for many products. For calculation purposes we will assume that domestic cheeses are transported by land if produced in province or air if produced out of province. For land transportation the average fuel consumption of large, class 8, refrigerated trucks was assumed to be 30L/100km based on an informal search on rental services and freight truck manufacturing websites. International cheeses are likely transported by air, but we factored in ocean transport to account for uncertainty of transportation methods used by each company.

The processing element of our GHG calculation was also generalized. Different cheeses within the categories were considered to undergo similar processing, despite having different ripening times (leading to higher or lower overall emissions) and specialized ingredients in reality. In regards to Goat products, the exact emission factor for production was unattainable and an approximation of goat emission being 70% of that of a cow was made based on available information (Environment Canada, 2011) and the processing was assumed to be similar to cow cheese processing. The processing emissions for cream cheese were not attainable and, therefore, we will be assuming that the processing is similar to other cheeses. These assumptions are both for ease of calculation and due to Fresearch availability and time constraints.

Results

Production

The production emission factors for the non-milk dairy products (Appendix II) are derived from the production values for whole milk (cheeses) and partly skimmed milk (yogurt) (EWG, 2011). Soy production emission factors include the production and harvest, however because this product is likely from out-of-Canada it is difficult to obtain a truly reflective emission factor (EWG, 2011).

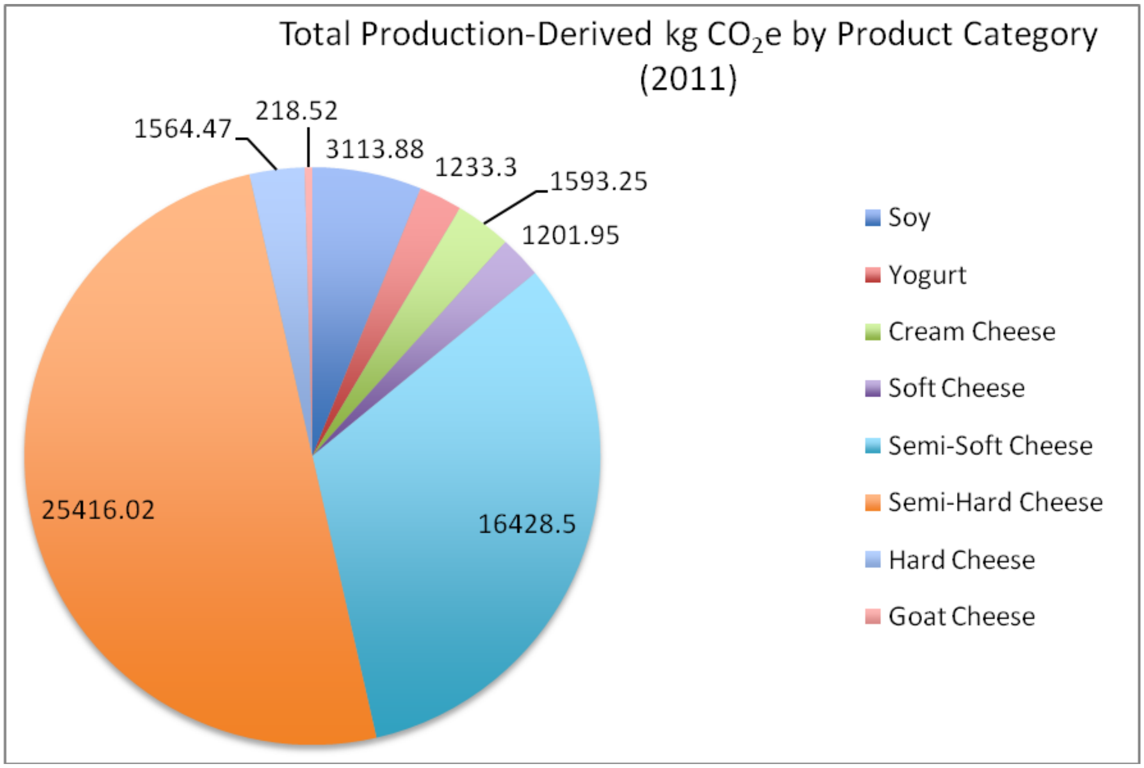

Figure 5: Production-derived emissions from the products purchased by UBC in 2011. The production for all cheeses is assumed to be the same, despite having slight variation in reality depending on milk fat requirement. Soy and non-domestic cheese production data is difficult to attain and assumptions are based on domestic production and values provided by the EWG (2011).

Total production-derived emissions: **50, 679.89 kg CO_2e**

Table 2 Summary table of production-derived GHG emissions.

Product Category	Production GHG Emissions (kg CO_2e)	Percentage of Total
Soy	3,113.88	6.13 %
Yogurt	1,22.30	2.43 %
Cream Cheese	1,593.23	3.14 %
Soft Cheese	1,201.95	2.37 %
Semi-Soft Cheese	16,428.5	32.36 %
Semi-Hard Cheese	25,416.02	50.06 %
Hard Cheese	1,564.47	3.08 %
Goat Cheese	218.52	0.43 %
Total	**50,769.89**	**100%**

Processing

The processing of these non-milk dairy products (excluding soy) (**Figure 6**) in this report begins with milk processing – a process with a high level of energy demands. As mentioned in the assumptions, all cheeses including cream and goat cheese were reported using the same emission factor (for dairy-cow production). Soy processing is also an energy-intensive process that is difficult to find data for due to the variations in global production.

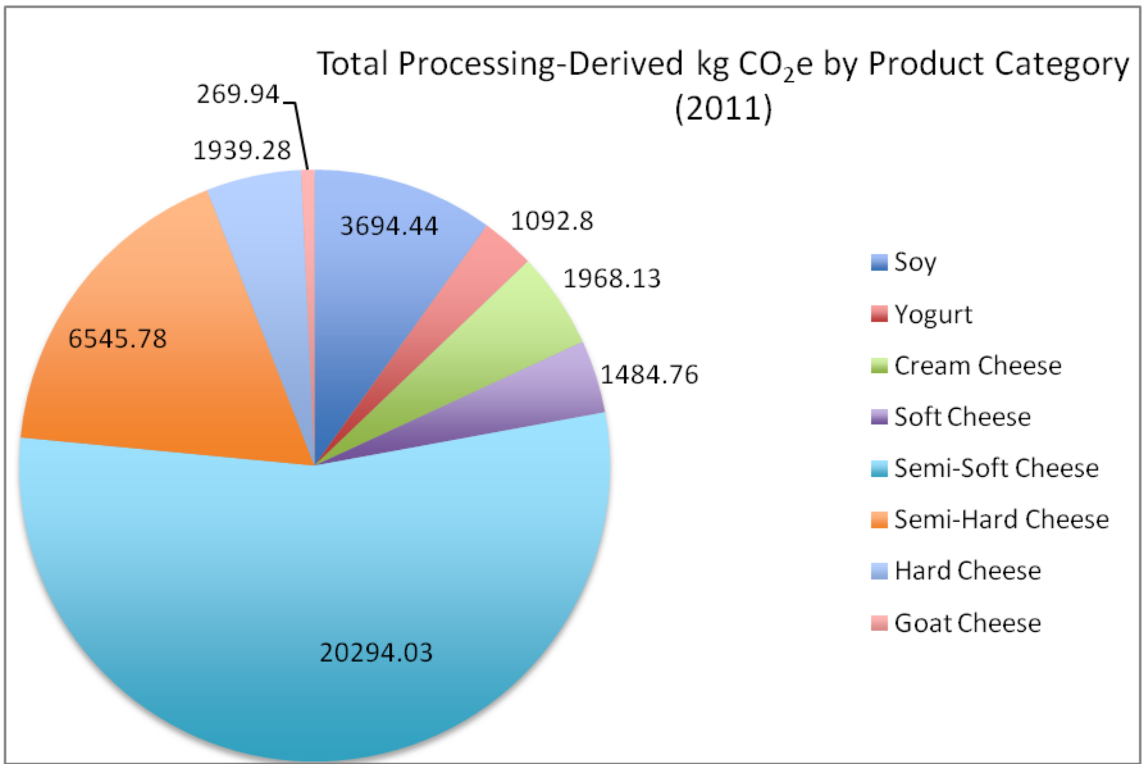

Figure 6 Processing-derived emissions from the products purchased by UBC in 2011. The processing for all cheeses and cream cheese is assumed to be the same, despite having slight variation in reality depending on ripening age, specialized ingredients, *etc*.

Total processing-derived emissions: **37, 289.16 kg CO_2e**

Table 3: Summary table of processing-derived GHG emissions

Product Category	Processing GHG Emissions (kg CO_2e)	Percentage of Total
Soy	3,694.44	9.21&
Yogurt	1,092.8	2.93%
Cream Cheese	1,968.13	5.28 %
Soft Cheese	1,484.76	3.98 %
Semi-Soft Cheese	20,294.03	54.42 %
Semi-Hard Cheese	6,545.78	17.55 %
Hard Cheese	1,939.28	5.20 %
Goat Cheese	269.94	0.72 %
Total	**37,289.16**	**100%**

Transportation

The greenhouse gas emissions from transport (**Figure 7**) can arise from land, sea, or air transport. It is assumed that imported and trans-Canada products are transported by air and in-province products are transported by refrigerated truck. The emission factors associated with these modes of transportation differ (Appendix II).

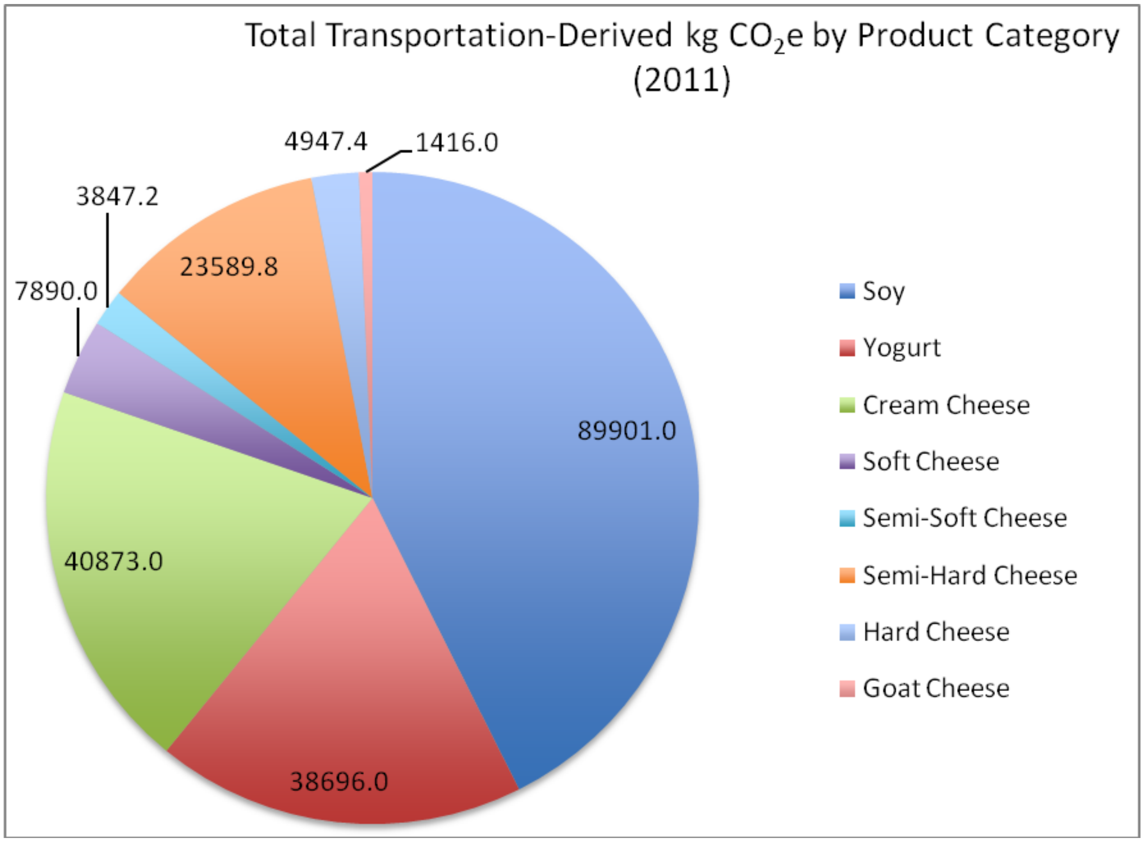

Figure 7: Transport-derived emissions from the products purchased by UBC in 2011. Soy products are the main contributor to GHG emissions (89,901.0kg) as the majority of these products are imported. It is important to note that these calculations do *not* include out-of-country origins.

The total transport-derived emissions = **211, 160.36 kg CO_2e**.

Table 4: Summary table of transportation-derived GHG emissions.

Product Category	Transportation GHG Emissions (kg CO_2e)	Percentage of Total
Soy	89,901.0	42.6 %
Yogurt	38,696.0	18.3 %
Cream Cheese	40,873.0	19.4 %
Soft Cheese	7,890.0	3.7 %
Semi-Soft Cheese	3,847.2	1.8 %
Semi-Hard Cheese	23,589.8	11.2 %
Hard Cheese	4,947.4	2.3 %
Goat Cheese	1,415.0	0.67 %
Total	**380,088.65**	**100%**

Packaging

The number of packages purchased in 2011 (**Figure 8**) was calculated using data provided by the UBC Velocity report (UBC, 2012). These values can be used to provide an estimate of how much waste is produced by non-milk dairy products in 2011. While we cannot safely calculate the volume, the quantity (756, 982) can be used as a benchmark figure for waste reduction.

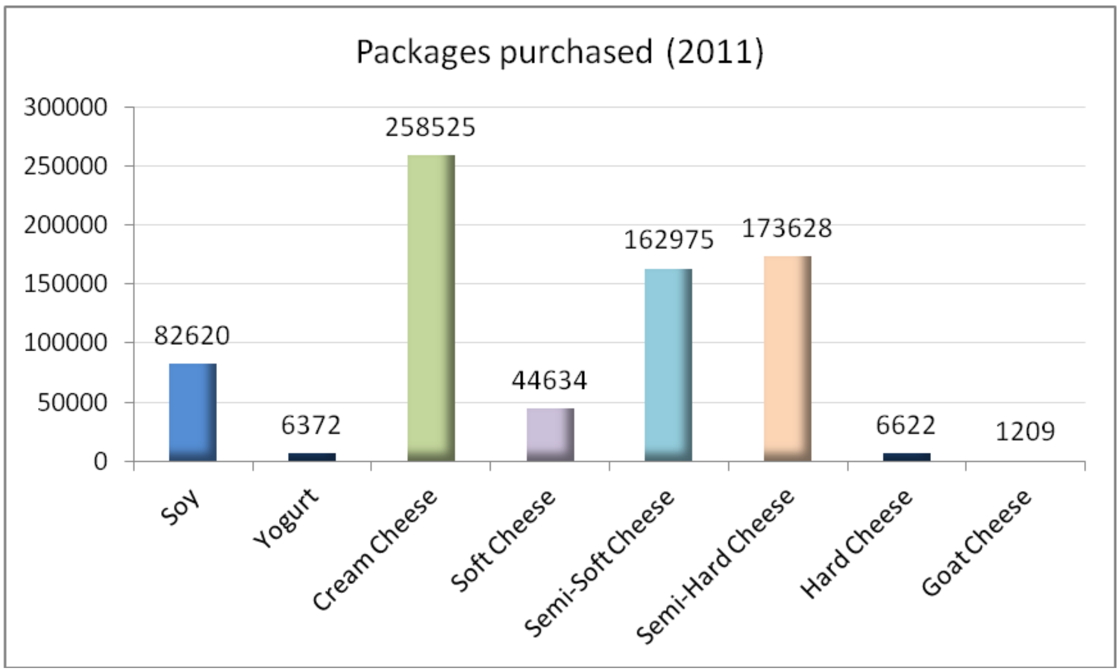

Figure 8: The number of individual packages purchased in 2011. The total number purchased is 756,982 individual packages. It is evident that the individual cream cheese (n =11) produces the bulk of the packaging and, in turn, waste. Semi-hard cheeses (n = 21) also have a high number of packages in 2011, however this category includes mozzarella and cheddar – both of which are used in sandwiches, pizzas, pastas, and other common food items.

Carbon Equivalents Summary

The total carbon equivalents produced by these products are summarized in **Figure 9** and **Table 5**. It appears the majority of the CO_2e emissions derive from soy products, which, in turn, are primarily transportation-derived emissions (**Figure 10**). Despite having the least number of products, yogurt is responsible for 13.7% of the total emissions (**Table 5**) much of which is also transportation (**Figure 10**).

The emissions from semi-soft cheeses, which account for 13.6% of the total emissions, are derived primarily through production rather than transportation (**Figure 10**). This is likely due to the majority of the products being processed in-province and, therefore, requiring little transportation. This product category is the most truly reflective of the dairy sector.

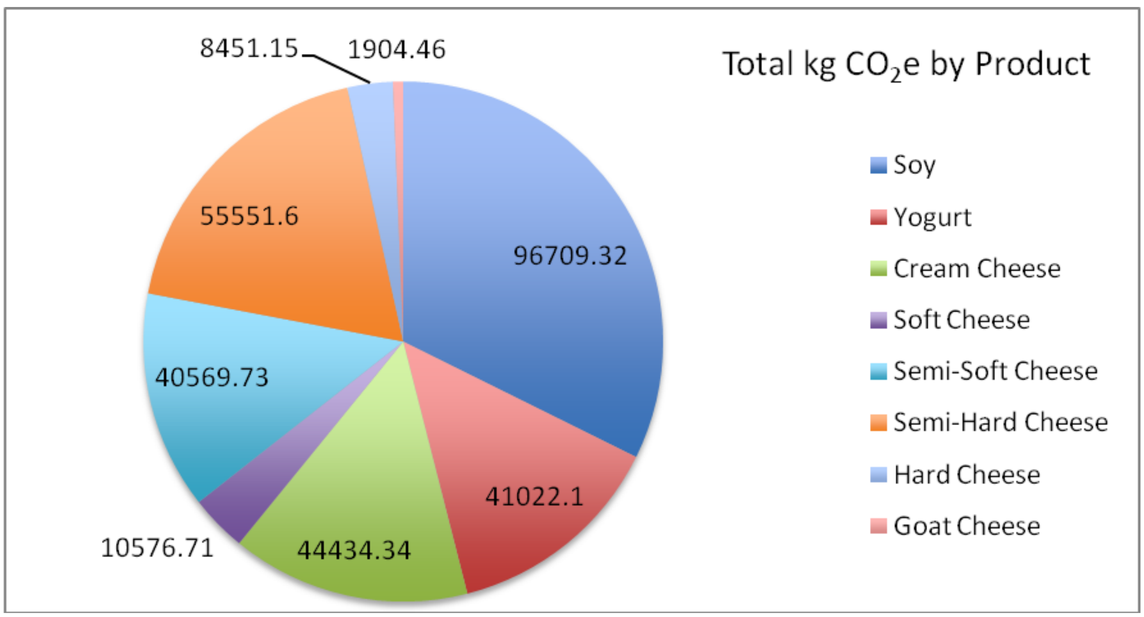

Figure 9: The breakdown of total kg CO_2e by product. Soy produces the majority of the emissions (32.3%), followed by semi-hard cheese (18.6%)

Total kg CO_2e from non-milk dairy products: **299,219.41** kg

Table 5: Summary table of total GHG emissions.

Product Category	GHG Emissions ($kg\ CO_2e$)	Percentage of Total
Soy	96,709.32	32.3 %
Yogurt	41,022.1	13.7 %
Cream Cheese	44,434.3	14.9 %
Soft Cheese	10,576.71	3.5%
Semi-Soft Cheese	40,569.7	13.6%
Semi-Hard Cheese	55,551.6	18.6 %
Hard Cheese	8,451.2	2.8 %
Goat Cheese	1,904.5	0.64%
Total	**299,219.41**	**100%**

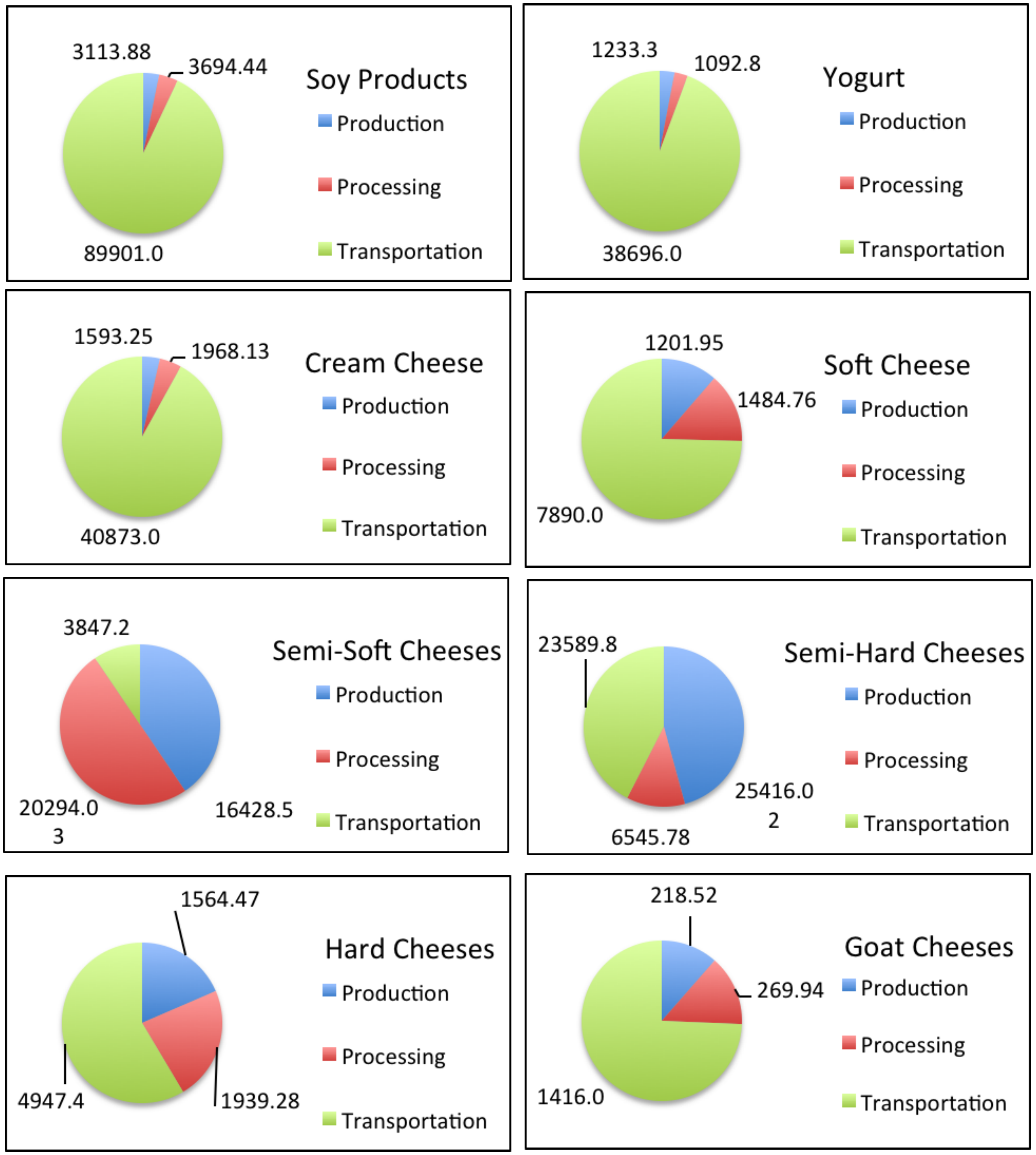

Figure 10: A comparison of the emission sources for the product categories.

Transportation is the source of the majority (70.57%) of the calculated emissions (**Figure 11**). This is not truly reflective of the dairy sector as a whole but, given the inclusion of soy products and yogurt source, is appropriate in the case of this report.

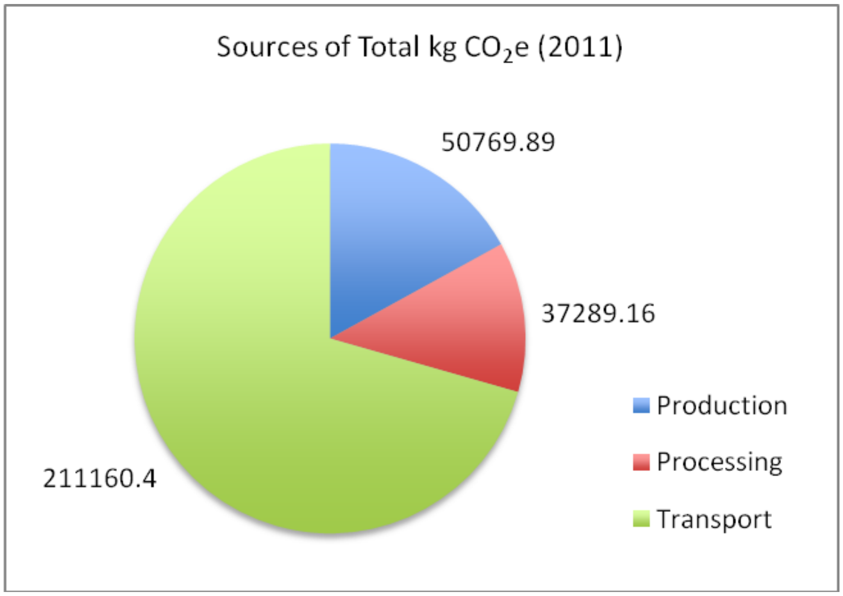

Figure 11: The sources of the total kg CO_2e. Transport is the source of the majority (70.6%) of the emissions.

Table 6: A summary of the sources of overall greenhouse gas emissions

	Transportation GHG Emissions (kg CO_2e)	**Percentage of Total**
Production	50,769.89	16.97 %
Processing	37,289.16	12.46 %
Transport	21,1160.40	70.57 %
Total	**299 219.45**	**100 %**

Discussion

Results

It is important to note that the majority of these results are likely underestimations due to a lack of availability of data. The results indicate that the majority of the greenhouse gas emissions arise from transportation. This is not in alignment with the Canadian standard that the majority of dairy sector emissions deriving from the on farm production (CDIC, 2011). Due to shortcomings in availability of data regarding processing emissions and exact production data, our most detailed results for dairy products are related to transportation. The inclusion of soy products, which are most from international sources, makes the resulting data have a higher transportation value (**Figure 11**) than the dairy sector standard.

Measures of Sustainability

Greenhouse gas emissions may not be the best indicator of sustainability for the dairy system due to its complexity and the myriad impacts it has on the environment. Although it is easy to point to climate change as an impending threat, there are more pressing issues arising from the dairy sector that can affect the environment severely on a much shorter time scale.

An example of short-term issues associate with animal agriculture is eutrophication of water sources, which occurs when large amounts of nutrients are added to a body of water. This sudden availability of resources can cause local algal populations to increase at an extremely rapid rate. The rapid population growth consumes oxygen in the water, bringing it to dangerously low levels, which can kill other organisms living in the water. Run off resulting from dairy operations and agriculture to produce food for dairy farms can have serious impacts on biodiversity in riparian areas and watersheds around commercial animal operations (Filip & Middlebrooks, 1976).

It may be more effective to consider the efficiency and surplus of nitrogen used in the agricultural setting to determine a farm's sustainability. Nitrous oxide (N_2O) is a side product of ruminant digestion, is released from manure as well (Sneath, Beline, Hilhorst, & Peu, 2006) and has a global warming potential 296 times greater than an equivalent mass of carbon dioxide (Environmental Protection Agency, 2011). Looking at nitrogen (N) surplus on a farm is useful because it provides an input/output view of what is being produced rather than simply focusing on output, as would be the case if we were to focus exclusively on GHG emissions. Non-carbon emissions in a dairy system can be closely tied to production as well, since the nitrogen surplus scales correspondingly with how many animals are present in a certain area (Oleson, et al., 2006). Surplus can also be determined fairly easily by looking at what inputs are brought into a farm (e.g.: feed, fertilizer), outputs (e.g.: manure, milk, meat), and the amount of N is incorporated into crops which gives a complete picture about waste products in a system (Oleson, et al., 2006). Nitrogen efficiency may be a better measure of the sustainability of the dairy sector; this is a measure of how much N is produced by a system in relation to its productivity.

Looking at dairy systems using N efficiency as a measure of sustainability is interesting because it gives an edge to conventional practices: organic milk production has a poorer N efficiency than conventional dairy farms (Oleson, et al., 2006). Organic farming practices prohibit the use of chemical pesticides and fertilizers in production, and as a result release fewer potential pollutants into the environment than conventional agriculture (Forge, 2004). However, cows on dairy farms that make use of free-range organic practices actually produce *more* methane due to increased enteric fermentation required to digest forage. In order to produce the same quantity of milk an organic cow will produce a greater amount of GHGs than a conventional, grain-fed cow (Forger, 2004).

This information suggests that although organic production may have an edge in some aspects of production concerning environmental health there are drawbacks to going organic. However, organic dairy production may have a greater potential for emission mitigation when making use of improved management practices and reduction in herbicide, pesticide, and synthetic fertilizer use (Olsen, et al., 2005). Organic operations may have intrinsic value as well; organic operations are less intensive than their conventional counterparts and can actually improve biodiversity and soil condition where they exist (Cederberg & Mattsson, 2000).

Appropriateness of Carbon Calculators

As the general public becomes increasingly aware of the effect that anthropogenic activities are having on the environment there is a need for tools that effectively communicate personal involvement in a wide reaching system. Carbon calculators are tools that allow individuals to input information about their consumption habits and activities and calculate the amount of emissions associated with their lifestyle.

From several peer-reviewed papers we have gathered that carbon calculators are very much in their infancy and far from being able to generate specific, consistent, and reliable data on emissions. Currently, because of the diffuse nature of their development among a number of different non-government, private, and government organizations, there is a considerable degree of fragmentation concerning how emissions are being calculated (Kim & Neff, 2009). A significant portion of calculators address only direct factors of individual emissions such as transportation and energy use and neglect indirect factors, which would be associated with diet (Kim &

Neff, 2009). Different calculators will use different methods, emission factors, and data complexity to calculate emissions without adequately explaining their methodology, or will make use of proprietary methods to calculate emissions and fail to disclose their calculations (Padgett, Steinemann, Clarke, & Vandenberghe, 2008).

The failure of the majority of these calculators to include emissions resulting from diet is a significant concern as emissions from land and agricultural sources accounts for roughly 30% of all emissions (Lenzen, 2001). Omitting these factors from calculators also interferes with recognition on the part of the individual that their dietary choices do have a significant impact on their carbon footprint (Kim & Neff, 2009) and that there is more they can do to reduce emissions than drive the car less and turn down the air conditioning. Carbon calculators must also account for the source of energy generation rather than simply give a result based on energy used, as the method of generation used for power has a massive influence on emissions associated with electricity usage (Padgett *et al.*, 2008). There are also issues associated with the use of carbon equivalent values, with some calculators making use of different values or omitting the calculation of non-CO_2 greenhouse gases entirely (Kim & Neff, 2009).

Carbon calculators may be a promising tool for the future but they require further development to give more accurate and reliable results. This tool may prove useful for addressing general information for individuals, and providing recommendations to reduce emissions based on personal data but their numbers range too widely to be useful in a quantitative capacity. If results are coupled with recommendations, then education could be tailored to the individual, fostering awareness of more effective courses of action to mitigate climate change. No group has managed to produce a peer-reviewed carbon calculator and we would hesitate to recommend any calculators to UBC Food Services for evaluating products purchased.

Limitations of our Approach

Our approach was significantly limited by availability of emission factors for different products and difficulty addressing the complexity of every aspect involved in the dairy system. Due to the extremely diffuse nature of the dairy system with processors receiving milk from many different farms we were unable to determine emissions associated with transport from farm to processor that would increase our projected emissions. As we are analyzing GHG emissions associated with dairy production we have discounted the secondary product of meat from cattle once they can no longer be milked; this is a gain of efficiency over a purely beef-cattle system (Cederberg & Mattsson, 2000).

The collection of emission factors was difficult and required intensive review of government documents and relevant literature. Several assumptions were necessary to facilitate the lack of data or inferences from data that were made by the group. The emission factors (Appendix II) were collected from several sources and shared among the other greenhouse gas audit groups focusing on meats and vegetables to provide consistency. The units of many emission factors were appropriate for our data (kg CO_2e/kg), however the transportation EFs (g CO_2e/L) required further assumptions in vehicle fuel efficiency. Obtaining EFs for specialty products, such as goat cheese, and discerning between cheese types was virtually impossible and required further assumptions.

Recommendations

The UBC Climate Action Plan (CAP) is a project that was established in 2009 by leading campus-side consultations and working groups. This project was developed through a multi-year planning process involving over 200 UBC students, staff, faculties, and community experts (UBC Sustainability, 2012). The goals of the CAP are to develop targets and solutions for greenhouse gas emissions reductions and accelerate efforts to respond to the impacts of climate change locally and globally (UBC Sustainability, 2012). The CAP's focus areas included food, transportation, fleets and fuel use, energy supply, management, *etc*. (UBC Supply Management, 2010).

An objective of this greenhouse gas audit was to provide recommendations to reduce emissions and increase sustainability of the food system. We would like to align with the UBC Climate Action Plan's goals of reducing emissions by 33% by 2015, 67% by 2020, and 100% by 2050 by improving UBC's dairy choices regarding transportation and packaging of dairy products (UBC Supply Management, 2010).

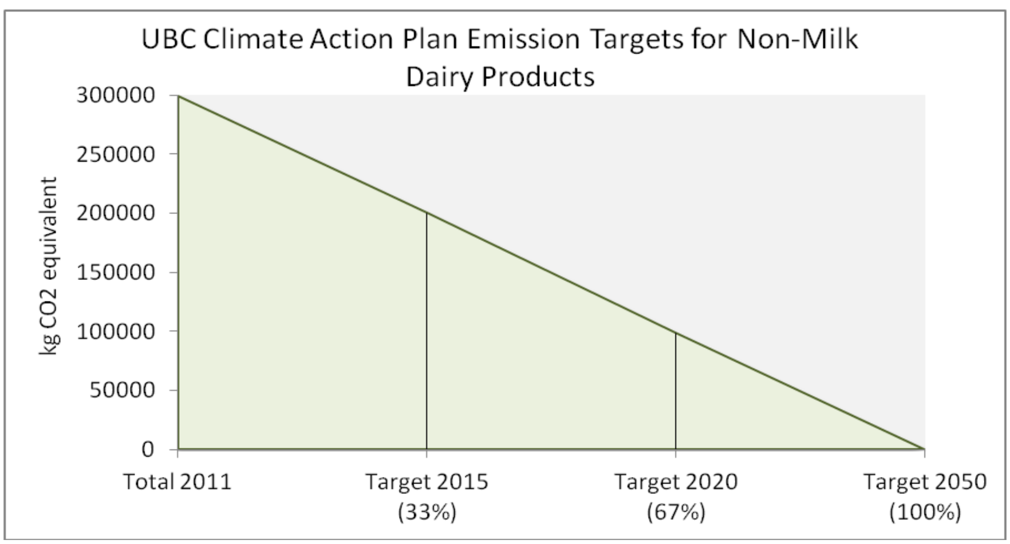

Figure 10: The UBC Climate action plan emission targets, as per the below data table

	Goal	kg CO_2e		Goal	kg CO_2e
2011	N/A	299,219.41	**2020**	67%	98,742.41
2015	33%	200,477.01	**2050**	100%	0.00

Our recommendations are structured following the S.M.A.R.T. guidelines, meaning that they must be: **S**pecific, **M**easurable, **A**ttainable, **R**ealistic and **T**ime-bound. Based on our results, we have created the following three recommendations:

1. Focus on local sourcing

Transportation emissions are major contributors to GHG emissions through the release of carbon dioxide and other pollutants from fossil fuel combustion. In the case of this report, transportation accounted for 70.6% (**Table 5**), despite many of UBC's dairy products being sourced in-province. To reduce transportation-related emissions, UBC should attempt to source and purchase more local products to minimize transportation distances.

This can be achieved by purchasing products from B.C. based subsidiaries of larger corporations or independent farms rather then importing products or sourcing products from the Eastern provinces. An example of this are the products purchased from Agropur's *Fine Cheese Division* located in Quebec. A West coast Agropur subsidiary, Island Farms, has the *Division Natrel* which produces similar cheese products and is located significantly closer (Island Farms, 2012). Another example involves the sole yogurt product, Yoplait's, *Yop*®. The transportation of this product is also significant (**Figure 9**, **Figure 10** and associated Tables). This product, likely has an alternative that does not require cross-Canada transport.

2. Engage in carbon mitigation

Emission reduction may be achieved through participation in a carbon offset program. Carbon offsetting is a service in which the purchaser pays another party to create greenhouse gas reductions on his or her behalf (David Suzuki Foundation and Pembina Institute, 2009). This is most often in the form of tree planting but can occur in other forms of carbon sequestration as well. In Canada there are approximately fourteen retail offset vendors currently selling offsets from a wide range of projects, including wind farms, tree planting and landfill gas recovery (David Suzuki Foundation and Pembina Institute, 2009). By initiating a carbon-offsetting program UBC will solidify its reputation as a leader of climate change mitigation and significantly contribute to achieving the goal of carbon neutrality by 2050 (UBC Sustainability, 2010).

3. Reduce packaging through bulk ordering

Unnecessary packaging waste causes high amounts of greenhouse gas emissions during the industrial production of the packaging materials. While this report was unable to provide quantitative figures on the emissions associated with packaging, the sheer quantity of packages associated with non-milk dairy products is significant (**Figure 8**). Bulk packaging is an option to reduce packaging. A single large container holds significantly more servings than individual containers, and will consequently produce fewer emissions during production than packaging individual servings. While this cannot be achieved for products requiring individual servings, such as cream cheeses for cafeterias and soymilk cartons, this can be a focus for food production areas.

In addition, the “Eco-to-Go” program at UBC Food Services outlets and in the Student Union Building provides alternatives to individual servings if yogurts and milks can be served from larger packages into reusable cups and bowls.

Recommendations to LFS Students

We have proposed some recommendations for future LFS students to further advance the project:

1. Continue research into the emission factors associated with these products, particularly packaging and packaging options.
2. The provided emission factors should be used to further assess the GHG emissions, and possibly include a more detailed analysis of only a few top purchased products.

Conclusions

The use of CO_2 emissions as an indicator for the sustainability of the dairy sector is still up for debate. The complexity of the dairy system, in a national and global context, makes it difficult to obtain reliable data at this level. More thorough analyses would include farm-based non-carbon greenhouse gas emissions and rely less on transport-related and second-hand data sources. However, given the nature of this preliminary report it appears that the primary goal has been achieved and a baseline inventory of the non-milk dairy product emissions has been completed to the best level possible.

Based on our analysis of the non-milk dairy products purchased by UBC Food Services, we have concluded that the emissions arise primarily from the transportation (70.6%) of the products – particularly soy products (32.3%) and semi-hard cheese (18.6%). The remainder is distributed in the industrial processing (12.5%) of the product. The total emissions for non-milk dairy product emissions are resulted to be **299,219.41 kg** of carbon dioxide. From these data, we have identified some areas for improvement and provided attainable recommendations:

1. Reduce or phase out the purchasing of drinkable yogurts from Quebec and opt for more local and mature products.
2. Engage in carbon mitigation programs to achieve the goal of zero net emissions by 2050.
3. Lastly, purchase as many bulk items and utilize the "Eco-to-Go" program to reduce waste where possible.

Due to limitations in data and the scope of the project, these recommendations are related primarily to transportation and packaging. It is not feasible for this group to recommend changes in overall purchasing of cheese products, nor it is it possible for recommendations to be targeted at farmers or distribution companies.

This project can be expanded by future LFS 450 students taking a more focused approach on highly purchased items using the emission factors collected in this report.

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Appendix I – List of products included in report (including supplier, product, distance, and quantity by weight)

Appendix I – List of products included in report (including supplier, product, distance, and quantity by weight)

Products	Brand Name (if available)	Supplier	Packaging	Quantity (kg)	Distance Travelled (km)
Soy					
Mozzarella Soy Cheese (shredded)	B.C. Castle Cheese	Castle Cheese (West) Inc.	4 x 2.27 kg	19.4	525.5
Nacho Blend Soy Cheese shredded)	B.C. Castle Cheese	Castle Cheese (West) Inc.			525.5
Original Soy Drink *	So Nice	Concord Sales Ltd.	24 x 250mL	1196.0	22.0
Vanilla Chai Soy Drink *	Soya World	Concord Sales Ltd.	24 x 250mL	102.0	22.0
Fortified Strawberry Soy Drink *	So Good	Concord Sales Ltd.	24 x 250mL	1580.26	22.0
Fortified Chocolate Soy Drink *	So Good	Concord Sales Ltd.	24 x 250mL	2370.39	22.0

Products	Brand Name (if available)	Supplier	Packaging	Quantity (kg)	Distance Travelled (km)
Yogurt					
Drinkable (various flavours)	Yoplait	Aliments Ultima Ltd	12 x 200mL	1561.14	4837.0

Products	Brand Name (if available)	Supplier	Packaging	Quantity (kg)	Distance Travelled (km)
Cream Cheese					
Herb & Garlic	Boursin	Agropur (Fine Cheese Division)	12 x 150.0 g	61.02	4831.67
Herb & Garlic (Port)		Kraft	120 x 26.0 g	248.3	27.5
Light	Philadelphia	Kraft	200 x 18.0 g	206.4	27.5
Plain		GFS	6 x 1.5 kg	47.2	31.5
Plain (tub)		GFS	2 x 2.0 kg	16.8	31.5
Plain	Philadelphia	Kraft	6 x 1.5 kg	137.04	27.5
Port	Philadelphia	Kraft	200 x 18.0 g	541.35	27.5
Spreadable	Lactantia	Parmalat Canada Inc.	2 x 2.0 kg	115.7	21.95
Spreadable	Philadelphia	Kraft	1 x 3.0 kg	144.91	27.5
Strawberry	Philadelphia	Kraft	120 x 26.0 g	43.29	27.5

Products	Brand Name (if available)	Supplier	Packaging	Quantity (kg)	Distance Travelled (km)
Soft Cheese					
Bocconcini (30gr)	B.C. Scardillo	Flamingo Foods Ltd.	1 x 2.0 kg	97.61	20
Bocconcini (90gr)	B.C. Scardillo	Flamingo Foods Ltd.	1 x 2.0 kg	444.92	
Brie (double cream)	Emma	Jan K. Overwheel Ltd.	1 x 3.0 kg	40.25	40.24
Brie (single cream)	B.C. Natural Pastures	Natural Pastures Cheese	1 x 2.5 kg	11.21	135
Brie (triple cream)	Cayer	Saputo Dairy Products	1 x 1.2 kg	4.69	22
Camembert (Danish) *	Kraft	Kraft Canada Inc.	12 x 125.0 g	38.5	27.5
Curd (fresh)	Village Cheese	The Village Cheese Co.	2 x 1.5 kg	3.15	473
Curd (poutine)	Kinsey	Saputo Dairy Products	100 x 60g	6.9	22
Mascarpone	Tre Stella	Arla Foods Inc.	6 x 475.0 g	73.58	20
Provolone	Emma	Jan K Overwheel Ltd.	3 x 3.0 kg	449.19	53
Ricotta **	Bari	Saputo Dairy Products	1 x 4.0 kg	39.96	22

Products	Brand Name (if available)	Supplier	Packaging	Quantity (kg)	Distance Travelled (km)
Semi-Soft					
Asiago	Delissio	Kraft Canada In.	2 x 1.0 kg	22.6	27.5
Blue (crumbled)	Castello	Arla Foods Inc.	2 x 2.0 kg	4.43	20
Blue (Rosenborg Mini)		Arla Foods Inc.	8 x 125.0 g	2	20
Cambozola		Arla Foods In.	1 x 2.2 kg	20.51	20
Cheddar (medium)		GFS	2 x 2.27 kg	31.5	3673.5
Cheddar (medium, shredded)		GFS	2 x 2.5 kg	31.5	4553.28
Gorgonzola *	Ballarini	Jan K. Overwheel Ltd.	4 x 1.5 kg	40.25	21
Grogonzola (wheel) *	Castello	Arla Foods Inc.	1 x 1.5 kg	1.77	20
Harvarti (Jal-	Dofino	Arla Foods	1 x 4.2 kg	13.52	20

apeno)		Inc.			
Montary Jack (shredded)		GFS	2 x 2.5 kg	5.25	31.5
Mozzarella (pizza)	Black Diamond	Parmalat Canada Inc.	2 x 2.27 kg	1956.08	21.95
Mozzarella (block)		GFS	8 x 2.3 kg	2332.88	31.5
Mozzarella (shredded)		GFS	2 x 2.5 kg	3770.83	31.5
Swiss (Canadian)		GFS	2 x 3.0 kg	1670.74	31.5

Products	**Brand Name (if available)**	**Supplier**	**Packaging**	**Quantity (kg)**	**Distance Travelled (km)**
Semi-Hard					
Asiago (wheel)	Tre-Stella	Arla Foods Inc.	1 x 5.5 kg	5.78	20km
BC Combo Box		Little Qualicum Cheese-Cheeseworks	1 x 1.2 kg	186.42	82km
Blue (Danish, wheel) *	Rosenborg/Castellow	Arla Foods Inc.	1 x 3.0 kg	146.9	
Combination box		Little Qualicum Cheese-Cheeseworks	1 x 1.2 kg	186.42	82
Cheddar (marble)		GFS	2 x 2.27 kg	220.9	31.5
Cheddar (medium 32%)		GFS	2 x 2.27 kg	2.37	31.5
Cheddar (medium, port)		Kraft	100 x 21.0 g	0	27.5
Cheddar (mild)	Black Diamond	Parmalat Canada Inc.	12 x 500.0 g	278.44	21.95
Cheddar (Old, white)		GFS	2 x 2.27 kg	47.5	31.5
Feta		GFS	1 x 3.0 kg	609.25	31.5
Feta (Cow milk) *	Petros	Parthenon Food Importers	1 x 11.0 kg	464	21
Gouda (smoked)	Uniekaas	Elco Fine Foods Inc.	4 x 2.7 kg	119.87	39.75
Havarti	Cayer	Saputo Dairy Products	1 x 4.0 kg	1026.81	22
Monteray Jack (shredded)		GFS	2 x 2.5 kg	364.48	31.5
Monteray Jack (w/hot pepper)		Parmalat Canada Inc.	2 x 4.54 kg	699.17	21.95

Monteray Jack (white, block)		GFS	2 x 2.27 kg	7.58	31.5
Monteray Jack (pizza mozzarella)		GFS	2 x 2.5 kg	79.35	31.5
Pacific Pepper (½ Wheel)		Natural Pastures Cheese	1 x 2.5 kg	2.84	135
Swiss (Gruyere) *	Von Muhlenen	Jan K Overwheel Ltd	6 x 2.75 kg	277.6	40.25

Products	**Brand Name (if available)**	**Supplier**	**Packaging**	**Quantity (kg)**	**Distance Travelled (km)**
Hard Cheese					
Cheddar (old)		GFS	2 x 2.5 kg	21.3	31.5
Grana Padano (1/8 wheel)	Cremona	Arla Foods Inc.	1 x 4.0 kg	28.32	20
Parmesan (BC)	BC Farmstead	The Village Cheese Co.	1 x 2.25 kg	2.35	473
Parmesan (grated)		Kitch Essential	2 x 2.5 kg	114.45	22.2
Parmasan (shredded)		GFS	2 x 1.0 kg	1183.6	31.5
Parmesan (value blend)		Kitch Essential	2 x 2.5 kg	181.5	22.2
Parmesan Sardo *	Italissima	Bosa Foods	1 x 3.65 kg	7.21	18

Products	**Brand Name (if available)**	**Supplier**	**Packaging**	**Quantity (kg)**	**Distance Travelled (km)**
Goat Cheese					
Camembert Gaot Juliette		Saltspring Island Cheese Co.	6 x 160.0 g	0	95
Cow blend	Cayer	Saputo Dairy Prodcuts	2 x 1.0 kg	170.94	22
Crumbled	BC Happy Days	Arla Foods Inc.	2 x 1.0 kg	5	20
Feta (crumbled)	BC Happy Days	Arla Foods Inc.	2 x 1.0 kg	32.5	20
Romano Peccorino (sheep milk)	Lupa	Arla Foods Inc.	1 x 5.0 kg	5.8	20

*** Assumed imported by air**

Appendix II – Table of Emission Factors used for emission calculations

Product	Production ($kg\ CO_2e/kg$)	Processing ($kg\ CO_2e/kg$)	Transportation ($kg\ CO_2e/km$)
Soy	0.25[1] 0.59[2]	0.70[2]	8.0[4] *
Yogurt	0.79[2]	0.70[2]	8.0[4]
Cream Cheese	1.02[2]	1.26*	8.0[4]
Cheese (domestic)	1.02[2]	1.26[2]*	8.0[4]
Cheese (imported)	1.02[2]	1.26[2]*	20.0[2] * ($kg\ CO_2e/kg$)
Goat Cheese	0.71[2] *	1.26[2]*	8.0[4]

[1] Carlsson-Kanyama and González, 2009

[2] EWG, 2011

[3] IPPC, 1998 Table 1-32

[4] Transport Canada, 2012

* see *Assumptions*