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Estimating and Reducing the Climate Footprint of Food Served by Kaiser Permanente

2011 Group Project Final Report

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1. Abstract

Kaiser Permanente is a healthcare provider that aims to be a leader in the U.S. healthcare industry. As a major healthcare organization, Kaiser Permanente recognizes that climate change presents great risks to human health. The company also recognizes the importance of preventative measures, which can be critical in mitigating those risks. As a member of the Climate Registry, Kaiser Permanente has determined its carbon footprint utilizing the Registry's General Reporting Protocol. However, this protocol does not require reporting of emissions associated with food.

Kaiser Permanente has determined the need to develop a framework for estimating the climate footprint of the major food categories served throughout its operations as food systems. This report aims to take on this task in addition to identifying major food groups contributing to greenhouse gas emissions and providing recommendations to mitigate those emissions. In this report, an economic input-output life cycle assessment was used to calculate greenhouse gas emissions from procurement data. The results were verified using a process-based method to benchmark values. This document reports these results and recommends actions that will reduce the environmental impact of Kaiser Permanente's food system in the future.

2. Executive Summary

2.1 Purpose

As an ongoing participant in the Green Guide for Healthcare, Kaiser Permanente has taken the first steps toward sustainability in its food sector. In a November 2004 vision statement, Kaiser Permanente's Environmental Stewardship Council vowed that they "will promote agricultural practices that are ecologically sound, economically viable and socially responsible by the way we purchase food".[1] To complement their vision statement, this report has conducted a comprehensive economic input-output life cycle assessment (EIO-LCA) and a process-based approach to quantify the greenhouse gas (GHG) emissions associated with food procurement through Kaiser Permanente's operations. The results of this report are intended to provide Kaiser Permanente with guidance for the management of identifiable, high-emitting food products purchased. Data collection and analysis methods were given careful consideration to avoid generalizations and assumptions. The findings from our report have thus, allowed us to recommend potential food systems management actions that will effectively reduce Kaiser Permanente's GHG emissions from food related purchases.

2.2 Background

GHG emissions from the life cycle of food products are a significant contributor to anthropogenic environmental impacts. To enable Kaiser Permanente to reduce GHG emission via their food purchasing, we utilized an EIO-LCA model to generate GHG emissions from their purchase data and evaluated high-emitting products.

2.3 Methods

After careful reorganization and categorization of received data we were able to successfully input our data into a Comprehensive Environmental Data Archive (CEDA) 4.0, a model for EIO-LCA analysis. The model interlinks input and output tables, environmental emissions, and resource use statistics to calculate the quantity of GHG emissions emitted by a given product's purchase amount. The next step was to benchmark results with a process-based model. Unlike CEDA, this type of method is a bottom up approach-the traditional type of Life Cycle Assessment (LCA). This method covers a product's lifecycle on a physical basis (mass) rather than on an economic basis. After

[1] Garske, Lynn (2006). *Kaiser Permanente's Comprehensive Food Policy* [PowerPoint slides]. Retrieved May 16, 2010 from http://siri.uvm.edu/ppt/40hrenv/index.html

GHG emissions were determined we used Carnegie Melon University's Economic Input-Output Life Cycle Assessment method to determine toxic releases of each product we categorized. In doing so, we were able to determine the correlating health impacts of a particular food category.

2.4 Results

The estimate of total emissions associated with food purchased by Kaiser Permanente in 2009 was approximately 23,400 tons CO_2e. Meat accounts for over one quarter of these emissions, with beef contributing over 2,000 tons, followed by poultry and then pork. Cooking and serving supplies were found to be the next largest group, with emissions from beverages right behind, at 9% of the total. Prepared items, which consist primarily of premade entrees, soups, and breakfast items, were also a major contributor, at around 8%, while vegetables and dairy were each closer to 7%.

Our substitution analysis compared complementary items in these categories, as well as the categories which had less emissions overall. The largest potential for emissions reductions were found, however, in substitutions involving meat and involving beverages. Replacing beef with poultry and juice with tap water were found to have reduction potentials of hundreds of tons, even when substituting small percentages of these items overall. Additionally both of these substitutions were found to have large cost reductions. Emissions reductions were found in substituting various vegetables and fruits between their frozen, fresh, and canned forms, but on a significantly smaller scale than those for meat and beverages. Similarly, there are opportunities for reductions between margarine and butter, soymilk and milk, and other processed and unprocessed foods.

The toxic emissions results showed quite a lot of variation between the different emissions types for the various product groups. Particular groups of items were much more environmentally harmful than others in some categories while being relatively benign in others. The supplies group, for example, was by far the largest contributor to terrestrial and aquatic ecotoxicity, with more processed products contributing to greater acidification in terrestrial and aquatic environments. Drinks, particularly soft drinks, also had substantial toxic emissions factors for eutrophication and carcinogenic emissions. The toxicity factors for poultry emissions was also generally higher than those for beef and pork products, leading to a greater contribution to the overall total.

2.5 Conclusion and Recommendations

The substation analyses provide a guide for purchasing managers to reduce emissions by hundreds of tons while making relatively small changes. Replacing beef with poultry is the most cost-effective and emissions-reducing option for meat substitution, but due to the potential for environmental harm from increasing poultry consumption, should be balanced with the other substitution options. Identifying environmentally-friendly sourcing options for poultry is advisable, because not all farm management practices will be represented by the toxicity factors used in this analysis. Perhaps the most straightforward way to reduce emissions and costs while ensuring a smaller environmental footprint overall is through replacing juice and carbonated beverages with tap water. Soft-drink manufacturing and sugar production were both large contributors to several toxicity categories, and reduced sugar consumption has additional direct health benefits. Substitutions between the various types of processed foods, fruits, and vegetables must be considered by purchasing managers in the context of appealing to the tastes of consumers as well as the capacity of institutions to freeze, refrigerate, and prepared these foods. There are sufficient opportunities for targeted emissions and cost reductions that directing increased funds towards more sustainably produced, yet more carbon-intensive food options such as organic and grass-fed beef may not lead to increased emissions overall. In the case that they do, there is the possibility of purchasing carbon offsets, which should be considered regardless of purchasing decisions given the relatively low cost.

3. Project Objectives

This project aimed to estimate and reduce Kaiser Permanente's food-related climate footprint by developing an approach for measuring the relative impact on climate of food served throughout the organization. Based on the results, this project compiled a list of potential GHG emission reduction activities. The listed activities were then prioritized based on the maximization of health-related co-benefits. The determination of health-related co-benefits could include, for example, weighing the health benefits of organic produce against non-organic produce, in relation to associated GHG emissions. If the production and transport of organic produce is found to have lower GHG emissions, in addition to significant health benefits from lowered pesticide exposures, the purchase and consumption of organic produce can be then be considered a "maximization of health-related co-benefits."

Broadly speaking, the project objectives were to:

- To develop an appropriate framework, such as a Life Cycle Assessment (several options included EIO-LCA, Process LCA, Gabi4 software, FoodCarbonScope), for calculating the climate footprint of foods served at Kaiser Permanente's different locations and throughout its supply chain, while also standardizing the methods to best fit each location.
- Based on the results obtained (from an initial EIO-LCA), identify the foods that can significantly affect the balance of the GHG emission reduction goals and go more in depth from there.
- Propose a definition for "sustainable food" keeping in mind Kaiser Permanente's goals of emission reduction and health-related co-benefits from sustainability.
- Form a priority list of strategies -- to establish targets and assess progress – that can be followed by Kaiser Permanente's supply chain partners, internal purchasers and members, for achieving reductions in the climate footprint of their food.

4. Project Significance

Kaiser Permanente is an integrated healthcare firm, serving as both a health insurer and a health care provider. Unlike many other American private healthcare providers, Kaiser Permanente's business model integrates fixed-price health insurance with treatment at its own hospitals and clinics. This integrated approach, along with an incentive structure that rewards quality of care over quantity, is considered innovative, for it encourages investment in the form of long-term care for patients.[2] In Kaiser Permanente's system, preventative medicine can save the company significant expenditures. For this reason, the company is interested in providing healthcare actions that are preventative, rather than adaptive, wherever possible.

Kaiser Permanente's emphasis on preventative healthcare is also reflected in its approach to addressing climate change. According to the British Medical Journal, climate change belongs at the "heart" of health services management, for the institutions of healthcare can have enormous power to do good or harm to the natural environment and to increase or diminish carbon emissions.[3] Kaiser Permanente has adopted this agenda as well. While the company recognizes the significant role healthcare providers will play in protecting and treating those harmed by climate change into the future, it also realizes the benefits of implementing mitigation policies in the present time. Although Kaiser Permanente has already initiated several internal sustainability measures relating to, for example, green building components in its facilities, it is continually seeking to determine operational areas in which its contribution to climate change has not yet been defined. One such area is the impact of its food services sector.

[2] The Economist (2010, April 29). *Another American way.* Retrieved May 13, 2010 from http://www.economist.com/business-finance/displaystory.cfm?story_id=16009167

[3] Coote, A. (2006). What health services could do about climate change. *British Medical Journal*, 332, 1343-1344. Retrieved May 1, 2010 from http://www.bmj.com/cgi/context/extract/332/7554/1343.

The goal of this project was to provide Kaiser Permanente with tactical tools, supported by the project's data analysis and recommendations, which will allow the company to reach their immediate goal of reducing GHG emissions from its food services sector. These tools were aligned with sustainability business management practices that aimed to increase the environmental performance and quality of Kaiser Permanente's "product," healthcare services. Unlike most previous sustainable food- related research, we explicitly connected health co-benefits to environmentally sustainable food choices.

The significance of this project will be determined by our successfulness in demonstrating how Kaiser Permanente can improve upon its product quality performance through sustainability practices. In the existing body of literature, researchers have not been able to support whether sustainability practices contribute to greater quality performance of business products. This project implemented state of the art valuation studies to assess how quality performance can, in fact, be enhanced by sustainability measures. Additionally, this project aimed to be able to quantify and project Kaiser Permanente's potential cost savings through the sustainability activities that are recommended and prioritized. Ultimately, the implications of this project extend beyond the group project itself. Through the outcomes of this project, Kaiser Permanente has been provided with a factual basis on which to better inform its food purchasing decisions. Kaiser Permanente's pursuant actions can then have even further reaching effects. As Kaiser Permanente moves to address the environmental impact of this area of its operations, other healthcare providers – locally, nationally and internationally – may have incentive to follow. Kaiser Permanente will be able to maintain its role as an innovator within the industry, not just in terms of healthcare but now additionally in terms of environmental leadership.

5. Background

5.1 Climate Footprint

According to the Intergovernmental Panel on Climate Change, human activities result in the emissions of four principal GHGs: carbon dioxide (CO2), methane (CH4), nitrous oxide (N20) and halocarbons (a group of gases that contains fluorine, chlorine and bromine).[4] A climate footprint, therefore, is a measure of a product, service or entity's contribution to global warming, in terms of amount of GHG emissions produced during the lifetime of that product, service or entity (whether it be an individual, household, company, community, city, state or nation). The footprint is typically measured in units of carbon dioxide equivalent, CO2e, which is a unit for comparing the radiative forcing of a GHG to carbon dioxide.[5,6] It is typically the sum of two parts: the direct or primary footprint is a measure of direct emission of CO2 from the burning of fossil fuels, including domestic energy consumption and transportation; the indirect or secondary footprint is a measure of the indirect CO2e emissions from the whole lifecycle of products and services, from manufacture to disposal.[7]

A climate footprint can also be considered a smaller subset of analysis covered by a more complete Life Cycle Assessment (LCA). The European Platform on Life Cycle Assessment defines LCA as:

[4] Intergovernmental Panel on Climate Change (2007). Changes in Atmospheric Constituents and Radiative Forcing. In *IPCC Fourth Assessment Report: Climate Change 2007* (Chapter 2). Retrieved May 13, 2010 from: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2.html

[5] Kenny, T., & Gray, N. (2009). Comparative performance of six carbon footprint models for use in Ireland. *Environmental Impact Assessment Review*, *29*(1), 1-6. Retrieved May 13, 2010 from http://dx.doi.org/10.1016/j.eiar.2008.06.001

[6] British Standards Institution (2008). *Publicly Available Specification 2050 – 2008: Specification for the assessment of the life cycle GHG emissions of goods and services.* Retrieved May 15, 2010 from http://shop.bsigroup.com/en/Browse-by-Sector/Energy--Utilities/PAS-2050

[7] Kenny, T., & Gray, N. (2009). Comparative performance of six carbon footprint models for use in Ireland. *Environmental Impact Assessment Review*, *29*(1), 1-6. Retrieved May 13, 2010 from http://dx.doi.org/10.1016/j.eiar.2008.06.001

> "an internationally standardized method (ISO 14040, ISO 14044) for the evaluation of environmental burdens and resources consumed along the life cycle of products; from the extraction of raw materials, the manufacture of goods, their use by final consumers or for the provision of a service, recycling, energy recovery and ultimate disposal."[8]

"Environmental burdens and resources consumed," can refer to, for example, problems such as acidification, deforestation, and toxic releases. Since climate change is also one of the major impact categories within an LCA, essentially a climate footprint is an LCA with the analysis limited to emissions that have an effect on climate change.

Climate Footprint Models

Climate footprint models play an important role in educating the public and private sectors about management and reduction of CO_2 emissions. The calculation of climate footprints at various levels is a powerful tool, enabling people to measure their own CO_2 emissions and connect those emissions to their activities and behavior. That connection can then be strong motivation to enact changes. Additionally, unlike the vast amount of other types of scientific research, climate footprinting has a broad appeal to those outside the scientific community. The calculated value of a footprint can be readily understood and placed into the context of one's daily life, which explains why the concept has continued to ease into the public mindset in many areas of the world.[9]

The idea of the climate footprint has significantly increased in popularity over the past few years, particularly in Western Europe.[10] Socially and environmental conscious companies, have, in large part, been responsible for pushing the idea, followed by non-governmental organizations, companies and various private entities.[11] These companies are drawn to GHG for several reasons. Many hope to provide their customers with more transparency regarding their operations, while other companies may intend to capitalize off the new markets created by climate footprinting. For example, some companies may offer airplane tickets for purchase alongside carbon offsets.[12]

Shortcomings and Strengths

The major strength of climate footprinting – relative simplicity - can also be seen as its primary weakness. Reliance on one environmental indicator can be misleading, and one should be aware of the dangers of oversimplification. For example, an examination of biofuels, which have a low carbon footprint, could give the impression that they are genuinely eco-friendly products. Yet biofuels are also associated with negative land use impacts, which ultimately increase the pressure on rainforests and other areas rich in biodiversity around the world. Climate

[8] European Commission Joint Research Center, European Platform on Life Cycle Assessment (2006). *Carbon Footprint - what it is and how to measure it.* Retrieved May 15, 2010 from http://lca.jrc.ec.europa.eu/Carbon_footprint.pdf

[9] Weidema, B. P., Thrane, M., Christensen, P., Schmidt, J., & Løkke, S. (2008). Carbon Footprint: A Catalyst for Life Cycle Assessment. *Journal of Industrial Ecology*, *12*(1), 3 - 6. Retrieved May 13, 2010 from http://www.indiaenvironmentportal.org.in/files/Carbon footprint.pdf

[10] Weidema, B. P., Thrane, M., Christensen, P., Schmidt, J., & Løkke, S. (2008). Carbon Footprint: A Catalyst for Life Cycle Assessment. *Journal of Industrial Ecology*, *12*(1), 3 - 6. Retrieved May 13, 2010 from http://www.indiaenvironmentportal.org.in/files/Carbon footprint.pdf

[11] Weidema, B. P., Thrane, M., Christensen, P., Schmidt, J., & Løkke, S. (2008). Carbon Footprint: A Catalyst for Life Cycle Assessment. *Journal of Industrial Ecology*, *12*(1), 3 - 6. Retrieved May 13, 2010 from http://www.indiaenvironmentportal.org.in/files/Carbon footprint.pdf

[12] Weidema, B. P., Thrane, M., Christensen, P., Schmidt, J., & Løkke, S. (2008). Carbon Footprint: A Catalyst for Life Cycle Assessment. *Journal of Industrial Ecology*, *12*(1), 3 - 6. Retrieved May 13, 2010 from http://www.indiaenvironmentportal.org.in/files/Carbon footprint.pdf

footprinting may not be able to account for those additional environmental impacts, which could be considered equally important to the overall health of the planet.[13]

Nonetheless, researchers in the LCA community have acknowledged that environmental impacts from energy-related emissions are an important factor that contributes to the overall impact potential for most products and services. While there will inevitably be instances in which climate footprinting is misleading or interpreted incorrectly, if decisions based on the indicator are headed in the right direction 80% of the time, they believe would still be better to use this method of indicator than no method at all.[14]

5.2 Life Cycle Assessment

Any product or service has a life cycle which begins with the production and procurement of raw material for its manufacture, distribution, use and disposal including the transportation involved in moving the product or service. An LCA is the measure of the environmental impact of technology used in each of these life cycle stages and accounts for all the steps involved in the existence of the product or service from its cradle-to-its-grave.

The LCA approach has been widely accepted in different industries to evaluate environmental impacts of the products/processes and to identify the resource and emission intensive processes (hotspots) within the product's life cycle. Originally used to analyze industrial processes, it is only recently that LCAs have begun to be applied to assessing the environmental impacts of the food industry and agriculture. An LCA can help in comparing all major environmental impacts that may be caused and thus enable selection of a product or process with minimal environmental impact while also taking into consideration other factors such as cost and performance data.[15]

A typical LCA follows Environmental Management Standards set by the International Organization for Standardization (ISO) called the ISO 14040 series, which comes under a larger family of ISO 14000 standards. Additional details regarding guidelines for the steps of the LCA are provided by the ISO 14041, ISO 14042 and ISO 14043 standards which have also been mentioned below in each of the LCA stages. In 2006, ISO published an improved and updated ISO 14040 and a new ISO 14044 standard which were meant to replace previous standards. Also, since the publication of PAS 2050 standards in 2008, recent studies in assessing life cycle GHG emissions have begun using PAS 2050 due to its specific advantages over other standards.

According to ISO 14040, a general LCA process includes the following four phases:

Phase I- Goal Definition and Scoping: Outlining and defining the goal and the scope of LCA and deciding upon functional units (form in which the product is consumed by the end user) to be used in analysis. This step also determines the time and resources needed in conducting the LCA and follows ISO 14041 standards outlined and described by ISO.

Phase II- Inventory Analysis: This step entails compiling an inventory of relevant energy, water and material inputs and environmental releases (such as GHG emissions, solid waste generation etc.). According to the LCA Principles and Practice document published by the NRMRL, EPA "a life cycle inventory (LCI) is a process of quantifying energy and raw material requirements, atmospheric emissions, waterborne emissions, solid wastes, and other releases for

[13] Weidema, B. P., Thrane, M., Christensen, P., Schmidt, J., & Løkke, S. (2008). Carbon Footprint: A Catalyst for Life Cycle Assessment. *Journal of Industrial Ecology*, *12*(1), 3 - 6. Retrieved May 13, 2010 from http://www.indiaenvironmentportal.org.in/files/Carbon footprint.pdf

[14] Weidema, B. P., Thrane, M., Christensen, P., Schmidt, J., & Løkke, S. (2008). Carbon Footprint: A Catalyst for Life Cycle Assessment. *Journal of Industrial Ecology*, *12*(1), 3 - 6. Retrieved May 13, 2010 from http://www.indiaenvironmentportal.org.in/files/Carbon footprint.pdf

[15] Environmental Protection Agency (2006). *Life Cycle Assessment: Inventory Guidelines and Principles.* Retrieved May 13, 2010 from: http://www.epa.gov/nrmrl/lcaccess/

the entire life cycle of a product, process, or activity."[16] ISO 14041 is used as a standard for procedural guidelines for inventory methodology. Without an inventory, there is no basis for comparison of environmental impacts or improvements. The EPA document defines the following four steps of a life cycle inventory:

1. Develop a flow diagram of the processes being evaluated.
2. Develop a data collection plan.
3. Collect data.
4. Evaluate and report results.

The GHG Protocol Initiative, which has been a leader in other sectors, is currently "exploring the development" of agriculture and forestry specific GHG inventories. It offers cross-sector and sector-specific calculation tools, which might be useful for other parts of the supply chain, including electricity, transportation, refrigeration, production of ammonia, and incorporation of uncertainty into estimates.[17] A framework specific to agriculture is expected to be complete in May of 2010.

Phase III- Impact Assessment: This step entails evaluating the potential human health and environmental impacts (such as global warming, acidification, eutrophication, air/water pollution etc.) associated with identified inputs and releases that have been identified during the inventory analysis. The EPA document defines the following four steps of an impact assessment[18,19]:

1. Selection and definition of impact categories
2. Classification: assigning LCI results to impact categories
3. Characterization: modeling LCI impacts within impact categories using science-based conversion factors
4. Normalization: expressing potential impacts in ways that can be compared
5. Grouping: sorting or ranking the indicators
6. Weighting: emphasizing the most important potential impacts
7. Evaluating and Reporting LCIA results

ISO 14042 has been used as a standard guideline for conducting Impact Assessments.

Phase IV- Interpretation: To help make informed decisions about the environmental impacts caused by alternative products, processes or services, they need to be interpreted. The EPA document defines Life Cycle Interpretation as a 'systematic technique to identify, quantify, check and evaluate information from the results of the LCI and the LCIA and communicate them effectively'. For a Life Cycle Interpretation, ISO 14043 standards are used as a guideline. A sensitivity analysis is also usually carried out to improve the accuracy of the interpreted results, which determines how sensitive the model is to changes in the value of the parameter used in the model and the structure of the model.

Although today LCAs are predominantly applied on industrial products or processes, recently LCA methodology has been applied to a broader range of goods and services, including food. When LCAs are applied to food, they have typically been used to assess a part (or combined parts) of an agricultural production system. Following are several examples of this type of LCA work:

[16] Curran, M. A., (2006). *Life Cycle Assessment: Principles and Practice* (2006). Retrieved May 13, 2010 from http://www.epa.gov/nrmrl/lcaccess/pdfs/600r06060.pdf
[17] GHG Protocol – Ag and Forestry. Sector-specific guidance for GHG inventories in agriculture and forestry sectors. (n.d.). Retrieved May 18, 2010, from http://www.ghgprotocol.org/agriculture-and-forestry
[18] Environmental Protection Agency (2006). *Life Cycle Assessment: Inventory Guidelines and Principles.* Retrieved May 13, 2010 from: http://www.epa.gov/nrmrl/lcaccess/
[19] Curran, M. A., (2006). *Life Cycle Assessment: Principles and Practice* (2006). Retrieved May 13, 2010 from http://www.epa.gov/nrmrl/lcaccess/pdfs/600r06060.pdf

Organic vs. Conventional Agriculture

Due to the lack of international standardization of the LCA method, LCAs stemming from different case studies regarding organic vs. conventional agriculture cannot be compared directly.[20] Therefore conventional and organic production systems can generally only be compared within a single case study.[21] For example, in a study from the Netherlands assessing the environmental impact of conventional and organic milk production, researchers found that acidification potential (AP) of milk production is due mainly to NH3 emissions, which is not necessarily reduced by organic production.[22] Eutrophication potential (EP) per ton of milk per ha, on the other hand, was found to be lower for organic milk than for conventional.[23] In terms of Global Warming Potential (GWP), organic milk was found to be able to reduce GWP only if emissions of CO_2 and N_2O could be reduced.[24] Emissions of CH4 account for 48-65% of GWP in milk production, and the percentage actually increases when switching from conventional to organic.[25]

Fertilizer Use

LCA can also be used to assess varying environmental impacts from fertilizer use. In a study completed in Germany, three different Nitrogen fertilizers (calcium ammonium nitrate (CAN), urea ammonium nitrate solution (UAN) and urea) were used at optimum N rates for sugar beet production.[26] According to the LCA method employed, Eco-Indicator 95, the highest environmental impact was found for the system where urea was used as an N source, while the lowest impact was for the system using CAN.[27] In all three systems, the effects of eutrophication and acidification contributed most to the total environmental impact value.[28] The researchers concluded that the results demonstrated that LCA methodology is basically suitable to assess the environmental impact associated with agricultural production, despite the fact that some significant environmental issues such as land use were excluded.[29]

Livestock Feeding Period

In addition, the effects of feeding length have been analyzed according to LCA methodology. A study conducted in Japan evaluated the environmental impacts of Japan's beef-fattening system. Japanese Black cattle are fed for a

[20] de Vries, M., & de Boer, I. J. (2010). Comparing environmental impacts for livestock products: A review of life cycle assessments. *Livestock Science*, 128 (1-3), 1-11.

[21] de Vries, M., & de Boer, I. J. (2010). Comparing environmental impacts for livestock products: A review of life cycle assessments. *Livestock Science*, 128 (1-3), 1-11.

[22] de Vries, M., & de Boer, I. J. (2010). Comparing environmental impacts for livestock products: A review of life cycle assessments. *Livestock Science*, 128 (1-3), 1-11.

[23] de Vries, M., & de Boer, I. J. (2010). Comparing environmental impacts for livestock products: A review of life cycle assessments. *Livestock Science*, 128 (1-3), 1-11.

[24] de Vries, M., & de Boer, I. J. (2010). Comparing environmental impacts for livestock products: A review of life cycle assessments. *Livestock Science*, 128 (1-3), 1-11.

[25] de Vries, M., & de Boer, I. J. (2010). Comparing environmental impacts for livestock products: A review of life cycle assessments. *Livestock Science*, 128 (1-3), 1-11.

[26] Brentrup, F. (2001). Application of the Life Cycle Assessment methodology to agricultural production: an example of sugar beet production with different forms of nitrogen fertilisers. *European Journal of Agronomy*, 14(3), 221-233. doi: 10.1016/S1161-0301(00)00098-8

[27] Brentrup, F. (2001). Application of the Life Cycle Assessment methodology to agricultural production: an example of sugar beet production with different forms of nitrogen fertilisers. *European Journal of Agronomy*, 14(3), 221-233. doi: 10.1016/S1161-0301(00)00098-8

[28] Brentrup, F. (2001). Application of the Life Cycle Assessment methodology to agricultural production: an example of sugar beet production with different forms of nitrogen fertilisers. *European Journal of Agronomy*, 14(3), 221-233. doi: 10.1016/S1161-0301(00)00098-8

[29] Brentrup, F. (2001). Application of the Life Cycle Assessment methodology to agricultural production: an example of sugar beet production with different forms of nitrogen fertilisers. *European Journal of Agronomy*, 14(3), 221-233. doi: 10.1016/S1161-0301(00)00098-8

longer period than cattle in other countries, such as the US, in order to produce higher quality beef, and the researchers investigated how this longer feeding period could lead to inefficiencies and additional manure excretion.[30] The activities in the beef-fattening life cycle that were evaluated included feed production, feed transport, animal management, and the treatment of cattle waste.[31] The results showed that gut CH_4 emissions from cattle were the major source in the impact category of global warming, while NH_3 emissions from cattle waste were the major source in the impact categories of acidification and eutrophication.[32] Feed production was also a significant contributor to all impact categories.[33] The study concluded that a shorter feeding length would result in lower environmental impacts in all the environmental categories examined.

Production Systems

LCAs have been also conducted in more broad terms, comparing the major production systems of a food item.

Beef

Researchers in Australia employed LCA methodology to describe Australian red meat production in comparison with other overseas studies. The study investigated three supply chains in three different regions of the country over two years – a sheep meat supply chain in Western Australia, an organic beef supply chain in Victoria, and a premium export beef supply chain in New South Wales - in terms of primary energy consumption, GHG emissions, solid waste production and soil erosion potential.[34] When the GHG emissions and energy use data were compared with other international studies on red meat production, the researchers concluded that the Australian results were average or below average.[35] They also found that although lot-fed beef production systems require additional effort in terms of producing and transporting feed, this amount is offset by the increased efficiency of feedlots.[36] As a result, the lot-fed beef production systems in the study generate lower total GHG emissions than grass-fed production.[37]

[30] Ogino, A., Kaku, K., Osada, T., & Shimada, K. (2004). Environmental impacts of the Japanese beef-fattening system with different feeding lengths as evaluated by a life-cycle assessment method. *Journal of Animal Science*, *82*, 2115-2122. Retrieved May 16, 2010 from http://www.animal-science.org/cgi/content/full/82/7/2115

[31] Ogino, A., Kaku, K., Osada, T., & Shimada, K. (2004). Environmental impacts of the Japanese beef-fattening system with different feeding lengths as evaluated by a life-cycle assessment method. *Journal of Animal Science*, *82*, 2115-2122. Retrieved May 16, 2010 from http://www.animal-science.org/cgi/content/full/82/7/2115

[32] Ogino, A., Kaku, K., Osada, T., & Shimada, K. (2004). Environmental impacts of the Japanese beef-fattening system with different feeding lengths as evaluated by a life-cycle assessment method. *Journal of Animal Science*, *82*, 2115-2122. Retrieved May 16, 2010 from http://www.animal-science.org/cgi/content/full/82/7/2115

[33] Ogino, A., Kaku, K., Osada, T., & Shimada, K. (2004). Environmental impacts of the Japanese beef-fattening system with different feeding lengths as evaluated by a life-cycle assessment method. *Journal of Animal Science*, *82*, 2115-2122. Retrieved May 16, 2010 from http://www.animal-science.org/cgi/content/full/82/7/2115

[34] Peters, G.M., Rowley, H.V., Wiedemann, S., Tucker,R., Short′ M.D. and Schulz, M (2010). Red Meat Production in Australia and Comparison with Overseas Studies. *Enviromental Science and Technology*, 44 (4), pp 1327–1332. DOI: 10.1021/es901131e

[35] Peters, G.M., Rowley, H.V., Wiedemann, S., Tucker,R., Short′ M.D. and Schulz, M (2010). Red Meat Production in Australia and Comparison with Overseas Studies. *Enviromental Science and Technology*, 44 (4), pp 1327–1332. DOI: 10.1021/es901131e

[36] Peters, G.M., Rowley, H.V., Wiedemann, S., Tucker,R., Short′ M.D. and Schulz, M (2010). Red Meat Production in Australia and Comparison with Overseas Studies. *Enviromental Science and Technology*, 44 (4), pp 1327–1332. DOI: 10.1021/es901131e

[37] Peters, G.M., Rowley, H.V., Wiedemann, S., Tucker,R., Short′ M.D. and Schulz, M (2010). Red Meat Production in Australia and Comparison with Overseas Studies. *Enviromental Science and Technology*, 44 (4), pp 1327–1332. DOI: 10.1021/es901131e

One of the most comprehensive studies investigating how LCAs can be applied to food production systems was completed by the UK's Department of Environment, Food and Rural Affairs (DEFRA).[38] DEFRA examined the GHG emissions of dozens of common food products in the UK:

Chicken

A comparison was conducted between three types of chicken production systems: intensive indoor chicken meat (defined as chickens that spend their lifetime indoors, fed on predominantly cereal based diet); extensive outdoor chicken meat (defined as chickens that have access to outdoors for 6% of life based on an initial housed period followed by limited access to the outdoors, fed on a predominantly cereal based diet); and organic outdoor chicken meat – (defined as chickens who have access to outdoors for 12% of life based on an initial housed period followed by some restriction to outdoors, at organic stocking densities and fed on an organic cereal based diet). The study found that the intensive system had the lowest GHG emissions and that raw materials had the great impact in all systems. Within raw materials, feed provided the largest contribution to GHG emissions. In terms of processes, animal and soil emissions (N_2O and CH_4) and waste (animal remains) were the major sources of GHG emissions.

Milk

A comparison was conducted between three types of milk production systems: intensive high yielding milk (defined as originating from a dairy herd with high inputs of feed, spending 48% of time grazing, and fed maize and grass silage and cereals); extensive low yielding milk (defined as originating from a dairy herd with low inputs of feed, spending 48% of time grazing, and fed maize and grass silage and cereals); and organic milk (defined as originating from a dairy herd raised to organic standards on organic feed, spending 53% of time grazing, and fed grass silage and cereals). The study found that the intensive system had the lowest emissions and that animal and soil emissions had the greatest impact in all systems. For all three systems, feed provided the largest contribution to GHG emissions of raw materials, while animal and soil emissions (N_2O and CH_4) and waste (animal remains) were major contributors to the GHG emissions of all three processes.

Cereal

A comparison was conducted between four types of cereal production systems: intensive winter feed wheat, extensive spring feed wheat, organic winter feed wheat and winter feed barley. The study found that the extensive spring wheat system had the lowest emissions and raw materials and soil emissions had the greatest impacts in all three systems. In the conventional systems, nitrogen was the major contributor to the GHG emissions of raw materials. In the organic systems, however, the emissions from the fertility building crop were responsible for the greatest raw material GHG emissions. In terms of processes, soil emissions (from N20 and N application) offered the great contribution to GHG emissions.

Tomatoes

A comparison was conducted between three types of tomato production systems: UK conventional oil heated tomatoes, which are produced intensively in UK glasshouses heated using oil or LPG; UK conventional waste heat tomatoes, which are produced intensively in UK glasshouses heated using waste heat from alternative supplies; and Spanish conventional tomatoes, which are produced intensively in Spanish glasshouses with low heat requirements and slightly reduced fertilizer inputs (they are shipped by refrigerated truck from Spain to the UK). The study found that The UK waste heat system had the lowest emissions. In UK waste heat system, raw materials were the greatest contributor to GHG emissions; in the conventional oil heating system, the energy used for heating was the most significant component. Transportation was a significant component of the Spanish system. Specifically in the raw materials analysis, nitrogen and Rockwool slabs were the main contributors to GHG

[38] Department of Environment, Food and Rural Affairs. (2009). Scenario building to test and inform the development of a BSI method for assessing GHG emissions from food. *Finance*, *5*(020).

emissions. In terms of emissions from processes, soil emissions (N2O from N application) were the major contributors.

Foods from Overseas Commodities

The DEFRA research also covered foods from overseas commodities, such as imported coffee and sugar.

Instant coffee

The functional unit (FU) used in the study was a 100 g pack of freeze-dried instant coffee in a glass jar. The coffee was grown in Kenya, by small-scale production, and for the production stage, the assessment was based on 1 kg of cherries delivered to a processing factory. The study assessed how field work was conducted (by hand), pesticide and fertilizer usage, land use and whether the coffee was shade grown or intensive sun-grown. The life cycle state for processing included raw materials processing (including packaging), transportation of raw materials and of final products, resource use during manufacture and waste treatment and disposal. The study found that emissions of GHGs from the coffee were dominated by raw materials input (59%) and soil emissions (40%). In terms of the raw materials, 75% of the emissions were due to releases from nitrogen fertilizer. 99% of GHG emissions from processes used in production of coffee cherries were found to be from soil emissions of N2O.

Sugar

The FU used in this study was a 1 kg paper bag of granulated sugar. The sugar was grown on the largest sugar plantation in Zambia. For the production stage, the assessment was based on 1 kg of sugar cane, harvested and delivered to the local factory. The study assessed transport, fertilizers and pesticides, production and processes. The study found that the largest component of GHG emissions, 46%, came from soil emissions. In terms of raw materials, fertilizers were the major source of GHG emissions, while in terms of processing, soil emissions were the largest contributor of emissions (72%).

Industrial Food Products

Industrial food products are foods produced through an industrialized process line. Common industrial foods studied have included bread, beer and tomato ketchup. Studies on bread, one of the most important industrial food products throughout the world, have included parameters such as crop production methods, milling technologies, bread production processes, packaging and cleaning agents.[39] According to these studies, the primary production and transportation stages were found to be highly significant for most impact categories, while the processing stage (baking) was significant in terms of photo-oxidant formation and energy use.[40] Koroneos et al. found that the subsystem of bottle production, followed by packaging and beer production, accounted for most GHG emissions.[41] In the case of tomato ketchup, packing and food processing were determined to be the "hotspots" for many impact categories.[42,43]

Complex Food Products

Complex food products are those which contain multiple separately identifiable food components and can be considered stand-alone "ready meals." One must note that because of the presence of numerous different product lines being combined, a certain level of uncertainty arises when calculating GHG emissions for the final product. A

[39] Roy, P., Nei, D., Orikasa, T., Xu, Q. Y., Okadome, H., Nakamura, N., et al. (2009). A review of life cycle assessment (LCA) on some food products. *Journal of Food Engineering*, 90(1), 1-10.

[40] Roy, P., Nei, D., Orikasa, T., Xu, Q. Y., Okadome, H., Nakamura, N., et al. (2009). A review of life cycle assessment (LCA) on some food products. *Journal of Food Engineering*, 90(1), 1-10.

[41] Koroneos, C. (2005). Life cycle assessment of beer production in Greece. *Journal of Cleaner Production*, 13(4), 433-439. doi: 10.1016/j.jclepro.2003.09.010

[42] Andersson, K. (1998). Screening life cycle assessment (LCA) of tomato ketchup: a case study. *Journal of Cleaner Production*, 6(3-4), 277-288. doi: 10.1016/S0959-6526(98)00027-4.

[43] Andersson K, Ohlsson T. Including Environmental Aspects in Production Development: A Case Study of Tomato Ketchup. *Lebensmittel-Wissenschaft und-Technologie*. 1999;32(3):134-141.

factory typically only monitors energy and water use at the factory level, and currently differentiation of use by production lines or at a product level is not feasible.[44]

Duck in hoisin sauce

Duck in hoisin sauce is manufactured in a factory that produces a large number of different products, and there are differences in the way the range of products are manufactured.[45] For this study, however, the components of the meal were generally received, stored, cleaned or washed, assembled by hand and packed.[46] The study found that in terms of raw materials, shredded duck and noodles (i.e. largely animal-derived raw materials) were responsible for the largest amount of GHG emissions.[47] In terms of packing, the PET tray containing the meal resulted in the highest GHG emissions.[48] Transportation was found to have a minimal impact, roughly 0.03%, of the total GHG emissions. However, lack of information regarding the original sources and transportation logistics for many of the meal's components lead to reliance on assumptions, so this number may imprecise.[49] In terms of processing, again lack of information lead to imprecision. The study used production data for the target product and for the factory as a whole and from that calculated that the target product accounted for 0.42% of the total output for the factory.[50] Waste was analyzed by whether the waste underwent effluent treatment or was disposed of in a landfill and was found to have minimal GHG emissions compared to the other sectors.[51]

Packaging

Packaging is a fundamental element of almost every food product and can also be considered in LCA analyses of food products for this reason. LCAs of packaging have concluded that the production stage of the packaging system is the major source of environmental impacts.[52] For example, Hospido et al. found that the production and transportation of packaging materials contribute to one-third of the total global environmental impact of the life cycle of beer in the case of glass beer bottles.[53] In a comparative study on egg packaging, Zabaniotou and Kassidi concluded that polystyrene packages contribute more to acidification and smog and that recycled paper packages contribute more to heavy metal and heavy carcinogenic releases.[54] Hyde et al. expanded the scope of LCA packaging by offering predictions of economic impacts to the industry.[55] They argued that a 12% reduction of raw

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[44] Department of Environment, Food and Rural Affairs. (2009). Scenario building to test and inform the development of a BSI method for assessing GHG emissions from food. *Finance*, *5*(020).

[45] Department of Environment, Food and Rural Affairs. (2009). Scenario building to test and inform the development of a BSI method for assessing GHG emissions from food. *Finance*, *5*(020).

[46] Department of Environment, Food and Rural Affairs. (2009). Scenario building to test and inform the development of a BSI method for assessing GHG emissions from food. *Finance*, *5*(020).

[47] Department of Environment, Food and Rural Affairs. (2009). Scenario building to test and inform the development of a BSI method for assessing GHG emissions from food. *Finance*, *5*(020).

[48] Department of Environment, Food and Rural Affairs. (2009). Scenario building to test and inform the development of a BSI method for assessing GHG emissions from food. *Finance*, *5*(020).

[49] Department of Environment, Food and Rural Affairs. (2009). Scenario building to test and inform the development of a BSI method for assessing GHG emissions from food. *Finance*, *5*(020).

[50] Department of Environment, Food and Rural Affairs. (2009). Scenario building to test and inform the development of a BSI method for assessing GHG emissions from food. *Finance*, *5*(020).

[51] Department of Environment, Food and Rural Affairs. (2009). Scenario building to test and inform the development of a BSI method for assessing GHG emissions from food. *Finance*, *5*(020).

[52] Roy, P., Nei, D., Orikasa, T., Xu, Q. Y., Okadome, H., Nakamura, N., et al. (2009). A review of life cycle assessment (LCA) on some food products. *Journal of Food Engineering*, 90(1), 1-10.

[53] Hospido, A.; Moreira, M.T.; & Feijoo, G (2005). Environmental analysis of beer production. *International Journal of Agricultural Resources, Governance and Ecology*, 4(2), 152-162.

[54] Zabaniotou, A. & Kassidi, E. (2003). Life cycle assessment applied to egg packaging made from polystyrene and recycled paper. *Journal of Cleaner Production*, 11(5), 549-559. doi: 10.1016/S0959-6526(02)00076-8.

[55] Hyde, K.; Smith, A.; Smith, M.; & Henningson, S. (2001). The challenge of waste minimisation in the food

materials in the food and beverage industry can make a large contribution to company profitability by improving yields per unit output and by reducing costs associated with waste disposal.[56]

Food Miles

Food production and its long-distance transportation have been a source of debate regarding which of the two factors has more of an environmental impact in terms of GHG and other emissions. The Weber and Matthews's paper sought to assess the impact of food miles and came up with interesting results using I/O LCA. [57]Food miles are a measure of how far the food has travelled from its production to its final consumption, and it has been believed that transportation involved in moving food over large distances results in greater GHG emissions than the production of food. The results in this paper, derived using I/O LCA, however showed that food production has a greater environmental impact and that to make more sustainable food choices, reducing consumption of energy intensive foods such as red meat is a better option rather than locally sourcing the entire household's food.

Food Waste Management Systems

Food waste management systems can also be examined through LCA. For example, Ramjeawon concluded that wastewater in the sugar cane industry of Mauritius should be separated into two or three different streams.[58] In this way, the most polluted waste water could be processed separately from relatively unpolluted water, thereby reducing the scale and expense of treatment required.[59] Another study by Hirai et al. assessed four food waste treatment scenarios – incineration, incineration after bio-gasification, bio-gasification followed by composting and composting- and found that the contribution to GHG emissions and toxic chemical releases were lower in the scenarios with a bio-gasification process.[60] In a similar LCA of food waste management systems, Nyland et al. found that material recycling followed by incineration is a more environmentally benign option than direct waste incineration.[61] Overall, Roy et al. concludes that LCA studies on food waste management systems indicate that alternate waste systems are useful but that integrated waste management systems are much better at reducing overall the environmental burdens of food waste.[62]

As the above studies demonstrate, there have been a number of LCA studies conducted on certain aspects of specific food products, such as packaging or the entire life cycle of an item. Unlike these studies, however, this Group Project focuses on determining the environmental impacts of a complete system of food purchasing.

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and drink industry: a demonstration project in East Anglia, UK. *Journal of Cleaner Production*, 9(1), 57-64. doi: 10.1016/S0959-6526(00)00050-0.

[56] Hyde, K.; Smith, A.; Smith, M.; & Henningson, S. (2001). The challenge of waste minimisation in the food and drink industry: a demonstration project in East Anglia, UK. *Journal of Cleaner Production*, 9(1), 57-64. doi: 10.1016/S0959-6526(00)00050-0.

[57] Weber, C.L., Matthews, S.H. (2008). Food-Miles and the Relative Climate Impacts of Food Choices in the United States. *Environmental Science & Technology 42* (10), 3508-3513.

[58] Ramjeawon, T. (2000). Cleaner production in Mauritian cane-sugar factories. *World*, *8*, 503-510.

[59] Ramjeawon, T. (2000). Cleaner production in Mauritian cane-sugar factories. *World*, *8*, 503-510.

[60] Hirai, Y.; Murata, M.; Sakai, S.; & Takatsuki, H. (2000). Life cycle assessment for food waste recycling and management. In: *Proceedings of the Fourth International Conference on Ecobalance, Tsukuba, Japan.* Retrieved May 16, 2010 from http://homepage1.nifty.com/eco/pdf/ecobalanceE.pdf

[61] Nyland, C. A., Modahl, I. S., Raadal, H. L., & Hanssen, O. J. (2003). Application of LCA as a decision-making tool for waste management systems. *The International Journal of Life Cycle Assessment*, *8*(6), 331-336. doi: 10.1007/BF02978506

[62] Roy, P., Nei, D., Orikasa, T., Xu, Q. Y., Okadome, H., Nakamura, N., et al. (2009). A review of life cycle assessment (LCA) on some food products. *Journal of Food Engineering*, 90(1), 1-10.

6. Methodology

6.1 Economic Input-Output Models

<u>Background</u>

One approach to life cycle assessment for a product or service is through economic input-output models. Economic input-output (EIO) LCA models are a top-down approach to LCA. They are based off of national economic input-output (IO) tables, which represent the monetary transactions between industry sectors in mathematical form and therefore indicate what goods or services are consumed by other industries. In the US, IO tables (benchmark accounts) are created by the Bureau of Economic Analysis (BEA) every five years and represent the transactions among some 400 industry sectors as determined by the North American Industry Classification System (NAICS).[63] They are constructed based on survey data from a sample of all operating facilities in the various sectors[64]. The surveys are conducted by the Bureau of the Census.[65]

The benchmark accounts are presented in a variety of different forms: standard make and use tables and several supplementary tables, which include modified standard make and use tables and four requirements tables.[66] Make tables show the commodities that are produced by each industry and use tables show the inputs to industry production and the commodities that are consumed by final users.[67]

The requirements tables, which are derived from the supplementary make and use tables, are slightly more complex because unlike the standard tables they are constructed after redefinitions or reclassifications.[68] Redefinitions refer to instances where the BEA moves the outputs or inputs of some secondary production activities between industries. This is done in one of two cases: when the BEA decides that a product that the Census Bureau has designated as a primary product should instead be a secondary product for IO purposes or when a product is primary to more than one industry.[69] For example, according to the Census Bureau's classification system, the primary product of the newspaper industry is newspaper sales and newspaper advertising. However the BEA sees the primary product of the newspaper as industry newspapers while advertising is treated as a secondary product of the industry. Advertising is then reclassified to the advertising commodity.[70] Redefinitions are also done when different production processes are used to produce the same final product. An example of this would be the reclassification of sheets, which can be constructed by knitting or

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63 Bureau of Economic Analysis (2011). Industry Economic Accounts Information Guide. Retrieved February 15, 2011 from http://www.bea.gov/industry/iedguide.htm

64 Bureau of Economic Analysis (2011). Industry Economic Accounts Information Guide. Retrieved February 15, 2011 from http://www.bea.gov/industry/iedguide.htm

65 Bureau of Economic Analysis (2011). Industry Economic Accounts Information Guide. Retrieved February 15, 2011 from http://www.bea.gov/industry/iedguide.htm

66 Bureau of Economic Analysis (2011). Industry Economic Accounts Information Guide. Retrieved February 15, 2011 from http://www.bea.gov/industry/iedguide.htm

67 Bureau of Economic Analysis (2011). Industry Economic Accounts Information Guide. Retrieved February 15, 2011 from http://www.bea.gov/industry/iedguide.htm

68 Bureau of Economic Analysis (2011). Industry Economic Accounts Information Guide. Retrieved February 15, 2011 from http://www.bea.gov/industry/iedguide.htm

69 Implan (n.d.). The controlled vocabulary of IMPLAN-specific terms. Retrieved March 13, 2011 from http://www.implan.com/V4/index.php?option=com_glossary&task=list&glossid=13&letter=R

70 Implan (n.d.). The controlled vocabulary of IMPLAN-specific terms. Retrieved March 13, 2011 from http://www.implan.com/V4/index.php?option=com_glossary&task=list&glossid=13&letter=R

weaving mills or by purchasing fabric. The BEA will treat all sheets as a single commodity and regroup them as the product of curtain and linen mills.[71] These Redefinitions are required for the derivation of the requirements tables.

There are four types of requirements tables: commodity-by-industry direct requirements, commodity-by-commodity total requirements, industry-by-commodity total requirements and industry-by-industry total requirements.[72] The direct requirements table shows the amount of a commodity that is required by an industry to produce a dollar of the industry's output, while the total requirements tables show the production that is required, directly and indirectly, from each industry and each commodity to deliver a dollar of a commodity to final users.[73] EIO models will apply a calculation procedure to one of these requirements tables to derive another table that fits the needs of the model.

Derivation of IO Tables

To visualize the interrelationships between different sectors in a given economy, suppliers are first categorized into different tiers. In this simplified example, the final product is blueberry jam. To produce blueberry jam, containers and jam itself are needed as inputs. These inputs to the final producer are the outputs of the first tier suppliers. Next, to produce containers, metal and glass are needed, and to produce jam, sugar and blueberries are needed. The outputs of the second tier suppliers - metal, glass, sugar and blueberry industries - are considered inputs to the first tier suppliers. Likewise the outputs of the third tier suppliers are considered inputs to the second tier suppliers and so on.

[71] Implan (n.d.). The controlled vocabulary of IMPLAN-specific terms. Retrieved March 13, 2011 from http://www.implan.com/V4/index.php?option=com_glossary&task=list&glossid=13&letter=R
[72] Bureau of Economic Analysis (2011). Industry Economic Accounts Information Guide. Retrieved February 15, 2011 from http://www.bea.gov/industry/iedguide.htm
[73] Bureau of Economic Analysis (2011). Industry Economic Accounts Information Guide. Retrieved February 15, 2011 from http://www.bea.gov/industry/iedguide.htm

Figure 6.1: Example of Supplier Tiers for Final Product of Blueberry Jam

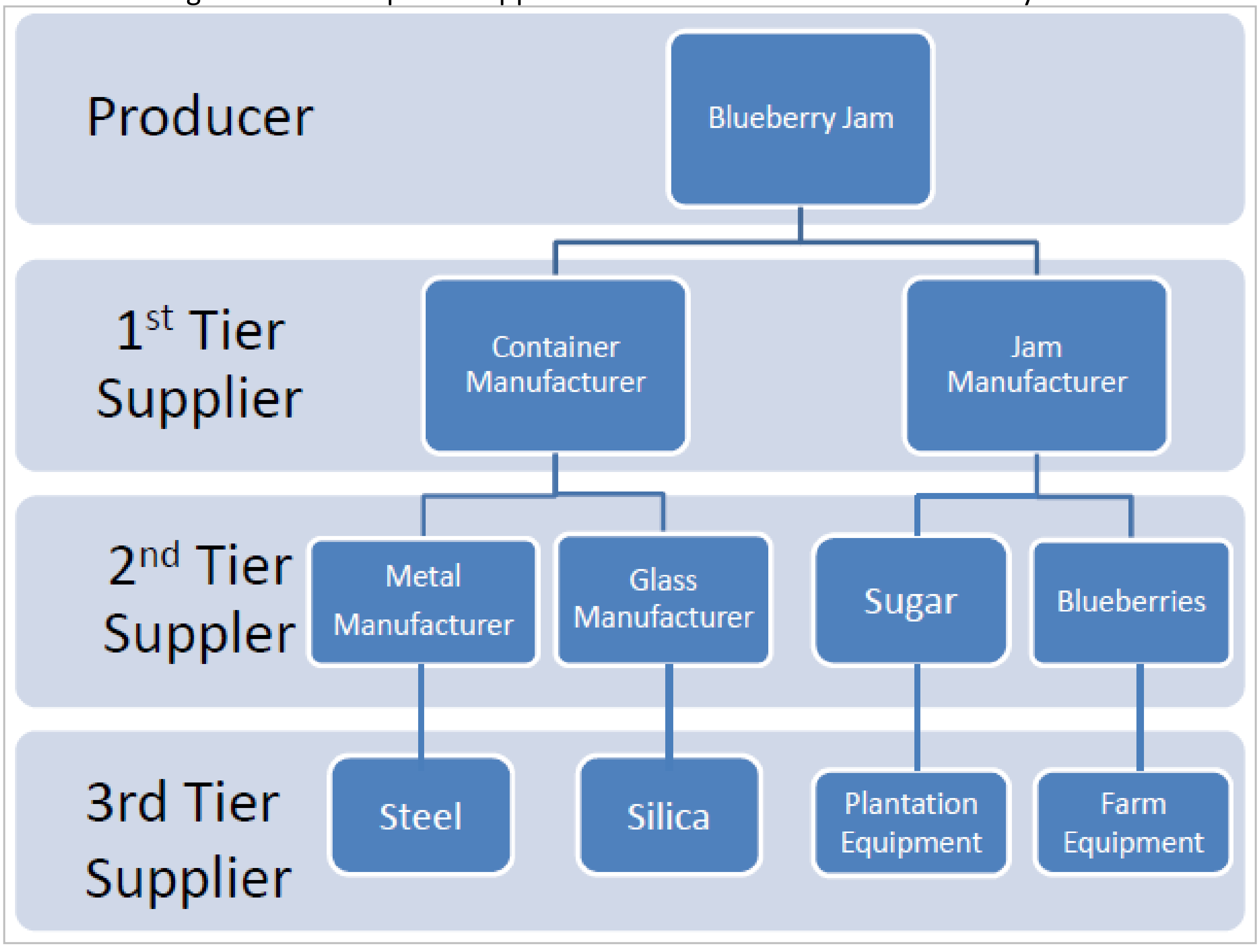

Figure 6.2: Sample of IO Table

	a	b	c	d	e
a	$ 0.2				
b	$ 0.1				
c	$ 0.1				
d	$ 0				
e	$ 0.3				

Source: Geyer (2011)[74]

So for every dollar output from a producer, by matrix multiplication the required output from each of the producer's 1st tier suppliers can be found. To put it another way, the inputs required by the producer to create a product is equal to the total first tier suppliers' output:

Figure 6.3: Sample of IO Table, Matrix Multiplication through First Tier Suppliers

Example 1

	a	b	c	d	e
a	$ 0.2				
b	$ 0.1				
c	$ 0.1				
d	$ 0				
e	$ 0.3				

x

Producer output
$ 1
$ 0
$ 0
$ 0
$ 0

=

Producer input = 1st tier suppliers output
$ 0.2
$ 0.1
$ 0.1
$ 0
$ 0.3

$$A \times \vec{O} = \vec{I}$$

Source: Geyer (2011)[75]

This process is continued for second tier suppliers. The input of producers is equal to the output of the first tier suppliers, and again by matrix multiplication we can find the required output of 2nd tier suppliers to serve as inputs to 1st tier suppliers, as shown:

[74] Geyer, R. "Linear Algebra Workshop." ESM 282, Industrial Ecology. Bren School of Environmental Science and Management, University of California, Santa Barbara. January 15, 2011.

[75] Geyer, R. "Linear Algebra Workshop." ESM 282, Industrial Ecology. Bren School of Environmental Science and Management, University of California, Santa Barbara. January 15, 2011.

Figure 6.4: Sample of IO Table, Matrix Multiplication through Second Tier Suppliers

$$A \times A \times \vec{O}$$

	a	b	c	d	e
a	0.2	0.1	0	0.2	0.1
b	0.1	0	0.1	0.2	0.3
c	0.1	0.2	0.2	0	0
d	0	0.4	0.2	0	0.3
e	0.3	0	0.1	0.4	0

x

	a	b	c	d	e
a	0.2				
b	0.1				
c	0.1				
d	0				
e	0.3				

x

Producer output
1
0
0
0
0

=

2nd tier suppliers output
0.08
0.12
0.06
0.15
0.07

$$A \times \vec{O}_p = \vec{O}_1$$ input of producers = output of 1st tier suppliers

$$A \times A \times \vec{O}_p = \vec{O}_2$$ input of 1st tier suppliers = output of 2nd tier suppliers

Source: Geyer (2011)[76]

Finally, to find the total economic implications of producing a given output by the producer, the required outputs from each different tier of suppliers are continually added through the nth tier, until the entire economic system is captured. This is represented by the expression $(1+A+A^2+A^3....)$ or $(1-A)^{-1}$, which is called the total requirements matrix or the Leontif Inverse matrix. This is multiplied by the producer output, O_p, and results in the total outputs of all the suppliers required to generate the producer output, or O_{Total}:

$$(1 + A + A^2 + A^3 + A^4 \ldots) \times \vec{O}_p = \vec{O}_{Total} \quad \text{(eq. 1)}$$

Calculation of Environmental Impacts

An IO table can then be augmented with additional, non-economic data like environmental burdens such as criteria air pollutants, global warming gases, or hazardous wastes, to find the total environmental impact associated with a producer output. This calculation is what constitutes an environmental input output model. O_{Total} is multiplied by an environmental intervention matrix, represented by B, which gives the environmental intervention per dollar of output from each sector. Finally, a vector of the total environmental impacts associated with producer output, shown here as E, can be obtained by multiplying the total economic output required for producer output at each stage by B:

$$B \times (1 - A)^{-1} \times \vec{O}_p = B \times \vec{O}_{Total} = \vec{E} \quad \text{(eq. 2)}$$

Advantages of EIO Models

EIO models are frequently utilized for life cycle assessment due to their many advantages over process-based models:

Lack of Boundary

[76] Geyer, R. "Linear Algebra Workshop." ESM 282, Industrial Ecology. Bren School of Environmental Science and Management, University of California, Santa Barbara. January 15, 2011.

The main advantage in using EIO-LCA models is that there is no boundary problem as is found in process-based models. The entire economy is accounted for, including all material and energy inputs.[77]

Speed

In contrast to process-based LCAs, which may take months to complete, EIO studies can be completed within a few hours or days.[78]

Cost

EIO-LCA software can be found for free on the internet, whereas process model software from a consulting company could cost hundreds to thousands of dollars.[79]

Transparency

Analyses based on EIO-LCA models are transparent because only publicly available data and standard calculations are used.[80]

Limitations and Uncertainty in EIO Models

While there are many advantages to using EIO models, there are also a number of limitations and points of uncertainty:

Linearity

An EIO-LCA is a linear model. For example, a $1000 change in demand or level of economic activity will automatically be 10 times the result of a $100 change in demand.[81]

Imports and Exports

While imports and exports constitute a major part of an economy's transactions, IO tables represent only the economies of a single nation. Therefore in EIO-LCA models, imports are assumed to have the same production characteristics as comparable products made in the country of interest whether or not that is true in actuality.[82] For example, if a computer is imported and used by a US company, the environmental impact of the production of the computer abroad is assumed to be comparable to a computer made in the US.

Uncertainty in Original Data

All of the data used in an EIO-LCA model originated from surveys and forms submitted by industries to governments for national statistical purposes.[83] Subsequently, the usual uncertainties associated with surveys –

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[77] Hendrickson, C.T., Lave, L., and Matthews, H.S. (2006). *Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach.* Washington, D.C.: Resources for the Future.

[78] Hendrickson, C.T., Lave, L., and Matthews, H.S. (2006). *Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach.* Washington, D.C.: Resources for the Future.

[79] Hendrickson, C.T., Lave, L., and Matthews, H.S. (2006). *Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach.* Washington, D.C.: Resources for the Future.

[80] Hendrickson, C.T., Lave, L., and Matthews, H.S. (2006). *Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach.* Washington, D.C.: Resources for the Future.

[81] Green Design Institute – Carnegie Mellon University (n.d.). *Assumptions, Uncertainty and other Considerations with the EIO-LCA Method.* Retrieved February 15, 2011 from http://www.eiolca.net/Method/assumptions-and-uncertainty.html

[82] Green Design Institute – Carnegie Mellon University (n.d.). *Assumptions, Uncertainty and other Considerations with the EIO-LCA Method.* Retrieved February 15, 2011 from http://www.eiolca.net/Method/assumptions-and-uncertainty.html

[83] Green Design Institute – Carnegie Mellon University (n.d.). *Assumptions, Uncertainty and other Considerations with the EIO-LCA Method.* Retrieved February 15, 2011 from http://www.eiolca.net/Method/assumptions-and-uncertainty.html

such as sampling errors, response rate, missing/incomplete data, and so on – are also inherent in the EIO-LCA models.[84]

Old Data
The data within an EIO-LCA model are representative of the year of the model, so consideration should be taken when applying the model to current conditions. While some industries may not exhibit dramatic change over years, others will, due to technological advances, consumer trends, etc. Likewise, environmental data can also change over time due to advances in process efficiency, government regulation and so on.[85]

Incomplete Original Data
The original economic and environmental data compiled within the EIO-LCA may also be incomplete in that they underestimate true values. For example, only certain facilities – that reach a certain emissions threshold or are under certain industry classifications - are required to submit toxics release data. As a result, the real value of toxic emissions may be underestimated. The same issue may also arise for other environmental data sources.[86]

Aggregation of Original Data
Sometimes data is categorized in a way that does not directly correspond to the economic input-output sectors specified in the IO matrix. For example, the USDA categories farms by crop type, not using NAICS. In these cases, values must be allocated to the appropriate using weighted averages, or information from other data sources or publications.[87]

Aggregation of Sectors
The aggregation of sectors within an EIO model is the most significant disadvantage to this LCA approach. Since IO tables aggregate data based on sectors, not by detailed data for a process, EIO LCAs may not be able to accurately represent a given process.[88] For example, an IO table cannot distinguish between a product created using old technology and a product created using newer technology (i.e. generating electricity from an old coal plant versus using a new combined-cycle gas turbine).[89] An IO table may also aggregate the information for several different industry types into one industry sector, which again leads to uncertainty in how a particular industry is modeled.[90] For instance, according to NAICS, all soft drink manufacturing falls into the same industry category. While processes and purchases may differ between beverage companies and products, an EIO LCA is unable to capture those differences.

[84] Green Design Institute – Carnegie Mellon University (n.d.). *Assumptions, Uncertainty and other Considerations with the EIO-LCA Method.* Retrieved February 15, 2011 from http://www.eiolca.net/Method/assumptions-and-uncertainty.html
[85] Green Design Institute – Carnegie Mellon University (n.d.). *Assumptions, Uncertainty and other Considerations with the EIO-LCA Method.* Retrieved February 15, 2011 from http://www.eiolca.net/Method/assumptions-and-uncertainty.html
[86] Green Design Institute – Carnegie Mellon University (n.d.). *Assumptions, Uncertainty and other Considerations with the EIO-LCA Method.* Retrieved February 15, 2011 from http://www.eiolca.net/Method/assumptions-and-uncertainty.html
[87] Green Design Institute – Carnegie Mellon University (n.d.). *Assumptions, Uncertainty and other Considerations with the EIO-LCA Method.* Retrieved February 15, 2011 from http://www.eiolca.net/Method/assumptions-and-uncertainty.html
[88] Hendrickson, C.T., Lave, L., and Matthews, H.S. (2006). *Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach.* Washington, D.C.: Resources for the Future.
[89] Hendrickson, C.T., Lave, L., and Matthews, H.S. (2006). *Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach.* Washington, D.C.: Resources for the Future.
[90] Green Design Institute – Carnegie Mellon University (n.d.). *Assumptions, Uncertainty and other Considerations with the EIO-LCA Method.* Retrieved February 15, 2011 from http://www.eiolca.net/Method/assumptions-and-uncertainty.html

Available EIO Models

There are currently only two EIO models available for the US. One is the Comprehensive Environmental Data Archive, and the other is Carnegie Mellon University's EIO-LCA.

6.2 Comprehensive Environmental Data Archive 4.0

The Comprehensive Environmental Data Archive, or CEDA, was developed at the Institute of Environmental Sciences at Leiden University around the year 2000 and was built off of earlier databases known as Missing Inventory Estimation Tool (MIET). MIET 1.0 was first released in 2001, and a subsequent version in 2002 offered improved calculation algorithms and expanded coverage of environmental emissions.[91] The 2003 version of MIET was re-named CEDA and used 1998 input output tables and environmental statistics, covering around 1,300 different environmental interventions.[92]

The latest version of the program, CEDA 4.0, was released in 2009 and was even more comprehensive than its predecessors due to three major updates. First, utilizing input output tables and environmental statistics from 2002, CEDA 4.0 offered users the choice between two allocation methods – economic allocation and system expansion or only economic allocation - to assign environmental interventions to relevant economic category.[93] Second, users were also now able to choose whether or not to exclude capital goods in the supply chain. According to the UK's Publicly Available Specification (PAS) 2050 for carbon footprinting, capital goods (and thus their carbon emissions) should be excluded from the system, but CEDA 3.0 included them.[94] In CEDA 4.0, only the standard version does. Third, the number of environmental interventions increased in CEDA 4.0 to over 2,500 and now included data on water use, total fossil energy consumption, and emission of 17 different dioxin types.[95]

Source of Economic Data

CEDA 4.0 utilizes the 2002 annual input-output tables produced by the BEA.[96] Specifically, CEDA uses make and use tables before and after redefinition to create a technology matrix. Redefined flows are identified by comparing the matrices before and after redefinition, and these flows are then used for reproducing the mixed-unit technology approach employed by the BEA.[97] This IO table is derived through a combination of economic allocation and system expansion (the mixed-technology approach). Another IO table that is only based on economic allocation is also produced. A CEDA user is given the choice to use either of the two allocation methods. This final matrix is called the Direct Requirement Matrix (Matrix A) and the choice of allocation method is denoted by an identifier a (economic value-based allocation) or b (mixed technology model).

[91] Suh, S. (2009). Developing the Sectoral Environmental Database for Input-Output Analysis: Comprehensive Environmental Data Archive of the US. In S.Suh (Ed.), *Handbook of Input-Output Economics in Industrial Ecology, Eco-Efficiency in Industry and Science,* 23 (8), 689-712. New York: Springer Science+Business Media.

[92] Suh, S. (2009). Developing the Sectoral Environmental Database for Input-Output Analysis: Comprehensive Environmental Data Archive of the US. In S.Suh (Ed.), *Handbook of Input-Output Economics in Industrial Ecology, Eco-Efficiency in Industry and Science,* 23 (8), 689-712. New York: Springer Science+Business Media.

[93] Suh, S. (2010). *CEDA 4.0 User's Guide.* Retrieved from personal contact with Dr. Sangwon Suh on November 11, 2010.

[94] Publicly Available Specification 2050. Retrieved March 14, 2011 from http://www.bsigroup.com/Standards-and-Publications/How-we-can-help-you/Professional-Standards-Service/PAS-2050

[95] Suh, S. (2010). *CEDA 4.0 User's Guide.* Retrieved from personal contact with Dr. Sangwon Suh on November 11, 2010.

[96] Suh, S. (2010). *CEDA 4.0 User's Guide.* Retrieved from personal contact with Dr. Sangwon Suh on November 11, 2010.

[97] Suh, S. (2010). *CEDA 4.0 User's Guide.* Retrieved from personal contact with Dr. Sangwon Suh on November 11, 2010.

Allocation by either method is done between industry sectors to create commodity specific values. For example, industry data on "dairy farms" can be broken into "dairy" and "meat" commodities.[98] As a result, Matrix A is a commodity-by-commodity matrix. As mentioned earlier, there are four different types of requirements tables - commodity-by-industry direct requirements, commodity-by-commodity total requirements, industry-by-commodity total requirements and industry-by-industry total requirements. Each table presents the interrelationships between US industries in a slightly different way. For example, while an industry-by-industry table shows the output required, directly and indirectly, by each industry to deliver a dollar of final demand of industry output to final users, a commodity-by-commodity table shows the output required, directly and indirectly, of each commodity to deliver a dollar of final demand of a commodity.[99] In a commodity-by-commodity table, columns show the commodity delivered to final users and rows show the total production of each commodity required to meet that demand.[100]

Sources of Environmental Data

CEDA 4.0 houses several different environmental databases with information on GHG emissions, criteria pollutants, toxic pollutants and other interventions. This information comes from a variety of sources, dependent on the impact category in question:

Table 6-1: Environmental Data Sources for CEDA

Type of Data	Units of the Matrix Elements	Source of Information	Year of Publication
Greenhouse Gas Emissions	Trillion Btu[101]	Energy Information Administration – *2002 Energy Consumption by Manufacturers, Data files*	2005
	Tg CO_2 Eq. or million metric tons CO_2 Eq.[102]	Environmental Protection Agency - *Inventory for US GHG Emissions and Sinks: 1990-2002.*	2004
Toxic Releases	Quantities of dioxin and dioxin-like compounds are reported in grams; all other chemicals are reported in lbs.[103]	EPA – *Toxics Release Inventory*	N/A

[98] Reich-Weiser, C., personal communication, March 14, 2011.
[99] Input-Output Accounts Tables Help (2010). Bureau of Economic Analysis. Retrieved March 13, 2011 from http://www.bea.gov/industry/iotables/help_section.cfm
[100] Social Science Dictionary (2008). *Total Requirements Table.* Retrieved March 13, 2010 from http://economics.socialsciencedictionary.com/BEA-Economic-Analysis-Dictionary/Total_requirements_table
[101] http://www.eia.doe.gov/emeu/mecs/mecs2002/data02/shelltables.html
[102] http://www.epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010_ExecutiveSummary.pdf
[103] http://www.epa.gov/tri/tridata/current_data/index.html

	Thousand short tons[104]	EPA - *National Emission Inventory*	N/A
	Lbs or lbs/acre[105]	NASS – *Agricultural Statistics*	2008
		USDA – *Agricultural Waste Management Field Handbook, National Engineering Handbook (NEH) Part 651*	2000
	Tons/acre[106]	USDA – *Model Simulation of Soil Loss, Nutrient Loss, and Change in Soil Organic Carbon Associated with Crop Production*	2006
Agrochemicals	Tons/year[107]	EPA – *Emissions Factors and AP 42, compilation of Air Pollutant Emissions Factors, Chapter 9: Food and Agricultural Studies*	1995
	Lb/acre[108]	NASS – *Agricultural and Chemical Use Data*	2009
	Lbs applied[109]	NCFAP – *Pesticide Use in the US Crop Production*	2000
	Pounds of pesticides applied; Leaching mass loss, pounds; Dissolved runoff mass loss, pounds; Adsorbed runoff mass loss, pounds[110]	USDA – *Natural Resource and Conservation Service, Environmental Indicators of Pesticide Leaching and Runoff from Farm Fields*	2000
Primary Energy Consumption and Other Resources Data Compilation		EIA – *Statistics for Natural Gas, Petroleum and Coal in the US, Data Files*	2009

[104] http://www.epa.gov/ttnchie1/trends/
[105] http://www.nass.usda.gov/Statistics_by_Subject/Environmental/index.asp
[106] http://www.nrcs.usda.gov/technical/nri/ceap/croplandreport/
[107] http://www.epa.gov/ttn/chief/ap42/ch09/related/nh3inventoryfactsheet_jan2004.pdf
[108] http://www.pestmanagement.info/nass/
[109] http://www.ncfap.org/pesticideuse.html
[110] http://www.nrcs.usda.gov/technical/nri/pubs/eip_pap.html

	Million metric tons of usable ore[111]	USGS – *Mineral Information: Iron Ore*	2009
		FAO – *Fishery Data Collections, Fishery and Aquaculture Department*	2009
	Million cubic feet harvested[112]	USDA – *Estimated Timber Harvest by US Region and Ownership, 1950-2002*	2006
Land Use Change	Million acres used for given purpose[113]	USDA - *Major Uses of Land in the United States 2002*	2005
Water Use	Mgal/day[114]	USGS – *Estimated Use of Water in the US in 2000*	2004
	Mgal/day[115]	USGS – *Estimated Use of Water in the US in 2005*	2009
Waste	Tons generated[116]	EPA – *The National Biennial RCRA hazardous waste report*	2005
		EPA - *Sustainable Materials Management: The Road Ahead*	2009

SOURCE: Suh, 2010.

Derivation of the Environmental Matrix

The abovementioned environmental information is compiled into another matrix which gives direct emissions of the respective intervention per dollar, called the B Matrix. This B matrix is an intervention-by- commodity matrix given that a commodity-by-commodity matrix is utilized for the input output part of the model (Matrix A).[117] CEDA's B matrix is based on the following equation:

$$E = B^I (I - A)^{-1} y \qquad \text{(eq. 3)}$$

[111] http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/
[112] http://www.fs.fed.us/pnw/pubs/pnw_gtr659.pdf
[113] http://www.ers.usda.gov/Publications/EIB14/
[114] http://pubs.usgs.gov/circ/2004/circ1268/
[115] http://pubs.usgs.gov/circ/2004/circ1268/
[116] http://www.epa.gov/osw/inforesources/data/biennialreport/
[117] Suh, S. (2009). Developing the Sectoral Environmental Database for Input-Output Analysis: Comprehensive Environmental Data Archive of the US. In S.Suh (Ed.), *Handbook of Input-Output Economics in Industrial Ecology, Eco-Efficiency in Industry and Science,* 23 (8), 689-712. New York: Springer Science+Business Media.

Where:

- B^I = an environmental intervention by industry matrix representing the environmental interventions caused by the production of $1 worth of industry output
- A = a commodity-by-commodity input-output technology coefficient matrix
- y = a final demand vector
- E = the total economy-wide environmental intervention calculated by this equation
- Matrix elements are given in kgCO2e, kg or kg active ingredient

Information on environmental interventions is compiled mainly on an industry rather than commodity basis. In order to assign environmental interventions to specific products, the aggregate environmental intervention of each industry must be assigned to its primary product, as well as its secondary products and scrap.[118] CEDA assigns environmental interventions to products through two different methods, giving users the opportunity to choose which they prefer: economic allocation (also known as a type of partitioning method, or the industry technology approach) or a combination of economic allocation and system expansion (also known as the mixed technology method).[119]

In the industry technology approach, it is assumed that the sum total of environmental interventions by a given industry is assigned proportionally to its primary and secondary products based on their economic value.[120] Thus the average environmental intervention due to a dollar's worth of commodity is calculated on the basis of market share, demonstrated by the following:

$$B^I = \frac{B}{D} \qquad \text{(eq. 4)}$$

Where:

- B^I = an environmental intervention-by-industry matrix representing the environmental interventions caused by the production of $1 worth of industry output
- B = environmental intervention-by-commodity matrix
- D = market share matrix derived from make and use matrices

This method was used for deriving the B Matrix in CEDA.

Alternatively CEDA also offers users the choice of utilizing a mixed technology approach, which combines the economic allocation and system expansion methods. Under the system expansion method, it is assumed that each commodity needs the same amount of input requirements and produces the same amount of environmental interventions, irrespective of the industry that produces it. The total environmental intervention of a primary product of a given industry is first calculated by subtracting the total environmental intervention due to secondary products. Next these interventions from secondary products are then assigned to industries producing these secondary products are primary products.[121] CEDA combines this method, with the method outlined above for economic allocation, to produce another matrix based on both methods. Similar to the economic data, the choice of allocation method is denoted by an identifier a (economic value-based allocation) or b (mixed technology model).

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[118] Suh, S. (2009). Developing the Sectoral Environmental Database for Input-Output Analysis: Comprehensive Environmental Data Archive of the US. In S.Suh (Ed.), *Handbook of Input-Output Economics in Industrial Ecology, Eco-Efficiency in Industry and Science,* 23 (8), 689-712. New York: Springer Science+Business Media.

[119] Reich-Weiser, C. personal communication, March 14, 2011.

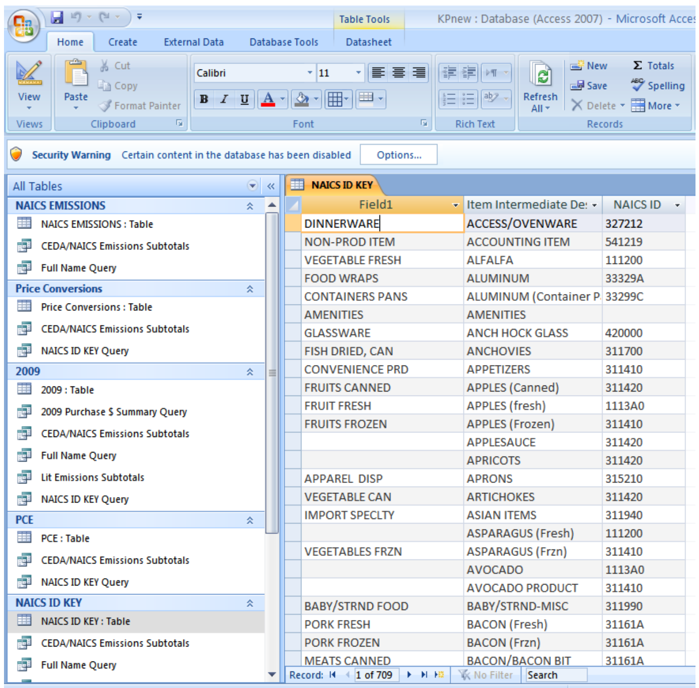
[120] Suh, S. (2009). Developing the Sectoral Environmental Database for Input-Output Analysis: Comprehensive Environmental Data Archive of the US. In S.Suh (Ed.), *Handbook of Input-Output Economics in Industrial Ecology, Eco-Efficiency in Industry and Science,* 23 (8), 689-712. New York: Springer Science+Business Media.

[121] Suh, S. (2009). Developing the Sectoral Environmental Database for Input-Output Analysis: Comprehensive Environmental Data Archive of the US. In S.Suh (Ed.), *Handbook of Input-Output Economics in Industrial Ecology, Eco-Efficiency in Industry and Science,* 23 (8), 689-712. New York: Springer Science+Business Media.

6.3 Calculating Emissions Using CEDA 4.0

In order to use CEDA 4.0, the data from Kaiser Permanente had to first be manipulated to fit our needs. The first step was organizing the data for entry into CEDA. Since CEDA assigns environmental impacts by NAICS code, all of Kaiser Permanente's food purchases needed to be classified by NAICS code as well. All of the food purchases were grouped by Item Intermediate Description, and each team member was tasked with assigning an appropriate NAICS code to that category based on information available from the official US Census NAICS website and the unofficial NAICS.com. For example, a purchase of fresh asparagus by Kaiser Permanente would be assigned NAICS code 11121, for vegetable and melon farming, while a purchase of frozen asparagus by Kaiser Permanente would be assigned NAICS code 31141, Frozen Food Manufacturing. The key showing all results was named "NAICS ID Key" and was uploaded to the Access database:

Figure 6.5: NAICS ID Key in Access



Next, a couple of conversions needed to be applied to the sum of spending for each Intermediate Description category. Since the data from Kaiser Permanente was in 2009 prices, while the CEDA database is structured using 2002 prices, the first conversion to be conducted is from 2009 Prices to 2002 Prices. The latest Personal Consumption Expenditure (PCE) Deflator (from years 1998-2009) available from the Bureau of Economic Analysis was used for this conversion. The PCE Deflator is a type of price index that tracks how the price of goods and services changes over time. There are a number of price indexes available for public use – all produced by US government agencies – including the PCE Deflator, the Consumer Price Index (CPI), and the Producer Price Index (PPI). The CPI compares a household's cost for a specific basket of finished goods and services with the cost of the same group of goods/services in a previous benchmark period, while the PPI uses a similar approach but at the establishment level.[122] In both cases the price given to an item in the "basket" is fixed. In contrast to the CPI and PPI, which use this fixed basket approach, the PCE Deflator takes a chain-weighted approach which links weighted

[122] Schwab Center for Financial Research (2007). *Schwab Guide to Economic Indicators: Price Indexes – CPI, PPI, PCE and Import Prices.* Retrieved February 17, 2011 from http://www.schwab.com/public/schwab/research_strategies/market_insight/1/4/leading_economic_indicators.html

averages from one year to the next.[123] This method is thought to better reflect changes in the composition of consumer spending, and the PCE Deflator is therefore seen as a more comprehensive and consistent method of tracking changes in price the CPI or PPI.[124] For this reason the PCE Deflator was selected as the approach to be used. Within the PCE Deflator, each NAICS category has a conversion factor that, when multiplied by a dollar value, will convert prices between 2009 and 2002. Spending totals by sector within the Kaiser Permanente data were multiplied by the appropriate conversion factor to arrive at spending totals in 2002 dollar values.

Since CEDA uses Producer Price, the second necessary conversion was from Purchaser Price to Producer Price. According to CEDA, products purchased through a wholesaler or retailer is generally in Purchaser's Price, which includes retail margin, wholesale margin and transportation costs. Since Kaiser Permanente orders its food through the food distributor SYSCO, as well as several other smaller distributors, it was assumed that the company's spending totals were nearer to Purchaser Price. In order to convert to Producer Price, the spending total for each NAICS code was multiplied by its appropriate conversion factor as given in CEDA's Price Conversions Factors database. This database, which was also derived from BEA data, gives Purchaser to Producer price conversion factors between the purchasing sector and sector that is purchased from. It was assumed that Kaiser Permanente purchases at wholesale prices, and thus the appropriate conversion factor to use is found at the intersection of the column "Wholesale trade [420000]" (purchasing sector) and the sector purchased from. The spending total for purchases from that sector is then multiplied by this conversion factor, which results in spending totals in 2002 Producer Price.

In the final step, these spending totals were multiplied by CEDA's GHG emissions factors. The GHG emissions factors are housed in CEDA's LCI data sheets, which, as mentioned above, give the option to use either sheet A (based on economic-based allocation of the economic data) or sheet B (based on a combination of economic-based allocation and system expansion of the economic data). Since ISO 14040 standards endorse the mixed technology model over economic-based allocation, sheet B was used in this analysis (S. Suh, personal communication, November 2, 2010). The emissions factors for the six GHGs (CO_2, CH_4, N_20, PFCs, HFCs, and SF_6 – all given in kg CO_2e) for each NAICS code were first summed and then multiplied by the spending total for that NAICS code in Access, resulting in the following overall equation:

$$Environmental\ Impact = Sum\ of\ spending * (2009 - 2002\ Price\ Conversion) * Purchaser\ to\ Producer\ Price\ Conversion * (CO_2 + CH_4 + N_2O + PFCs + HFCs + SF_6)$$

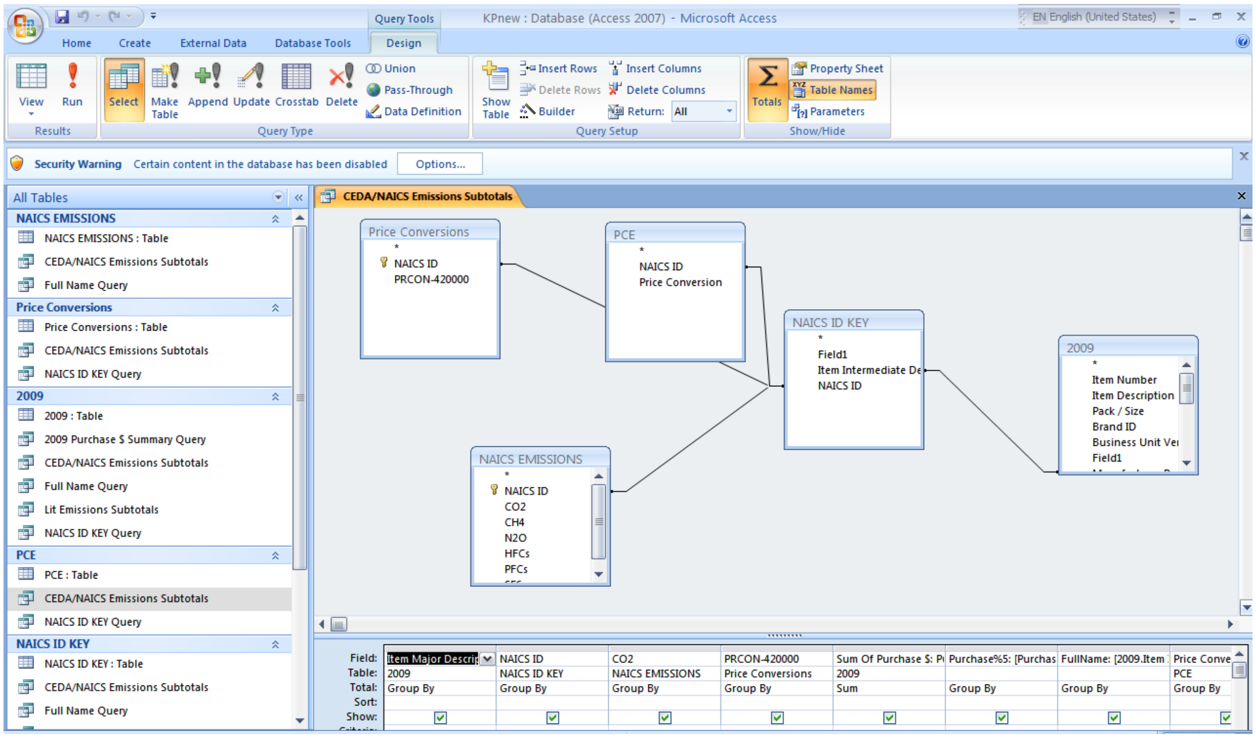
(eq. 5)

The actual calculation was conducted in the Access database by creating relationships between the various tables that housed the information and then multiplying the appropriate fields in a query called "CEDA/NAICS Emissions Subtotals":

[123] Schwab Center for Financial Research (2007). *Schwab Guide to Economic Indicators: Price Indexes – CPI, PPI, PCE and Import Prices.* Retrieved February 17, 2011 from http://www.schwab.com/public/schwab/research_strategies/market_insight/1/4/leading_economic_indicators.html

[124] Schwab Center for Financial Research (2007). *Schwab Guide to Economic Indicators: Price Indexes – CPI, PPI, PCE and Import Prices.* Retrieved February 17, 2011 from http://www.schwab.com/public/schwab/research_strategies/market_insight/1/4/leading_economic_indicators.html

Figure 6.5: Calculating GHG Emissions in Access



The final result is GHG emissions in kgCO2e for the spending total in each NAICS code.

6.3 Carnegie Mellon University EIO-LCA

Source of Economic Data

The CMU model offers users the option of utilizing either the 1997 or 2002 annual input-output tables produced by the BEA.

Sources of Environmental Data

Like CEDA, the CMU model houses several different environmental databases with information on GHG emissions, criteria pollutants, toxic pollutants and other interventions. This information comes from a variety of sources, dependent on the impact category in question:

Table 6.2: Environmental Data Sources for CMU Model

Type of Data	Units of the Matrix Elements	Source of Information	Year of Publication
Electricity Use	Trillion Btu[125]	Manufacturing Energy Consumption survey (manufacturing sectors), service sector electricity use	1998

[125] http://www.eia.doe.gov/emeu/mecs/contents.html

		is estimated using the detailed use table and average electricity prices for these sectors	
Fuel Use		Calculated from commodity purchases (contained in input-output model use table) and average 1997 prices	1997
Energy Use		Calculated by converting fuel use per sector and 31% of electricity use into TJ (31% is the amount of electricity produced in 1997 from non-fossil fuel sources)	1997
Conventional Pollutant Emissions		US EPA	N/A
Greenhouse Gas Emissions		Calculated by emissions factors from fuel use	N/A
Toxics Releases	Quantities of dioxin and dioxin-like compounds are reported in grams; all other chemicals are reported in lbs.[126]	Derived from EPA's 2000 Toxics Release Inventory (published 2001)	2000
Weighted Toxics Releases		CMU-ET is a weighting scheme for toxics emissions to account for their relative hazard; computed from occupational exposure standards (threshold limit values)	N/A
Hazardous Wastes	Tons generated[127]	RCRA Subtitle C hazardous waste generation, management and shipment was derived from EPA's 1999 National Biannual RCRA Hazardous Waste Report	1999

[126] http://www.epa.gov/tri/tridata/current_data/index.html
[127] http://www.epa.gov/osw/inforesources/data/biennialreport/

		(Published 2001)	
External Costs		Calculated from conventional air pollutant emissions and estimates of pollution damage taken from the economics literature (From Matthews' 1999 PhD Dissertation, *The External Costs of Air Pollution and the Environmental Impact of the Consumer in the US Economy*)	N/A
Water Use		Department of Commerce's Census of Manufacturers (US DOC 1986)	N/A
OSHA Safety Data		Bureau of Labor Statistics	N/A
Employment Data		Economic Census: Comparative Statistics for the US 1987, SIC basis	1997
		Bureau of Labor Statistics, Industry Illness and Industry Data	1997
		Statistical Abstract of the United States	1998-2000
		National Marine Fisheries Service, Employment, Craft and Plants (Table) Processors and Wholesalers (published 2000)	1999
		Bureau of Transportation Statistics	N/A
		USDA	N/A

* Based on the 1997 version of the CMU model; environmental databases may have been updated to more recent versions in the 2002 version.
SOURCE: Hendrickson, 2006

For a complete and robust EIO LCA analysis, apart from CEDA 4.0, Carnegie Mellon University's online EIO tool was used to supplement the GHG emissions information with toxic releases information.[128]

The CMU EIO-LCA tool provides guidance on relative impacts of different types of products, materials, services, or industries with respect to resource use and emissions throughout the supply chain. It is based on economic databases from the U.S. Bureau of Economic Analysis and it covers five impact categories – Economic Activity, Greenhouse Gases, Energy, Toxic Releases and Water Use.

Background - Toxic Releases

The database for Toxic Releases category has been compiled by the Green Design Institute using data from Impact Assessment models - IMPACT 2002, CML-IA and Eco-Indicator 99. Ten impact categories have been included such as carcinogens, acidification and eutrophication and emissions have been quantified in terms of various units of mass such as kg, Mg and Gg.

Table 6-3: Toxic Release Description

Toxic Release	Description
Carcinogens	Represents the toxicological risk and potential impacts of carcinogenic chemicals released into the air, water, soil, and agricultural soil from each sector (Mg C2H3CL equivalent). Values obtained from the IMPACT 2002 model.
Non-carcinogens	Represents the toxicological risk and potential impacts of non-carcinogenic chemicals released into the air, water, soil, and agricultural soil from each sector (Mg C2H3CL equivalent). Values obtained from the IMPACT 2002 model.
Respiratory Inorganics	Represents the respiratory health risks of inorganic particles released into the air from each sector (kg PM2.5 equivalent). Values obtained from Eco-Indicator 99.
Ozone Layer Depletion	Represents the ozone depletion impacts of chemicals released into the air from each sector (kg CFC-11 equivalent). Values obtained from the US Environmental Protection Agency Ozone Depletion Potential List and Eco-Incidator 99.
Respiratory Organics	Represents the respiratory health risks of organic particles released into the air from each sector (kg C2H4 equivalent). Values obtained from Eco-Indicator 99.
Aquatic Ecotoxicity	Represents the potential toxicity impacts of water due to chemicals released into air, water, and soil from each sector (Gg TEG water). Values obtained from the IMPACT 2002 model.
Terrestrial Ecotoxicity	Represents the potential toxicity impacts of soil due to chemicals released into air, water, and soil from each sector (Gg TEG soil). Values obtained from the IMPACT 2002 model.
Terrestrial Acidification & Nutrification	Represents the increase in acidity and the potential impacts on terrestrial ecosystems due to chemicals released into air from each sector (kg SO2 equivalent). Values obtained from Eco-Indicator 99.
Aquatic Acidification	Represents the increase in acidity to water due to chemicals released into air, water, and soil from each sector (kg SO2 equivalent). Values obtained from CML.
Aquatic Eutrophication	Represents the potential impacts on aquatic ecosystems due to chemicals released into air, water, and soil from each sector (kg PO4 P-lim). Values obtained from CML

[128] http://www.eiolca.net/cgi-bin/dft/use.pl

Methodology for Toxic Release Results using CMU EIO LCA

Using the online CMU EIO LCA tool, default model for US 2002 Producer price was selected. For each of the 65 different NAICS IDs used in the CEDA 4.0 analysis, toxic releases associated with $1 Million Dollars worth of economic activity were obtained and the results compiled into a Microsoft Excel table. Thus each of the NAICS ID sector had total toxic releases (classified into different impact categories) from all of the sectors which had contributed to the release. This table was then imported into Microsoft Access and linked with the Kaiser Permanente purchase prices to get an estimate of the toxic release emissions associated with each of those Kaiser Permanente purchases.

Figure 6.6: CMU EIO-LCA Results Output

Carnegie Mellon — Green Design Institute

eiolca.net

HOME >> USE THE TOOL >> BROWSE US 2002 (428) MODEL >> DISPLAYING...

Sector #1113A0: Fruit farming
Economic Activity: $1 Million Dollars
Displaying: Toxic Releases
Number of Sectors: Top 10

Change Inputs (Click here to view greenhouse gases, air pollutants, etc...)

Documentation:
The environmental, energy, and other data used and their sources.
Frequently asked questions about EIO-LCA.

This sector list was contributed by Green Design Institute.

	Sector	Carcinogens Mg C2H3Cl eq	Non-carcinogens Mg C2H3Cl eq	Respiratory inorganics kg PM2.5 eq	Ozone Dep kg CFC-11 eq	Respiratory organics kg C2H4 eq	Aquatic ecotoxicity Gg TEG water	Terrestrial ecotoxicity Gg TEG soil	Terrestrial acid/nutri kg SO2 eq	Aquatic acidif kg SO2 eq	Aquatic eutro kg PO4 P-lim
	Total for all sectors	*116.*	*1220*	*7.45*	*0.301*	*10.7*	*321.*	*263.*	*918.*	*306.*	*0.007*
2122A0	Gold, silver, and other metal ore mining	105.0	1100	0.006	0	0.000	10.2	35.1	0.785	0.227	0
221100	Power generation and supply	6.22	66.2	0.031	0	0.007	25.7	21.7	3.82	40.3	0
212230	Copper, nickel, lead, and zinc mining	2.19	34.7	0.000	0	0.001	244.0	173.0	0.013	0.013	0
331411	Primary smelting and refining of copper	1.47	15.9	0.000	0	0.000	29.8	15.1	0.000	0.004	0
562000	Waste management and remediation services	0.350	3.42	0.000	0.000	0.001	3.53	5.65	0.000	0.006	0.007
212100	Coal mining	0.143	1.56	0.005	0	0	0.585	0.720	0.583	0.201	0
325188	All other basic inorganic chemical manufacturing	0.092	2.28	0.040	0.076	0.038	0.622	2.08	4.87	1.67	0.000
324110	Petroleum refineries	0.066	0.011	0.061	0.003	1.37	0.048	0.054	7.53	2.82	0

6.4 *Process-Based Models*

Process based LCA is a bottom-up approach towards life cycle assessments and is usually considered the traditional type of LCA. It is typically denominated in terms of mass and follows the flow of materials through a supply chain and associated industrial processes. A product or process' lifecycle is covered on a physical basis rather than on an economic basis and thus the analysis requires energy and mass balances for all the stages of the life cycle of the product or the process. In U.S., the two main agencies for standardizing process LCA are the Society of Environmental Toxicology and Chemistry (SETAC) and the U.S. Environmental Protection Agency (U.S. EPA). ISO 14040 standards outline the process model approach and software products such as GaBi and Ecobalance are used to conduct the analyses. [129]

[129] Hendrickson, C.T., Lave, L., and Matthews, H.S. (2006). *Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach.* Washington, D.C.: Resources for the Future.

A process based LCA approach offers some advantages over EIO approach such as the analysis being more detail oriented than an EIO LCA. This is mainly because an EIO LCA covers the entire economy and all activities of a particular sector while the Process based LCA is mainly focused on examining a single process in detail.
Also, with Process LCA, specific product comparisons can be made and the analysis allows scope for identification and improvement of the process at weak points in the supply chain. This is not so easily done with an EIO LCA. The disadvantage of a Process LCA however, is that it tends to be more time consuming and expensive and there is also the issue of system boundary. Also, in many cases where confidential data is used, it is difficult to replicate the process and thus verify accuracy.[130]

Given the data, scope of our project and the amount of time and resources available, it would have been impossible to individually calculate emissions using Process based LCA. Therefore a method to include an analysis similar to a Process LCA was devised using literature studies on food LCAs. Thus, apart from using EIO LCA (CEDA and CMU) to calculate GHG and toxic release emissions numbers, a literature survey was also conducted to identify process based LCA studies on food products and the emission numbers found in those studies were used to calculate emissions for Kaiser Permanente's food data.

In general, large emitter categories such as beef, fruits and vegetables were identified via EIO LCA, and then emissions based on specific functional units were calculated using their corresponding literature emissions values.

Literature emissions study

Over a period of one month, our group searched for and selected global food LCA studies to get emissions numbers (factors) associated with food production and procurement. These factors were compiled in spreadsheets along with their associated functional units. For the main analysis, based upon the large emitter categories identified via EIO LCA, studies such as a DEFRA report[131], a WWF-UK report[132] and other papers were selected.

The Department for Environment, Food and Rural Affairs (DEFRA) is a Government Department in the UK and they have produced a report to explore the validity and suitability of methods described in PAS 2050 – a standard developed by the British Standards Institute - for the specification of LCAs of goods (food) and services. It was chosen as a basis for comparison of literature emissions values of beef, poultry and pork with studies by Phetteplace et al.[133] and Kanyama & Gonzalez[134]. Emissions for all meat products were reported in kgCO_2eq. From these studies, emissions were based on a functional unit of 1 kg hung carcass of meat. Beef emission numbers included aspects of beef production process such as production of livestock parents and grandparents, rearing of the commodity animals and the eventual disposal of the animal.

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[130] Hendrickson, C.T., Lave, L., and Matthews, H.S. (2006). *Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach.* Washington, D.C.: Resources for the Future.
[131] Wiltshire J., Wynn S., Clarke J., Chambers B., Cottrell B., Drakes D., Getting J., Nicholson C., Phillips K., Thorman R., Tiffin D., and Walker O. (2009). *Scenario building to test and inform the development of a BSI method for assessing greenhouse gas emissions from food (Final Report*). ADAS.
[132] Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C., and Williams, A. (2009). *How low can we go? An assessment of greenhouse gas emissions from the UK food system and the scope to reduce them by 2050.* FCRN-WWF-UK.
[133] Phetteplace, Hope W., Donald E. Johnson & Andrew F. Seidl (2001). *Greenhouse gas emissions from simulated beef and dairy livestock systems in the United States.* Nutrient Cycling in Agroecosystems, 60, 99–102
[134] Carlsson-Kanyama A, González AD (2009). *Potential contributions of food consumption patterns to climate change*. American Journal of Clinical Nutrition, 89(5):1704S-1709S.

The WWF-UK study was produced by WWF-UK along with FCRN (Food Climate Research Network, UK) in 2009. Their analysis was based on an inventory of commodity consumption, production and trade data from DEFRA, USDA (United States Department of Agriculture) and the UNFAO (United Nations Food and Agriculture Organization). Emissions were reported in kgCO_2eq. For vegetables, emissions were based on a functional unit of 1 kg of the product and included emissions from production up to distribution.

Since no information about Kaiser Permanente's food product purchase by mass was available, the first step in conducting the literature emissions based study was to calculate Kaiser Permanente purchase in mass (kg) from the product prices provided by Sysco (Kaiser Permanente's largest supplier). Two databases for product price indices and price conversions were selected in order to calculate Kaiser Permanente Purchase by mass.

One of the databases was 'USDA Food Plans-Cost of food database' found on the USDA Center for Nutrition Policy and Promotion website. This database (in excel sheet format) contains the corresponding price per 100g of all food commodities purchased in the U.S. for year 2003-2004 which is the most recent database. [135]

The other database used was the Consumer Price Index (CPI) database compiled by the Bureau of Labor Statistics, U.S. Department of Labor. It is based off of prices paid by urban consumers for a representative basket of goods and services. On the CPI website, there are several different CPIs and owing to its high specificity, CPI-U (All Urban Consumers – Current Series) was selected[136]. The consumer price index was used to calculate the change in price of a commodity from the purchase year (2009) to the year for which USDA price per 100g of food commodity (2003) was available. This conversion accounted for any inflation of food process which might have occurred from 2003 to 2009 and aimed at conducting a more robust analysis.

Methodology for calculating emissions based on literature review studies

The product of interest (beef, vegetables, and fruits) was chosen and using item descriptions from the Kaiser Permanente Purchase data, its Kaiser Permanente spending total found. Meanwhile, the CPI Conversion factor was calculated using 2009 and 2003 year data and Kaiser Permanente spending in 2009 converted into Kaiser Permanente spending in 2003. After obtaining the Kaiser Permanente Spending total in 2003 Dollars the next step was to record the USDA price per 100g of that particular product in 2003. Kaiser Purchase by mass (in g) was then calculated using the spending total in 2003 and USDA price of commodities per 100g.

Kaiser Permanente purchase by mass was obtained based on different functional units of the products for which emissions numbers were recorded. For example, if the literature emissions study on fresh beef had emissions numbers per functional unit of 1 kg fresh beef, the amount of fresh beef purchased by Kaiser Permanente was estimated in kilograms.

After obtaining Kaiser Permanente purchases in mass, they were multiplied with the emissions factors (obtained via literature reviews) to get total emissions associated with each product relative to its mass purchased by Kaiser Permanente. The emissions were recorded in kgCO_2eq meaning that they accounted for emissions from all GHGs.

7. Data Management

Kaiser Permanente utilizes the services of Entegra – a food procurement service, to record and track all of its food purchases from the various suppliers. Kaiser Permanente's largest supplier, accounting for 80% of the total

135 http://www.cnpp.usda.gov/usdafoodplanscostoffood.htm
136 http://www.bls.gov/cpi/

purchases is Sysco. The remaining 20% of food is procured from other smaller suppliers. For the purpose of this project, the group focused solely on data from Sysco purchases.

Data management was a large component of the project. In October 2010, files containing information about Kaiser Permanente's year 2009 food-related purchases such as item descriptions, brands, pack size and weights and spending totals were received. Consistency of the data was checked and several issues were discovered. The 2009 Sysco Purchase Data for Kaiser Permanente had been received in 3 month increments (in 4 excel files) but the format of the data from October-December 2009 was different from the format for the first nine months. A large amount of 'unassigned' data was also discovered. After contacting Kaiser Permanente in November 2010, Entegra, provided us with reformatted Sysco Purchase data in 2 month increments (in 6 excel files). However, the spending totals from this set of data were different from spending totals obtained in the earlier set. SKU number purchases were different and negative purchase values were also observed. Finally, in December 2010, Entegra re-ran Sysco's purchase data for Kaiser Permanente and provided the group with a consistent data set which was accepted and the group moved ahead with data formatting and processing. In the end 326,736 lines of data were received. The group proceeded to utilize SYSCO's descriptive hierarchy for the food products that Kaiser Permanente buys from them.

Figure 7-1: Food Description Hierarchy

Item Description	Category Description	Item Major Description	Item Intermediate Description	Spending Total
2% Milk	DAIRY	MILK	LOW-FAT MILK	$120.19
Peeled carrots	PRODUCE	FRESH VEGETABLES	CARROTS	$567.88
Paper cups	SUPPLIES	CUPS	PAPER	$2569.34
Whole wheat bread	BAKERY	BREAD	WHEAT	$4641.73
Turkey sandwich meats	MEAT	DELI	TURKEY	$3459.67

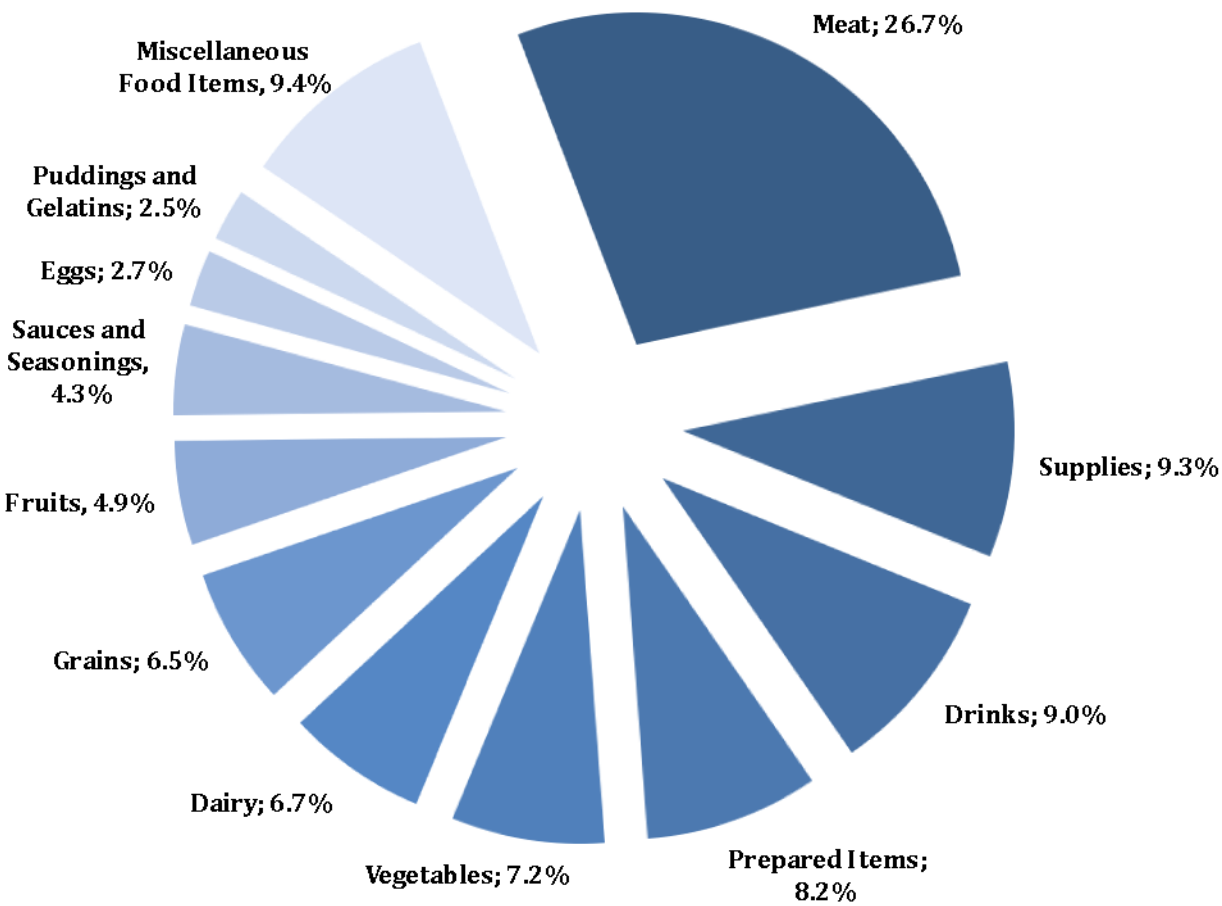
Food Items have 3 levels of descriptiveness - Category Description, Item Major Description and Item Intermediate Description. Category Description is the broadest classification and Item Intermediate Description is the most specific. Each of the over 8000 Item descriptions fit within about 700 Item Intermediate Description categories.

8. Results

8.1 CEDA Results

The estimate of total emissions for 2009 using CEDA emissions factors is approximately 18.7 million kg CO2e, or 18,700 metric tons CO2e. This number represents all of the emissions from purchases through Sysco, which accounts for approximately 80% of all food spending. Extrapolating the Sysco spending to 100% of spending requires the assumptions that the additional 20% of spending is divided up over the same proportions of items, and that these items have the same emissions factors. Therefore the total emissions for 2009 are estimated to be approximately 23,400 tons CO2e. To put this mass in context, it can help to consider about equivalent of the annual average tailpipe emissions from vehicles. Based on an estimate from the EPA and Department of Energy that the average automobile in the U.S. emits between 6 and 9 tons of CO2 annually137, the total emissions from food are equivalent to the use of approximately 2,600 to 3,900 vehicles.

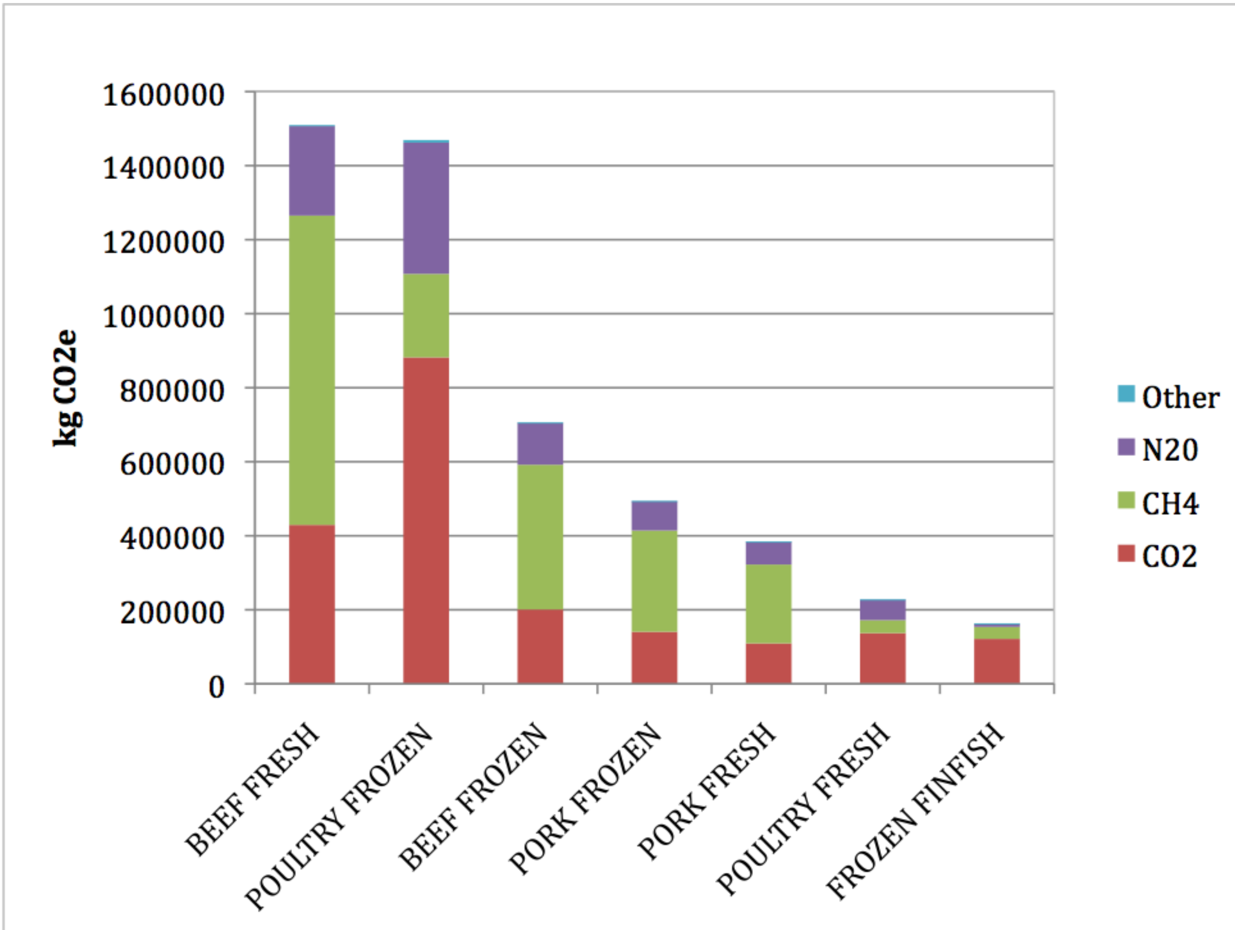
Figure 8.1: CEDA Emissions Estimates as a Percentage of Total Emissions



The first step in analysis of spending changes was getting an understanding of how CEDA divides up the total amount of emissions in general food types. For **Figure 8.1** we simply assigned a basic label to each of the Item Major Descriptions (IMDs) to group them together. Products that don't fit into general categories ("Other") were found to have the highest percentage of the total within this grouping system, and account for many smaller IMDs of miscellaneous products. Prepared products derived from many products in other categories are the largest portion of the "Other" group, with what SYSCO describes as "Convenience Products" (such as prepared entrees) accounting for over 8% of total emissions. Other notable products in this "Other" category include eggs and pudding, each at around 2.5%. Outside of this group of miscellaneous and non-as-easily-substituted products, the most obvious hot spot for emissions reductions is Meat.

[137] http://www.fueleconomy.gov/feg/FEG2010.pdf

Figure 8.2: CEDA Emission Estimates for the IMDs for Meat and Seafood with the Largest Emissions Totals



Dividing up emissions estimates for the Meat group we find relative emissions amount for different meat types (see **Figure 8.2)**. Combining fresh and frozen varieties of the different products, we find that beef has the highest total overall, at over 2 million kg CO2e, followed by poultry, and the pork, at less than 1 million kg CO2e. For context, the largest of the seafood IMDs, Frozen Finfish, was included on this graph, demonstrating seafood's relatively small importance from an emissions perspective when compared to meat. Including the different greenhouse gases in this graph we also get a clearer idea of the distribution of gases, as well as how CEDA accounts for different production processes. The large portion of CH_4 (methane) emission for beef products indicates that on-farm enteric emissions from livestock have greater carbon-intensity per dollar than other processes that emit CO2 or N20. For poultry, on the other hand, methane is not as significant, with N20, most likely emitted due to fertilizer use during feed production, accounting for a larger portion than methane. The "Other" group in the legend combines HFCs, PFCs, and SF_6, and is miniscule for all of these products.

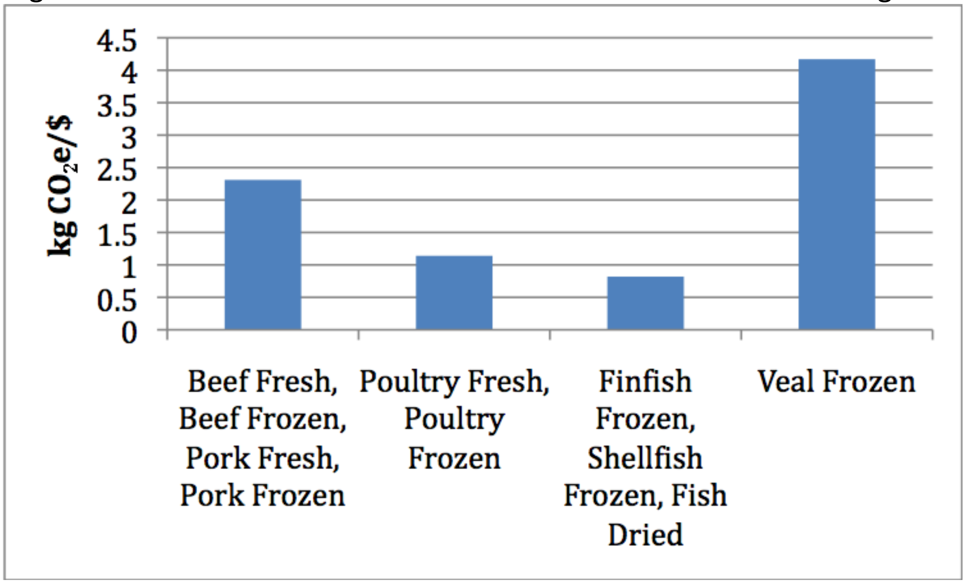
We utilized the model developed by Carnegie Mellon University (CMU) as a benchmark for the CEDA emissions estimates. While there were some significant differences between product types (see **Table 9.1**), overall the CMU estimate of total emissions was only 0.5% less than the total found using CEDA. In the table below, which is sorted from highest to lowest by CEDA emissions subtotals for Major Description product types, we find that differences between EIO methodologies can result in different portions of the emissions totals for product types. One of the most significant differences is with meat products, with beef and pork products in CMU having over 25% greater emissions than for CEDA. The result is that fresh beef replaces convenience products as the largest Major Description, increasing from 8.4% of the total to 10.8% of the total. There is little means to explain these differences in emissions, however. Using the CMU tool we can determine which portions of the supply chain contribute most heavily to emissions, but this is not possible using CEDA. For a table of all comparisons for all the Major Descriptions, see Appendix B.

Table 8.1: CEDA and CMU Emissions Comparison

Item Major Description	CEDA Emissions Subtotals (kg CO2e)	Percent of Total Emissions (CEDA)	CMU Emissions Subtotals (kg CO2e)	Percent of Total Emissions (CMU)	Percent Difference in Subtotals
CONVENIENCE PRD	1,548,556	8.8	1,464,143	8.3	-5.5
BEEF FRESH	1,479,857	8.4	1,891,042	10.8	27.8
POULTRY FROZEN	1,447,573	8.2	1,400,748	8.0	-3.2
JUICES/DRINKS	1,103,924	6.3	989,181	5.6	-10.4
BEEF FROZEN	692,416	3.9	884,807	5.0	27.8
CHEESE	673,821	3.8	678,172	3.9	0.6
VEGETABLES FRZN	660,899	3.7	630,167	3.6	-4.6
EGGS	501,806	2.8	484,422	2.8	-3.5
FRUITS CANNED	495,697	2.8	440,415	2.5	-11.2
PORK FROZEN	484,593	2.7	619,240	3.5	27.8
GEL/PUDD/TOPPNG	463,569	2.6	441,938	2.5	-4.7
PORTION PAKS/PC	420,783	2.4	402,622	2.3	-4.3
CUPS	417,810	2.4	371,887	2.1	-11.0
SOUP,CHOWDR,BAS	397,464	2.3	363,328	2.1	-8.6
FRUIT FRESH	359,904	2.0	315,225	1.8	-12.4
COOKIE/CRK/CONE	359,594	2.0	345,659	2.0	-3.9
VEGETABLE FRESH	326,689	1.8	242,312	1.4	-25.8
PORK FRESH	324,293	1.8	414,400	2.4	27.8
COFFEE	268,783	1.5	231,412	1.3	-13.9
BAKERY PRODUCT	262,736	1.5	245,600	1.4	-6.5
POTATOES FROZEN	232,789	1.3	221,965	1.3	-4.6
SNACKS	228,333	1.3	230,182	1.3	0.8
YOGURT	227,768	1.3	229,498	1.3	0.8
POULTRY FRESH	224,950	1.3	217,673	1.2	-3.2
DIETARY FOODS	213,175	1.2	199,752	1.1	-6.3
RICE AND GRAINS	212,018	1.2	136,249	0.8	-35.7
CUTLERY PLASTIC	205,016	1.2	187,871	1.1	-8.4
NUTRITIONAL	193,323	1.1	184,302	1.0	-4.7
FROZEN FINFISH	163,552	0.9	195,093	1.1	19.3

Table 8.1 also exposes some significant inaccuracies caused by using CEDA emissions factors for all of our different products, however. Given the limited distinct NAICS categories, we have to group together products that would be expected to have different emissions factors into the same group. We cannot, for example, differentiate between frozen and fresh meat products. If we could, we would expect to find higher portions of the "Other" emissions group (which includes gases used in refrigeration) for frozen products. **Figure 8.3** demonstrates how CEDA requires us to use the same emissions factors different product types. Just as there is no distinction between fresh and frozen products, we also see that beef and pork products fall under the same emissions factor.

Figure 8.3: CEDA Emissions Factors Used for Different Product Categories



While **Figure 8.3** can be useful for identifying some limitations of using CEDA we can also use it to identify general differences in carbon-intensities of food products. Its strength is that many products can be compared with the same methodology, even if those products are in relatively low purchase amounts, such as frozen veal. This information would indicate that approximately 75% of the total emissions from frozen veal could be reduced if it were substituted with poultry. Similarly, fish products have lower emissions per dollar than meat products—one third of those for beef and pork products.

Substitution Scenarios with CEDA Results

To quantify emissions and economic reductions, substitution scenarios were generated. The substitution analysis allowed us to take carbon-intensive food items and determine how much emissions and costs could be reduced if it was replaced with a similar alternative food item. Using a model generated in Microsoft Excel, we gathered how much money was spent on a particular item, how many kilograms were bought, and how much emissions resulted from that item-all from the CEDA database results. Two sets of data were gathered per substitution scenario (one set for the substituted food item and one for the substitute food item). A series of calculations used in the model generated results that included overall Emissions Reduction and Cost Reductions. For further reference, Appendix A contains the excel data sheets that were produced for this analysis.

As stated earlier, meat procurement results in the largest fraction of Kaiser Permanente's GHGs within their food system. Due to this finding, we created substitution scenarios that replaced the highest meat emitter-beef, with meat options. Below is a table that presents our analysis of these substitutions.

Table 8.2: Substitution Scenarios for Beef

	PORK			SEAFOOD			CHICKEN		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric tons of CO2eq)	COST CHANGE ($1000s)
10	-0.01148%	-21.5	-7.2	-0.08486%	-158.7	42.1	-0.13340%	-249.5	-37.5
20	-0.02295%	-42.9	-14.3	-0.16972%	-317.4	84.2	-0.26680%	-498.9	-75.0
30	-0.03443%	-64.4	-21.5	-0.25457%	-476.1	126.4	-0.40020%	-748.4	-112.5
40	-0.04591%	-85.8	-28.6	-0.33943%	-634.7	168.5	-0.53360%	-997.8	-150.0
50	-0.05738%	-107.3	-35.8	-0.42429%	-793.4	210.6	-0.66700%	-1247.3	-187.6
60	-0.06886%	-128.8	-42.9	-0.50915%	-952.1	252.7	-0.80040%	-1496.8	-225.1
70	-0.08033%	-150.2	-50.1	-0.59400%	-1110.8	294.9	-0.93381%	-1746.2	-262.6
80	-0.09181%	-171.7	-57.2	-0.67886%	-1269.5	337.0	-1.06721%	-1995.7	-300.1
90	-0.10329%	-193.1	-64.4	-0.76372%	-1428.2	379.1	-1.20061%	-2245.1	-337.6
100	-0.11476%	-214.6	-71.5	-0.84858%	-1586.8	421.2	-1.33401%	-2494.6	-375.1

*- Emissions includes, CO2, CH4, N20 and Other (HFCs, PFCs, and SF_6)

Table 8.2 allows us to identify what meat alternative reduces the most emissions and costs. The left most column illustrates the percentage of beef that will be reduced. Moving horizontally across the grid we can observe the degree at which GHGs are reduced by a given percentage reduction in beef for a particular substitute (in this case: seafood, pork or chicken). Total emissions change indicates how much of Kaiser Permanente's *total* GHG (18.7 million kg CO2eq) will be reduced with the correlating percentage reduction in beef.

There will be an emissions reduction with any beef substitution since beef is the highest emitting meat purchased in large quantities. Pork provides the least reductions in the meat substitution table at an emissions reduction rate of 10.7 tons per 5% reduction. Seafood and chicken is reduced at a rate of 79.3 and 124.7 tons of GHG for every 5% replaced, respectively. It is important to consider the cost of reduction for each meat alternative. Seafood in this substitution scenario increases in cost because seafood is typically more expensive than beef. From the Food Price Database, certified by the USDA, seafood averaged about $14.80 for every kilogram while beef averaged $10.22 per kilogram. This explains why replacing, cheaper beef items with seafood items will result in a cost increase of $21,100 for every 5% of substitution. The optimal solution to reduce the greatest amount of greenhouse gasses while saving the most costs will be to substitute beef with chicken because, chicken is the least expensive and the least GHG intensive (according to our CEDA results).

It is not feasible however, for Kaiser Permanente to reduce all emissions in meat substitution because beef provides a level of nourishment that other meats do not. In addition, there is a demand for beef products from patients and workers. Due to this fact, we have simulated a variety of substitution scenarios for other high emitting foods. In doing this, we hope to give Kaiser Permanente a summary of their substitution options so that they can diversify their emission-reducing purchase choices without greatly disturbing the nutritional value of their menu and catering options.

Below is a series of graphs similar to **Table 8.2** for beef but for non-meat products. Beverages were found to be the next highest food-product emitters for Kaiser Permanente after the Meat and Other category. Juices and carbonated beverages were found at the top of our emissions list. Juice drinks accounted for 1,021,955 kg CO2e while carbonated beverages produced 444,605 kg CO2e. Juice drinks were thus compared to carbonated beverages and we found that replacing juice drinks with carbonated beverages would reduce GHG emissions by 39.1 tons of CO2e for a 10% drop in juice. Carbonated beverage purchases over juice will also provide a significant cost decrease since carbonated beverages average $0.30 less than juice drinks. However, there has been a strong correlation between the high fructose corn syrup content in juices/carbonated beverages with elevated insulin levels. Significant increase in insulin can overload the liver and contribute to stockpiling of calories as fat[138].

Due to these harmful health affects, we created a second substitution scenario for juice drinks by substituting juice with filtered tap water in **Table 8.3** -a much healthier substitution choice. Due to a lack of tap water data, we assumed that the purchase sum for juice was the same for tap water. The GHG emissions factors were based off a comparative life-cycle assessment of bottle vs. tap water study

[138] Taubes, Gary. Good Calories, Bad Calories. New York: Blackwell Publishing Ltd, 2008.

performed by the University of Michigan's Center for Sustainable Systems[139]. The data they collected varied for tap water depending on vessel type (i.e. glass cup, steel canister). We utilized the glass cup scenario, which revealed that 1000 gallons of water consumed contributed to 88kgCO2eq. Although Kaiser Permanente may use different vessel types such as plastic cups or paper cups, this substitution still gives

Kaiser Permanente a rough estimation of the GHG emissions and costs saved when purchasing tap water over juice. There exists a large cost reduction for the substitution scenarios for juice when both carbonated beverage and tap water replace juice products. However, we find that replacing tap water for juice beverages will result in the largest emission reductions. Kaiser Permanente can reduce GHG emissions by 200 metric tons of CO2eq by supplementing 20% of juice purchase with tap water.

Table 8.3: Substitution Scenarios for Juice Beverages

	CARBONATED BEVERAGES			TAP WATER		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
10	-0.02089%	-39.07	-28.60	-0.05349%	-100.03	-89.75
20	-0.04179%	-78.14	-57.20	-0.10698%	-200.06	-179.50
30	-0.06268%	-117.21	-85.80	-0.16048%	-300.09	-269.25
40	-0.08357%	-156.28	-114.41	-0.21397%	-400.12	-358.99
50	-0.10446%	-195.35	-143.01	-0.26746%	-500.15	-448.74
60	-0.12536%	-234.42	-171.61	-0.32095%	-600.18	-538.49
70	-0.14625%	-273.49	-200.21	-0.37445%	-700.22	-628.24
80	-0.16714%	-312.56	-228.81	-0.42794%	-800.25	-717.99
90	-0.18804%	-351.63	-257.41	-0.48143%	-900.28	-807.74
100	-0.20893%	-390.70	-286.02	-0.53492%	-1000.31	-897.49

Another beverage substitution scenario that could decrease beverage emissions impacts includes the swapping of tea for coffee. Coffee emissions are 224,825 kg CO2eq greater than tea emissions. Below, the table shows that a 50% reduction for coffee for tea could result in an 87.9 metric ton of CO2eq reduction in GHG emissions and a cost reduction of $85,400.

Table 8.4: Substitution Scenarios for Coffee

	TEA		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
10	-0.00941%	-17.6	-17.1

[139] Detorre, Christopher. "Comparative Life-Cycle Assessment of Bottled vs. Tap Water Systems."Center for Sustainable Systems, University of Michigan. December 14, 2009. http://css.snre.umich.edu/css_doc/CSS09-11.pdf

	TEA		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
20	-0.01881%	-35.2	-34.2
30	-0.02822%	-52.8	-51.3
40	-0.03762%	-70.4	-68.4
50	-0.04703%	-87.9	-85.4
60	-0.05644%	-105.5	-102.5
70	-0.06584%	-123.1	-119.6
80	-0.07525%	-140.7	-136.7
90	-0.08465%	-158.3	-153.8
100	-0.09406%	-175.9	-170.9

Dairy Products are also a food category we should focus on since the pie chart in **Figure 9.1** indicates that they make up 7% of all GHG emission for Kaiser Permanente. We compared conventional milk products (which included low-fat, non-fat and whole milk) with soymilk, categorized as "miscellaneous milk". We discovered that soymilk purchases were more energy intensive than conventional milk purchases. Consequently, replacing milk with soymilk would in effect, increase GHG emissions. Below is a chart that shows the scenario for replacing milk for soymilk and adjacent to it, the scenario for replacing soymilk with milk. Total GHG emissions will be increased when soymilk is purchased over regular milk according to **Table 8.5** under the column "Total Emissions Change".

Table 8.5: Dual Substitution Scenarios for Milk and Soymilk

	Replace Milk with Soymilk			Replace Soymilk with Milk		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
10	0.00381%	7.1	1.7	-0.00566%	-10.6	-2.6
20	0.00762%	14.2	3.4	-0.01132%	-21.2	-5.2
30	0.01143%	21.4	5.0	-0.01698%	-31.7	-7.9
40	0.01523%	28.5	6.7	-0.02263%	-42.3	-10.5
50	0.01904%	35.6	8.4	-0.02829%	-52.9	-13.1
60	0.02285%	42.7	10.1	-0.03395%	-63.5	-15.7
70	0.02666%	49.9	11.8	-0.03961%	-74.1	-18.3
80	0.03047%	57.0	13.5	-0.04527%	-84.7	-20.9
90	0.03428%	64.1	15.1	-0.05093%	-95.2	-23.6
100	0.03809%	71.2	16.8	-0.05659%	-105.8	-26.2

This table shows the benefit of replacing soymilk with milk rather than replacing milk with soymilk. This particular analysis leads us to believe that milk substitutions might not necessarily be emissions or cost reducing and that we should look further into other dairy products that could be the source of higher emissions (such as cheeses or butter-presented later in this section).

Vegetable and fruit production processes account for a significant amount of greenhouse gasses for Kaiser Permanente. Unfortunately we were unable to capture the overall benefits of switching completely from frozen to fresh fruits or fresh to canned vegetables because price variation was too large. Getting an average price for all fruits and vegetables would not be sufficiently representative. As a result, our substitution scenario analysis focused on three vegetables and two fruits. For vegetables we analyzed carrots, broccoli and spinach.

We found that replacing frozen vegetables in general would decrease emissions but cost decreases are not guaranteed. Here, in **Table 8.6** for frozen carrots, we find that increasing the purchases of fresh carrots to replace frozen carrots will actually cost more than purchasing frozen carrots. The cost of fresh and frozen carrots is very similar, with a variance of only $0.09. This could explain why frozen carrot distribution cost change stays at zero when frozen carrots are replaced by 0%-10% by fresh carrots.

Table 8.6: Substitution Scenario of Frozen Carrots

	FRESH CARROTS		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
10	-0.00013%	-0.3	0.0
20	-0.00027%	-0.5	0.1
30	-0.00040%	-0.8	0.1
40	-0.00054%	-1.0	0.2
50	-0.00067%	-1.3	0.2
60	-0.00081%	-1.5	0.3
70	-0.00094%	-1.8	0.3
80	-0.00107%	-2.0	0.4
90	-0.00121%	-2.3	0.4
100	-0.00134%	-2.5	0.5

Table 8.7: Substitution Scenario for Frozen Spinach

	FRESH SPINACH		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
10	-0.00017%	-0.3	0.4
20	-0.00035%	-0.6	0.8
30	-0.00052%	-1.0	1.2

	FRESH SPINACH		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
40	-0.00070%	-1.3	1.6
50	-0.00087%	-1.6	2.0
60	-0.00104%	-1.9	2.4
70	-0.00122%	-2.3	2.8
80	-0.00139%	-2.6	3.2
90	-0.00156%	-2.9	3.6
100	-0.00174%	-3.2	4.0

The spinach substitution is similar to carrots in that frozen spinach is a higher emitter than fresh spinach. Though, it should be noted that replacing fresh spinach for frozen spinach will cost $400-$4000 and Kaiser Permanente will have reduction in total emissions no more than 0.00174%. See **Table 8.7** Substitution Scenario for Frozen Spinach.

Unlike the carrot and spinach scenario, frozen broccoli is less carbon intensive than fresh broccoli. For almost the same amount of baseline mass, fresh broccoli emitted 25,071 kilograms of GHGs while frozen broccoli emits 9,474 kilograms GHGs. **Table 8.8** indicates that a 10% reduction in fresh broccoli to frozen broccoli could reduce costs by $188,800. This is a significant cost savings and can be attributed to the large price difference between frozen broccoli and fresh broccoli. Fresh broccoli costs $5.01 while frozen broccoli costs $2.99; this large cost difference could explain the drastic cost change.

What we can conclude from the analysis performed on these three vegetables is that price differences can significantly impact the total cost reductions. We can also deduce that frozen vegetables will not always be higher emitters than their fresh or canned counterparts.

Table 8.8: Substitution Scenario for Fresh Broccoli

	FROZEN BROCCOLI		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
10	-0.00068%	-1.3	-188.8
20	-0.00136%	-2.5	-377.5
30	-0.00204%	-3.8	-566.3
40	-0.00272%	-5.1	-755.1
50	-0.00340%	-6.4	-943.9
60	-0.00408%	-7.6	-1,132.6
70	-0.00476%	-8.9	-1,321.4
80	-0.00544%	-10.2	-1,510.2
90	-0.00612%	-11.4	-1,699.0
100	-0.00680%	-12.7	-1,887.7

Just like vegetables, fruits cannot be grouped entirely into ‘frozen’ categories and replaced by ‘fresh’ or ‘canned’ fruit categories of the same type. This is due to the USDA’s specific food item descriptions and their varying costs. For instance, pineapples cost $1.94 per kilogram while pomegranates cost $15.63 per kilogram. With this large difference, it would not be an accurate representation of fruit costs if fruit costs were averaged. As a result, we created substitution scenarios for apples and blueberries.

Table 8.9: Substitution Scenario for Canned Apples

	FRESH APPLES		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
10	-0.00003%	-0.1	-0.2
20	-0.00007%	-0.1	-0.3
30	-0.00010%	-0.2	-0.5
40	-0.00013%	-0.2	-0.6
50	-0.00017%	-0.3	-0.8
60	-0.00020%	-0.4	-0.9
70	-0.00023%	-0.4	-1.1
80	-0.00027%	-0.5	-1.2
90	-0.00030%	-0.6	-1.4
100	-0.00033%	-0.6	-1.5

The apple substitution scenarios lead us to believe that canning of apples will require more GHG emissions than fresh fruit. This could be explained by the additional processing services such as, transportation to cannery, electricity required for can manufacturing and fuel to power machines to cut and allocate apples to cans.

Conversely, the table below for the blueberry substitution scenario, we observe that the GHG emissions from frozen blueberries will lower than for fresh blueberries. This goes against what we found when comparing apples, spinach and carrots. In those scenarios, we found that frozen products had greater emissions and thus, reducing the purchase of frozen products would be cost efficient and emissions reducing. Blueberries have presented and interesting situation in that, freezing blueberries would result in less GHG emissions when one would perceive that to be the opposite. Blueberries are typically frozen through Individually Quick Frozen (IQF) processes. This flash freezes blueberries at an extremely low temperature. Fresh blueberries are picked and shipped to packing houses where they are chilled. After packaging, blueberries are imported domestically and internationally. Most blueberry production in the United States is on the Northeast region of the country. Considering both production processes presented for frozen and fresh blueberries, we can assume that the sum of GHG from fresh blueberry production is greater than the IQF GHG emissions from frozen blueberry production.

Table 8.10: Substitution Scenario for Fresh Blueberries

	FROZEN BLUEBERRIES		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
10.0	-0.00042%	-0.8	-0.1
20.0	-0.00084%	-1.6	-0.3
30.0	-0.00126%	-2.4	-0.4
40.0	-0.00168%	-3.1	-0.6
50.0	-0.00210%	-3.9	-0.7
60.0	-0.00253%	-4.7	-0.8
70.0	-0.00295%	-5.5	-1.0
80.0	-0.00337%	-6.3	-1.1
90.0	-0.00379%	-7.1	-1.3
100.0	-0.00421%	-7.9	-1.4

Fruit and vegetable results show data that, at times, are difficult to discern. There are uncertainties that we do not know such as; manufacturing processes, transportation distances and their fuel sources, electricity sources and so on. These factors will determine whether one frozen fruit product emits higher or lower GHGs than its fresh fruit complement. With that said, each vegetable and fruit type will generate a different optimal substitution scenario.

In the process-based method, instead of analyzing fruit and vegetables by process (frozen, canned, fresh) we created substitution scenarios that involved different entirely different fruit types. In doing this we were able to determine different kinds of fruits (i.e. pears, strawberries for apple) that could be substituted for high emitting fruits like apples and melons.

To further explore substitution scenarios with co-health benefits in mind, we have augmented our methods in a way to identify healthier alternative food products. We focused primarily on processed foods. Processed foods are defined as foods that have been altered from their natural state for safety and convenience. The methods used for processing foods include canning, freezing, refrigeration, dehydration and aseptic processing. Not all processed foods have negative health implication but we have focused this part of our study on processed foods that do. Some processed foods are known for containing high amounts of trans-fats, saturated fats, sodium, sugars and nitrites. Nitrites in certain meat products have been linked to childhood cancer risk.

Trans-fats and saturated fats can raise blood cholesterol. A high level of cholesterol in the blood is a major risk factor for coronary heart disease, which leads to heart attack, and also increases the risk of stroke (http://www.americanheart.org/presenter.jhtml?identifier=4582). One such food that can be found high in trans and saturated fat included processed cheese, cheese snacks and chips.

Table 8.11: Substitution Scenario for Processed Cheese and Cheese Snacks

	Replace Processed Cheese for Cheese Cubes			Replaces Cheese Snacks for Cheese Cubes		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
10	0.00027%	0.5	-2261.2	0.00055%	1.0	-6.1
20	0.00055%	1.0	-4522.4	0.00110%	2.1	-12.3
30	0.00082%	1.5	-6783.6	0.00165%	3.1	-18.4
40	0.00109%	2.0	-9044.8	0.00220%	4.1	-24.6
50	0.00137%	2.6	-11306.0	0.00275%	5.1	-30.7
60	0.00164%	3.1	-13567.2	0.00330%	6.2	-36.9
70	0.00191%	3.6	-15828.4	0.00385%	7.2	-43.0
80	0.00219%	4.1	-18089.6	0.00440%	8.2	-49.2
90	0.00246%	4.6	-20350.8	0.00495%	9.3	-55.3
100	0.00273%	5.1	-22612.0	0.00550%	10.3	-61.5

Processed cheese accounts for 113,174 kg CO2eq while cheese cubs and cheese snacks only account for only 12,129 kg CO2eq and 4,197 kg CO2eq, respectively. From this table we can conclude that natural cheese cubes are more energy intensive to produce than processed cheese or cheese snacks thus offering no emissions saving from substitution. However, we do see cost savings and a health benefit from buying more cheese cubes, particularly for processed cheese.

Another food product high in saturated fat is chips. Chips have been substituted for their natural food ingredient, potatoes. **Table 8.12** illustrates the emissions and costs saved for chip purchase reductions. Reducing chip purchases by 70% could cut back Kaiser Permanente's GHG emissions by 249,000 kg CO2eq and save Kaiser Permanente $147,400.

Table 8.12: Substitution Scenario for Chips

	POTATOES		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
10	-0.01909%	-35.7	-21.1
20	-0.03818%	-71.4	-42.1
30	-0.05726%	-107.1	-63.2
40	-0.07635%	-142.8	-84.2
50	-0.09544%	-178.5	-105.3
60	-0.11453%	-214.2	-126.3
70	-0.13362%	-249.9	-147.4
80	-0.15270%	-285.6	-168.5
90	-0.17179%	-321.3	-189.5
100	-0.19088%	-356.9	-210.6

Margarine is known to contain less saturated fat and cholesterol than butter. Margarine is made from polyunsaturated vegetable oils like corn oil, which do not contain saturated fats[140]. Choosing margarine over butter could thusly, be a healthier choice. Replacing margarine for butter can also decrease emissions by 5000 kg CO2eq if the replacement is 90%. This situation could also reduce costs by $5,200.

Table 8.13: Substitution Scenario for Butter

	MARGARINE		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
10	-0.00030%	-0.6	-0.6
20	-0.00059%	-1.1	-1.2
30	-0.00089%	-1.7	-1.7
40	-0.00119%	-2.2	-2.3
50	-0.00148%	-2.8	-2.9
60	-0.00178%	-3.3	-3.5
70	-0.00208%	-3.9	-4.0
80	-0.00237%	-4.4	-4.6
90	-0.00267%	-5.0	-5.2
100	-0.00297%	-5.5	-5.8

Like trans fats and saturated fats, high sodium intake can increase blood cholesterol levels. High sodium diets can also contribute to build-up of fluid in people with congestive heart failure, cirrhosis, or kidney disease. Sodium concentrations are high in food products like pre-cooked frozen dinners, soups and boxed meals. We evaluated Kaiser Permanente's soup and entrees purchases and came up with the following scenarios. One last substitution concerning saturated fats was performed substituting margarine for better. [141]

In **Table 8.14** we substituted soups and chowders for soup bases. Due to our lack of specific food ingredient lists, it is unclear whether soup supplementation with soup base will effectively reduce sodium intake. However, we can safely say that pre-made soups like chowders, stews and noodle soups will most likely contain more sodium than chicken stocks or vegetable stocks. Soup bases will undoubtedly reduce emissions and cost while providing less health harm but to be accurate on equivalent substitutions we must also factor in the vegetables and meats used for each soup product. A more elaborate substitution scenario is required here. What we can take away from this analysis is that when high sodium soups are substituted it can provide overall health benefits and GHG emissions reductions.

[140] http://my.clevelandclinic.org/heart/prevention/askdietician/margarine.aspx
[141] U.S. Department of Health and Human Services (HSS) and U.S. Department of Agriculture (USDA). Dietary Guidelines for Americans - 2005. Chapter 8: Sodium and Potassium. Accessed May 25, 2010

Table 8.14: Substitution Scenario for Soup

	SOUP BASES		
ERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
10	-0.02024%	-37.9	-23.0
20	-0.04049%	-75.7	-45.9
30	-0.06073%	-113.6	-68.9
40	-0.08098%	-151.4	-91.8
50	-0.10122%	-189.3	-114.8
60	-0.12147%	-227.1	-137.7
70	-0.14171%	-265.0	-160.7
80	-0.16196%	-302.9	-183.6
90	-0.18220%	-340.7	-206.6
100	-0.20245%	-378.6	-229.5

Frozen dinner and entrees are categorized in the total emissions pie as “other”. This portion of Kaiser Permanente’s GHG emissions makes up a whopping 33% of the total food systems emissions. To examine how entrees effect green house gasses, we evaluated the emissions of the following pre-made entrees; egg entrees, pasta entrees, beef entrees and chicken entrees. We substituted these entrees with their direct, fresh food complement. For example, we substituted egg entrees with fresh, raw eggs and poultry entrees with fresh poultry. One detail that we did not consider was the sides (green beans, mashed potatoes, corn etc.) and condiments (gravy, bbq sauce etc.) that accompany the meal. Further details on the entrée composition would allow us to simulate a more accurate substitution scenario but our limited data does not provide this. All entrees, when replaced with their fresh food counterpart, reduce emissions and costs except for poultry. However, the cost change from poultry entrees to fresh poultry is marginal. The nutritional benefits of fresh meals over pre-cook entrees may help reduce sodium consumption levels. Egg entrees substitution will provide the most emission and cost benefits followed by pasta entrée and poultry entrée substitutions.

Table 8.15 Substitution Scenarios for Pre-Cooked Entrees

	Raw Eggs for Egg Entrees			Fresh Pasta for Pasta Entrees			Poultry for Poultry Entrees		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
10	-0.00402%	-7.5	-3.1	-0.00003%	-0.1	-0.1	-0.00007%	-0.1	0.0
20	-0.00805%	-15.1	-6.2	-0.00007%	-0.1	-0.1	-0.00014%	-0.3	0.0
30	-0.01207%	-22.6	-9.3	-0.00010%	-0.2	-0.2	-0.00021%	-0.4	0.0
40	-0.01610%	-30.1	-12.3	-0.00013%	-0.2	-0.2	-0.00028%	-0.5	0.0
50	-0.02012%	-37.6	-15.4	-0.00016%	-0.3	-0.3	-0.00035%	-0.7	0.0

	Raw Eggs for Egg Entrees			Fresh Pasta for Pasta Entrees			Poultry for Poultry Entrees		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
60	-0.02415%	-45.2	-18.5	-0.00020%	-0.4	-0.4	-0.00043%	-0.8	0.0
70	-0.02817%	-52.7	-21.6	-0.00023%	-0.4	-0.4	-0.00050%	-0.9	0.1
80	-0.03220%	-60.2	-24.7	-0.00026%	-0.5	-0.5	-0.00057%	-1.1	0.1
90	-0.03622%	-67.7	-27.8	-0.00030%	-0.6	-0.5	-0.00064%	-1.2	0.1
100	-0.04025%	-75.3	-30.9	-0.00033%	-0.6	-0.6	-0.00071%	-1.3	0.1

It is a widely accepted notion that too much sugar consumption could lead to adverse health effects. Obesity, coronary heart disease[142] and displaced nutrients[143] are conditions exacerbated by high sugar diets. Due to this, we have created substitution scenarios for products known to contain elevated levels of unhealthy sugar by-products such as high fructose corn syrup. Cold breakfast cereal products are a prime example. Cold cereals contribute to a large amount of Kaiser Permanente's GHG emissions (285,707 kgCO2eq) therefore; substituting cold cereal for healthier alternatives will also reduce emissions impacts. In Table 9.15 the substitution replace cold cereal products with hot cereal products (products like oatmeal, and grits).

Table 8.16: Substitution Scenario for Cold Cereal

	HOT CEREAL		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
10	-0.01286%	-24.0	-24.3
20	-0.02571%	-48.1	-48.6
30	-0.03857%	-72.1	-72.9
40	-0.05143%	-96.2	-97.2
50	-0.06428%	-120.2	-121.5
60	-0.07714%	-144.3	-145.8
70	-0.09000%	-168.3	-170.1
80	-0.10286%	-192.3	-194.4
90	-0.11571%	-216.4	-218.7
100	-0.12857%	-240.4	-243.0

Cold cereal emits more GHG emissions per kg of product and is also more expensive hence the large reductions in emissions and costs. Kaiser Permanente also purchases other sugary breakfast products such as cereal bars and broadly categorized 'breakfast items.' We know that breakfast bars are likely to

[142] Yudkin J. Sugar and ischaemic heart disease. *Practitioner.* 1967; 198: 680–683.
[143] Jacobson MF. Liquid candy: how soft drinks are harming Americans' health. Available at: http://www.cspinet.net/new/pdf/liquid_candy_final_w_new_supplement.pdf. Accessed March 17, 2011

contain high levels of sugar and it is our assumption that breakfast items (like muffins, danishes and yogurt) do also.

Table 8.17 reflects the substitution scenario for replacing both cereal bars and breakfast items with hot cereal. The results from the table indicate that emissions will be reduced in both substitutions but costs significantly increase.

Table 8.17: Substitution Scenario for Cereal Bars and Breakfast Items

	Hot Cereal for Cereal Bars			Hot Cereal for Breakfast Items		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
10	-0.00039%	-0.7	4440.9	-0.00965%	-18.0	111178.1
20	-0.00079%	-1.5	8881.8	-0.01930%	-36.1	222356.2
30	-0.00118%	-2.2	13322.6	-0.02895%	-54.1	333534.2
40	-0.00158%	-2.9	17763.5	-0.03860%	-72.2	444712.3
50	-0.00197%	-3.7	22204.4	-0.04824%	-90.2	555890.4
60	-0.00236%	-4.4	26645.3	-0.05789%	-108.3	667068.5
70	-0.00276%	-5.2	31086.1	-0.06754%	-126.3	778246.6
80	-0.00315%	-5.9	35527.0	-0.07719%	-144.3	889424.7
90	-0.00355%	-6.6	39967.9	-0.08684%	-162.4	1000602.7
100	-0.00394%	-7.4	44408.8	-0.09649%	-180.4	1111780.8

Sodas and juices are a large source of sugars in the human diet. High fructose corn syrup in these beverages can increase insulin to unhealthy levels. In **Table 8.18** below we replaced both soda and juice for tap water.

Table 8.18: Substitution Scenario for Soda and Juices

	Tap Water for Soda			Tap Water for Juices		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
10	-0.02296%	-42.9	-43.1	-0.05349%	-100.0	-89.7
20	-0.04592%	-85.9	-86.1	-0.10698%	-200.1	-179.5
30	-0.06888%	-128.8	-129.2	-0.16048%	-300.1	-269.2
40	-0.09184%	-171.7	-172.3	-0.21397%	-400.1	-359.0
50	-0.11480%	-214.7	-215.3	-0.26746%	-500.2	-448.7
60	-0.13776%	-257.6	-258.4	-0.32095%	-600.2	-538.5
70	-0.16072%	-300.6	-301.5	-0.37445%	-700.2	-628.2
80	-0.18368%	-343.5	-344.5	-0.42794%	-800.2	-718.0

	Tap Water for Soda			Tap Water for Juices		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
90	-0.20664%	-386.4	-387.6	-0.48143%	-900.3	-807.7
100	-0.22960%	-429.4	-430.7	-0.53492%	-1000.3	-897.5

As pointed out earlier in this section, GHGs for juices are higher than sodas. Thusly, replacing soda with tap water will not produce larger reductions than replacing juice with tap water. The same goes for cost changes as well. Cost and emissions savings are twice as much for juice than soda when replaced with tap water. Below we find that replacing candy with apples will not only provide greater nutritional value, it will also provide a reduction in emissions and costs.

Table 8.19 Substitution Scenario for Candy

	APPLES		
PERCENTAGE CHANGE	**TOTAL EMISSIONS CHANGE**	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
10	-0.00033%	-0.6	-0.6
20	-0.00066%	-1.2	-1.3
30	-0.00099%	-1.9	-1.9
40	-0.00132%	-2.5	-2.6
50	-0.00165%	-3.1	-3.2
60	-0.00198%	-3.7	-3.8
70	-0.00232%	-4.3	-4.5
80	-0.00265%	-4.9	-5.1
90	-0.00298%	-5.6	-5.7
100	-0.00331%	-6.2	-6.4

The last processed food health concern that we address is nitrite levels. Nitrite additives in processed meats like hot dogs can form carcinogens. Other processed meats include bacon, sausage and lunch meats. A study performed revealed the relationship between the intake of certain nitrite-containing foods and the risk of leukemia in children from birth to age 10 near Los Angeles County. The study found that children eating more than 12 hot dogs per month have nine times the normal risk of developing childhood leukemia. To address these concerns we provided food purchase choices for processed meats in the following tables.

Table 8.20: Substitution Scenario for Processed Pork Products

	Fresh Pork For Bacon			Fresh Pork for Franks			Fresh Pork for Pizza Meat Topping		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
10	-0.00148%	-2.8	-12493.9	0.00292%	5.5	-1058.8	-0.00016%	-0.3	-0.1
20	-0.00297%	-5.5	-24987.7	0.00584%	10.9	-2117.6	-0.00032%	-0.6	-0.2
30	-0.00445%	-8.3	-37481.6	0.00875%	16.4	-3176.5	-0.00048%	-0.9	-0.3
40	-0.00593%	-11.1	-49975.4	0.01167%	21.8	-4235.3	-0.00063%	-1.2	-0.4
50	-0.00742%	-13.9	-62469.3	0.01459%	27.3	-5294.1	-0.00079%	-1.5	-0.5
60	-0.00890%	-16.6	-74963.2	0.01751%	32.7	-6352.9	-0.00095%	-1.8	-0.6
70	-0.01038%	-19.4	-87457.0	0.02042%	38.2	-7411.8	-0.00111%	-2.1	-0.6
80	-0.01187%	-22.2	-99950.9	0.02334%	43.6	-8470.6	-0.00127%	-2.4	-0.7
90	-0.01335%	-25.0	112444.8	0.02626%	49.1	-9529.4	-0.00143%	-2.7	-0.8
100	-0.01483%	-27.7	124938.6	0.02918%	54.6	10588.2	-0.00159%	-3.0	-0.9

We see that replacing bacon and pizza meat topping will reduce both emissions and costs. However in the franks (hot dog) substitution scenario we find that emission increase; the manufacturing processes utilized to produce franks could explain this. Franks might use less emissions intensive mechanisms to manufacture products compared to slaughterhouses and as a result, fresh pork replacing franks increase total GHG emissions.

In **Table 8.21** below it appears as though fresh pork will produce more emissions in production compared to ham or pork deli slice production. Even though fresh pork contains less additives and preservatives, ham and pork deli slices are cheaper to produce and probably more desirable for hospital sandwich meals. Nitrite ingredients in these meats should be considered before purchasing and alternative, lower nitrite containing meats should be researched as a healthier choice. Unlike pork deli-meats, lunchmeat replaced by fresh turkey meat reduces both emissions and costs while improving nutritional value.

Table 8.21: Substitution Scenarios for Deli Meats

	Fresh Pork for Ham			Fresh Pork for Pork Deli Slices			Fresh Turkey for Lunchmeat		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
10	0.00540%	10.1	3.2	0.00012%	0.2	0.1	-0.00014%	-0.3	0.0
20	0.01079%	20.2	6.3	0.00024%	0.5	0.1	-0.00029%	-0.5	-0.1
30	0.01619%	30.3	9.5	0.00036%	0.7	0.2	-0.00043%	-0.8	-0.1
40	0.02158%	40.4	12.6	0.00048%	0.9	0.3	-0.00058%	-1.1	-0.2

	Fresh Pork for Ham			Fresh Pork for Pork Deli Slices			Fresh Turkey for Lunchmeat		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
50	0.02698%	50.4	15.8	0.00060%	1.1	0.4	-0.00072%	-1.3	-0.2
60	0.03237%	60.5	18.9	0.00072%	1.4	0.4	-0.00086%	-1.6	-0.2
70	0.03777%	70.6	22.1	0.00085%	1.6	0.5	-0.00101%	-1.9	-0.3
80	0.04316%	80.7	25.2	0.00097%	1.8	0.6	-0.00115%	-2.2	-0.3
90	0.04856%	90.8	28.4	0.00109%	2.0	0.6	-0.00130%	-2.4	-0.4
100	0.05395%	100.9	31.5	0.00121%	2.3	0.7	-0.00144%	-2.7	-0.4

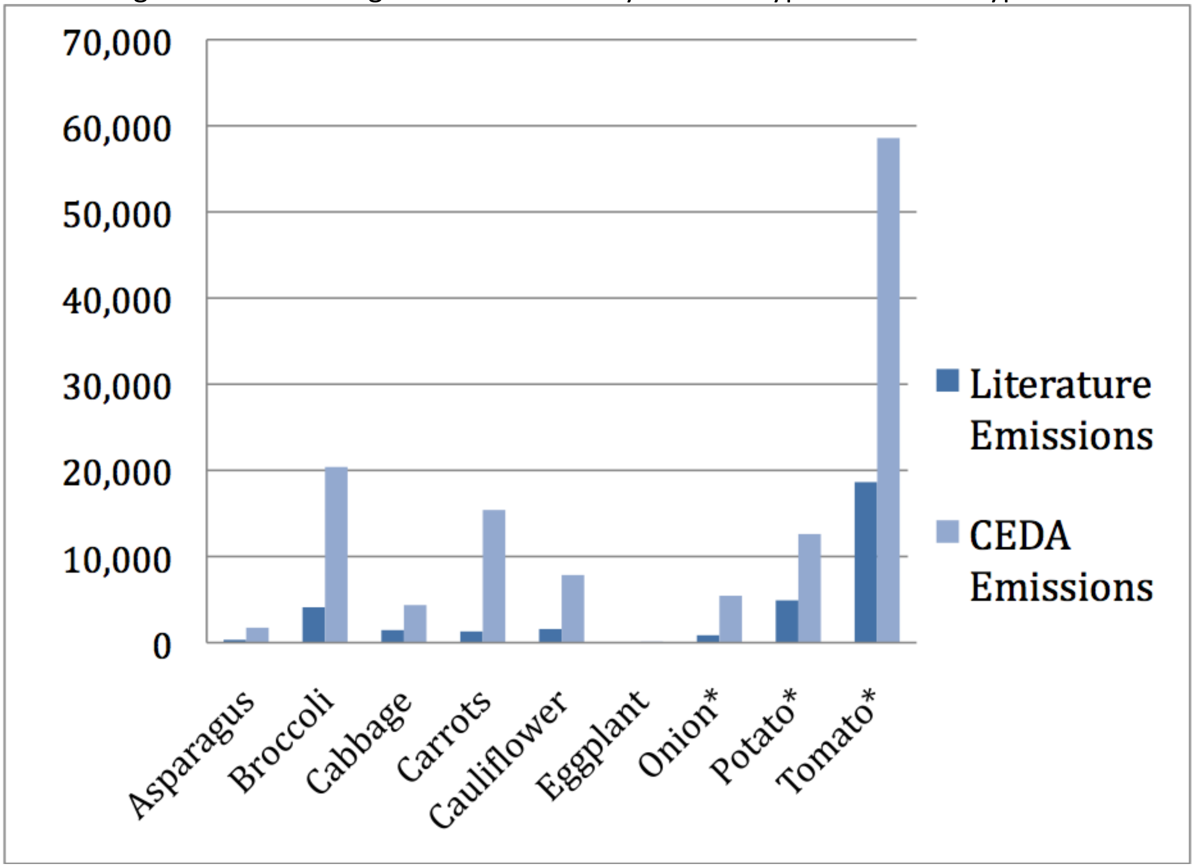
Overall, processed foods account for a percentage of Kaiser Permanente's GHG gas totals that cannot be ignored. We addressed the health consequences of processed food products by providing presumed healthier alternatives. In doing this we were able to also gauge the rate at which GHG emissions and costs could be reduced. Of the substitution scenarios generated, 65% of them produced reductions in both emissions and costs. It is clear that reductions in processed foods purchasing will more than likely, reduce emission, costs and provide health co-benefits.

8.2 Process-Based Model Results

Using a process-based approach it is possible to not only compare the different emissions levels found with various methodologies, but find more specific emissions factors than are available with CEDA. Appendix A lists all of the emissions results determined using the process-based model methodology.

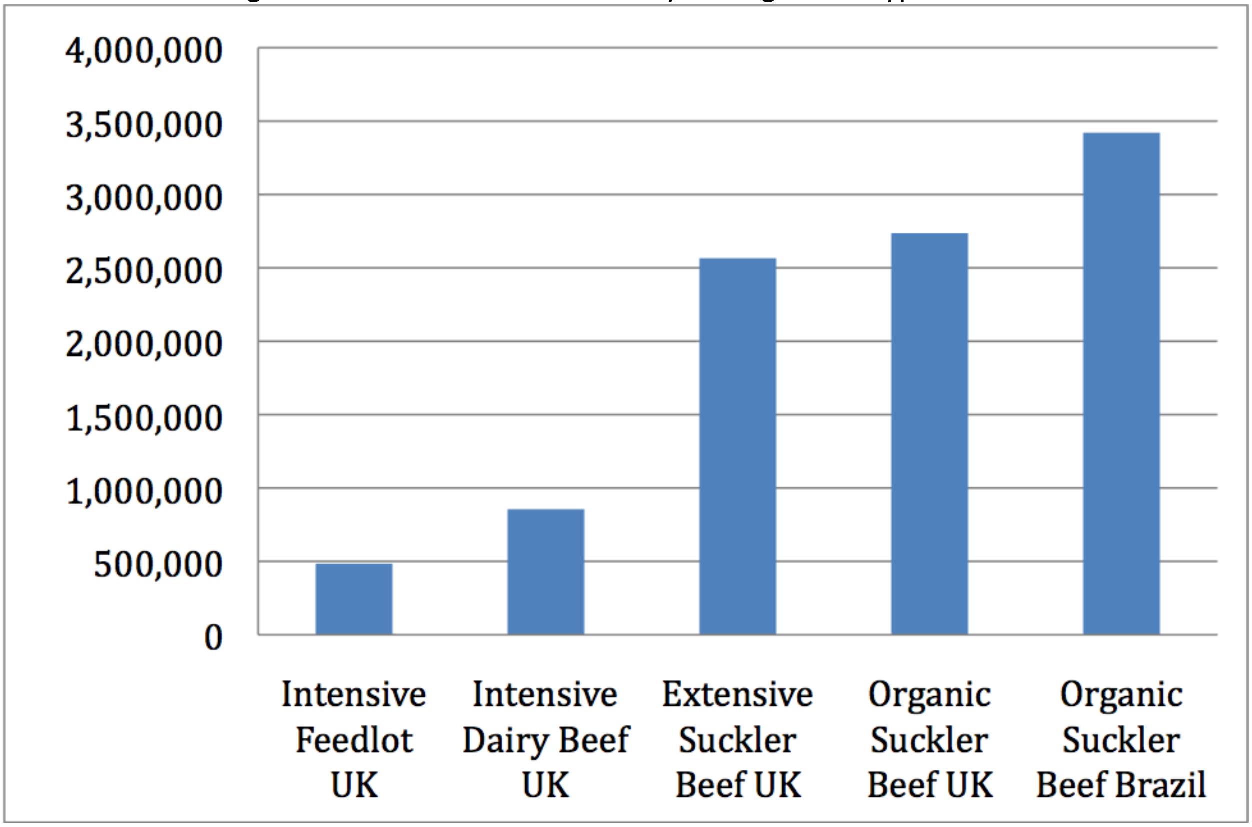
In **Figure 8.4** Fresh Vegetable Emissions by Product Type and Model Type, we use distinct emissions factors taken from the scientific literature for specific vegetables, and compare the overall effect on emissions subtotals between CEDA subtotals. It is important to note that the CEDA subtotals in this case are derived from a single emissions factor for fresh vegetables. While this is an average value for vegetables, it also represents emissions from an economy-wide, multi-tier input-output perspective, and thus the higher emissions totals would be expected. There is also the possibility that, since the emissions factors used in this example are derived from a process-based analysis in the United Kingdom, they would be lower than those found for a comparable study in the United States. Unfortunately, however, there are surprisingly few scientific studies on GHGs of food products in the United States, so we compare our results using the closest equivalents.

Figure 8.4: Fresh Vegetable Emissions by Product Type and Model Type.



Estimating more precise emissions totals using process-based approaches for different types of products doesn't give the greatest depth to our study as is possible. More specific emissions factors for different production and management practices for given products is ideal. Agricultural and livestock practices that have an influence on emissions can be incorporated into our estimates, illustrated by the example in **Figure 8.5** Fresh Beef Emissions by Management Type. In this case we illustrate how fresh beef emissions totals would vary depending on the type of management, with the most carbon-intensive type (Organic Suckler Beef from Brazil) almost seven times higher than the least (Intensive Feedlot). With this kind of information we can make some generalizations for purchasing decisions going forward, extrapolating that organic beef would be expected to have higher emissions than intensive beef, and that extensive beef would have higher emissions than intensive beef. Where information is lacking from Sysco food suppliers, purchasing decisions can be made based on inferences and studies for comparable products.

Figure 8.5: Fresh Beef Emissions by Management Type



Substitution Scenarios with Process Based-Results

We used the same substitution scenario explained in the CEDA section to generate more substitution choices for Kaiser Permanente based on Process-Based Data. The substitution scenarios presented by this data allow us to differentiate different management system for each product while CEDA data did not. Process-based Data also allows us to analyze products with different emissions factors. One setback for Process-based data is that there is no price differentiation because the USDA Price Data Sheet we used did not provide organic food prices or other management specific food product prices.

We first addressed meat products and created substitution scenarios for the most common meat processing manufacturing system, intensive feedlot. In intensive feedlots, dairy beef calves are produced from a dairy herd, raised intensively on predominantly cereal diets and housed 100% of the year. **Table 8.22** shows us that intensive feedlots for beef production generate low emissions compared to extensive suckler beef and organic suckler beef production. Extensive suckler beef calves are produced by beef suckler cows and raised with mother on a predominantly grass and forage based diet (housed 50% of the year). Organic suckler beef calves are produced by organic beef suckler cows and raised with the mother on a predominantly organic grass based diet, using organic management techniques and stocking densities (housed 45% of the year). These literature emissions were extracted from a UK study carried out by DEFRA. They concluded that animal and soil emissions contributed the most to emissions. Lower yields and slower growth rates in the organic beef systems meant that there were increased levels of animal and soil emissions allocated per kg of organic meat compared to extensive suckler beef and intensive feedlot beef. A 25% reduction in intensive feedlot beef for extensive suckler beef or organic suckler beef will result in 427.4 tons and 470.2 tons of CO2e emissions released, respectively.

Table 8.22: Substitution Scenario for Intensive Feedlot Beef

	Extensive Suckler Beef			Organic Suckler Beef		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
10	0.09143%	171.0	0.0	0.10057%	188.1	0.0
20	0.18286%	342.0	0.0	0.20115%	376.1	0.0
30	0.27429%	512.9	0.0	0.30172%	564.2	0.0
40	0.36573%	683.9	0.0	0.40230%	752.3	0.0
50	0.45716%	854.9	0.0	0.50287%	940.4	0.0
60	0.54859%	1025.9	0.0	0.60345%	1128.4	0.0
70	0.64002%	1196.8	0.0	0.70402%	1316.5	0.0
80	0.73145%	1367.8	0.0	0.80460%	1504.6	0.0
90	0.82288%	1538.8	0.0	0.90517%	1692.7	0.0
100	0.91431%	1709.8	0.0	1.00575%	1880.7	0.0

As a supplement to the intensive feedlot beef substitutions, we took an emission reducing and nutrition-improving approach. We created a situation where a quarter of the beef purchase would be supplemented with its caloric protein equal. We used refried beans and lima beans , two high-protein food products with adequate data available to us. Beans provide other nutritional benefits including, vitamin B, fiber and other important nutrients. Lima beans and refried beans contain 11.97 g and 13.83 g of protein per cup, respectively.[144] Below is table presenting the emissions and cost changes when a quarter of beef purchases are replaced with beans. We can see that savings will be very similar differing by <1 metric ton per 10% change; this is due the close emissions factors for refried and lima beans. It is apparent that substituting anyway beef product for non-beef protein products like beans will decrease emissions substantially.

[144]USDA National Nutrient Database for Standard Reference, Release 20

Table 8.23 Substitution Scenario for Intensive Feedlot Beef - Protein Supplement

	Intensive Beef + Lima Beans			Intensive Beef +Refried Beans		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (metric tons of CO2eq)	COST CHANGE ($1000s)
10	-0.00976%	-18.3	0.0	-0.01013%	-18.9	0.0
20	-0.01953%	-36.5	0.0	-0.02026%	-37.9	0.0
30	-0.02929%	-54.8	0.0	-0.03039%	-56.8	0.0
40	-0.03905%	-73.0	0.0	-0.04052%	-75.8	0.0
50	-0.04881%	-91.3	0.0	-0.05065%	-94.7	0.0
60	-0.05858%	-109.5	0.0	-0.06078%	-113.7	0.0
70	-0.06834%	-127.8	0.0	-0.07091%	-132.6	0.0
80	-0.07810%	-146.1	0.0	-0.08104%	-151.5	0.0
90	-0.08787%	-164.3	0.0	-0.09117%	-170.5	0.0
100	-0.09763%	-182.6	0.0	-0.10130%	-189.4	0.0

The same substitution scenarios were generated for pork and chicken. The following two tables present our findings. Please note that in all Process-based substitution scenarios, prices will remain the same hence the zero values for the Cost Change column in the substitution tables in this section.

Table 8.24: Substitution Scenario for Intensive Feedlot Pork

	Extensive Suckler Pork (outdoor pork)			Organic Pork		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
10	-0.00376%	-7.0	0.0	-0.00375%	-7.0	0.0
20	-0.00752%	-14.1	0.0	-0.00750%	-14.0	0.0
30	-0.01127%	-21.1	0.0	-0.01125%	-21.0	0.0
40	-0.01503%	-28.1	0.0	-0.01500%	-28.1	0.0
50	-0.01879%	-35.1	0.0	-0.01876%	-35.1	0.0
60	-0.02255%	-42.2	0.0	-0.02251%	-42.1	0.0
70	-0.02631%	-49.2	0.0	-0.02626%	-49.1	0.0
80	-0.03006%	-56.2	0.0	-0.03001%	-56.1	0.0
90	-0.03382%	-63.2	0.0	-0.03376%	-63.1	0.0
100	-0.03758%	-70.3	0.0	-0.03751%	-70.1	0.0

For pork we reveal that extensive suckler pork and organic pork production is less energy intensive than the beef substitution scenario. This could be attributed to the fact that livestock management practices for swine are less energy and GHG intensive than livestock management practice of cattle. Additionally, pork production emissions lack enteric emissions, which account for a large portion of emissions for cattle feedlots.

Table 8.25: Substitution Scenario for Intensive Feedlot Chicken

	Extensive Chicken			Organic Chicken		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
10	0.00096%	1.8	5787.7	0.00159%	3.0	5787.7
20	0.00191%	3.6	11575.5	0.00319%	6.0	11575.5
30	0.00287%	5.4	17363.2	0.00478%	8.9	17363.2
40	0.00383%	7.2	23151.0	0.00638%	11.9	23151.0
50	0.00478%	8.9	28938.7	0.00797%	14.9	28938.7
60	0.00574%	10.7	34726.5	0.00957%	17.9	34726.5
70	0.00670%	12.5	40514.2	0.01116%	20.9	40514.2
80	0.00765%	14.3	46302.0	0.01276%	23.9	46302.0
90	0.00861%	16.1	52089.7	0.01435%	26.8	52089.7
100	0.00957%	17.9	57877.5	0.01595%	29.8	57877.5

We find that intensively produced chicken creates the least emissions out of the three chicken-producing methods. Thusly, substitution intensive chicken with extensive or organic chicken will increase GHG emissions. A total of 1800 kg of CO2e will be added to Kaiser Permanente's total GHG emissions for food services if purchases shift from 10% Intensive chicken to extensive.

We first gather the top fruit emitters; fresh apples, melons and pineapples contribute to the highest fresh fruit emissions. Fresh apples emit 75090.4 kg CO2e and fresh melons emit 80349.8 kg CO2e. We substituted apples and melons with fresh fruits that had varying emissions factors to present Kaiser Permanente with the most efficient emissions and cost reducing scenarios.

Since literature emissions values were only available for apples and pineapples (the next higher emitter since melons were not available), the substitution analysis focused on scenarios for replacing apples and pineapples with another fresh fruit. The fresh fruits available for substitution within the literature emissions database were pears, peaches, bananas, oranges and mangoes.

In **Table 8.26**, apples were substituted with pears, peaches, bananas and oranges. In each case, the substitution increases emissions. We find that a substitution of apples with oranges results in the smallest emissions increase but also the greatest cost change. For example, for a 10% substitution, there is 0.04 tons of CO2e increase and a cost increase of about $10,830. A substitution of apples for pears, peaches or oranges would also lead to increases in emissions but would not be as costly. For example, an increase in the purchase of bananas instead of apples at a 10% change would result in an increase in 1.9 tons of CO2e but a cost savings of $2,400.

Table 8.26: Substitution of Apples for Other Fresh Fruits (Literature Emissions)

	PEARS			PEACHES			BANANAS			ORANGES		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
10	0.00042%	0.78	0.13	0.00042%	0.78	0.89	0.00102%	1.9	-1.49	0.00004%	0.08	10.83
20	0.00083%	1.56	0.25	0.00083%	1.56	1.78	0.00204%	3.81	-2.98	0.00009%	0.17	21.66
30	0.00125%	2.34	0.38	0.00125%	2.34	2.68	0.00305%	5.71	-4.48	0.00013%	0.25	32.49
40	0.00167%	3.13	0.51	0.00167%	3.13	3.57	0.00407%	7.61	-5.97	0.00018%	0.33	43.32
50	0.00209%	3.91	0.64	0.00209%	3.91	4.46	0.00509%	9.52	-7.46	0.00022%	0.42	54.14
60	0.00251%	4.69	0.76	0.00251%	4.69	5.35	0.00611%	11.42	-8.95	0.00027%	0.5	64.97
70	0.00293%	5.47	0.89	0.00293%	5.47	6.24	0.00712%	13.32	-10.44	0.00031%	0.58	75.8
80	0.00334%	6.25	1.02	0.00334%	6.25	7.13	0.00814%	15.23	-11.93	0.00035%	0.66	86.63
90	0.00376%	7.03	1.15	0.00376%	7.03	8.03	0.00916%	17.13	-13.43	0.00040%	0.75	97.46
100	0.00418%	7.81	1.27	0.00418%	7.81	8.92	0.01018%	19.03	-14.92	0.00044%	0.83	108.29

Given the fresh fruit emissions values available in the literature, pineapples were replaced with oranges and mangoes since they seem to be the most likely substitutes. A substitution with oranges decreases emissions, while a substitution with mangoes increases emissions. Both substitutions would result in cost savings for Kaiser Permanente.

Table 8.27 Substitution of Pineapple for Other Fresh Fruit

	ORANGES			MANGOES		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (Metric Tons of CO2eq)	COST CHANGE ($1000s)
10	-0.00027%	-0.51	-0.84	0.00089%	1.66	-2.4
20	-0.00055%	-1.02	-1.67	0.00178%	3.33	-4.8
30	-0.00082%	-1.53	-2.51	0.00267%	4.99	-7.21
40	-0.00110%	-2.05	-3.34	0.00356%	6.65	-9.61
50	-0.00137%	-2.56	-4.18	0.00444%	8.31	-12.01
60	-0.00164%	-3.07	-5.01	0.00534%	9.98	-14.41
70	-0.00191%	-3.58	-5.85	0.00622%	11.64	-16.81
80	-0.00219%	-4.09	-6.68	0.00711%	13.3	-19.22
90	-0.00246%	-4.6	-7.52	0.00800%	14.96	-21.62
100	-0.00274%	-5.12	-8.36	0.00889%	16.63	-24.02

In terms of vegetables, according to both CEDA and CMU, tomatoes, iceberg lettuce, romaine lettuce, beans and broccoli had the highest associated GHG emissions. Only broccoli and its likely substitutes, however, were available in the literature emissions database. The replacements available were cauliflower, cabbage and asparagus. A substitution with cauliflower and cabbage decreases emissions, while a substitution with asparagus increases emissions. The best substitution would be cabbage, since it also results in a cost savings. For example, a 10% replacement of broccoli for cabbage results in a reduction of 1.29 tons of kgCO2e and a cost savings of $950.

Table 8.28: Substitution of Broccoli for Other Fresh Vegetables

	CAULIFLOWER			CABBAGE			ASPARAGUS		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
10	-0.00053%	-1	0.53	-0.00069%	-1.29	-0.95	0.00032%	0.6	0.65
20	-0.00106%	-1.99	1.05	-0.00138%	-2.58	-1.89	0.00065%	1.21	1.3
30	-0.00160%	-2.99	1.58	-0.00207%	-3.88	-2.84	0.00097%	1.81	1.95
40	-0.00213%	-3.99	2.1	-0.00276%	-5.17	-3.78	0.00129%	2.41	2.59
50	-0.00266%	-4.98	2.63	-0.00345%	-6.46	-4.73	0.00161%	3.02	3.24
60	-0.00320%	-5.98	3.15	-0.00414%	-7.75	-5.68	0.00194%	3.62	3.89

	CAULIFLOWER			CABBAGE			ASPARAGUS		
PERCENTAGE CHANGE	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)	TOTAL EMISSIONS CHANGE	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
70	-0.00373%	-6.98	3.68	-0.00483%	-9.04	-6.62	0.00226%	4.22	4.54
80	-0.00426%	-7.97	4.2	-0.00552%	-10.33	-7.57	0.00258%	4.83	5.19
90	-0.00480%	-8.97	4.73	-0.00622%	-11.63	-8.52	0.00290%	5.43	5.84
100	-0.00533%	-9.97	5.25	-0.00691%	-12.92	-9.46	0.00322%	6.03	6.49

The results from the process-based emissions substitutions analysis are more limited in scope than substitutions analyses conducted in CEDA and CMU because they are restricted to the types of products available in the literature emissions database. However, these additional analyses offer Kaiser Permanente the opportunity to explore other factors such as management types and substitutions between specific items (for example, apples for oranges) – analyses which EIO LCA-based substitutions analyses are incapable of doing.

8.3 CMU Toxic Results

The two main categories found to be predominantly associated with large emissions of toxics are 'Supplies' and 'Others'. Supplies category includes items purchased by Kaiser Permanente for their kitchen maintenance, cleaning, storage, cutlery etc. Other category includes food products such as candy and nuts, cocoa, coffee, cookies, desserts etc. other than the large categories of Dairy, Drinks, Fruits, Vegetables, Convenience Products, Grains, Poultry and Meat.

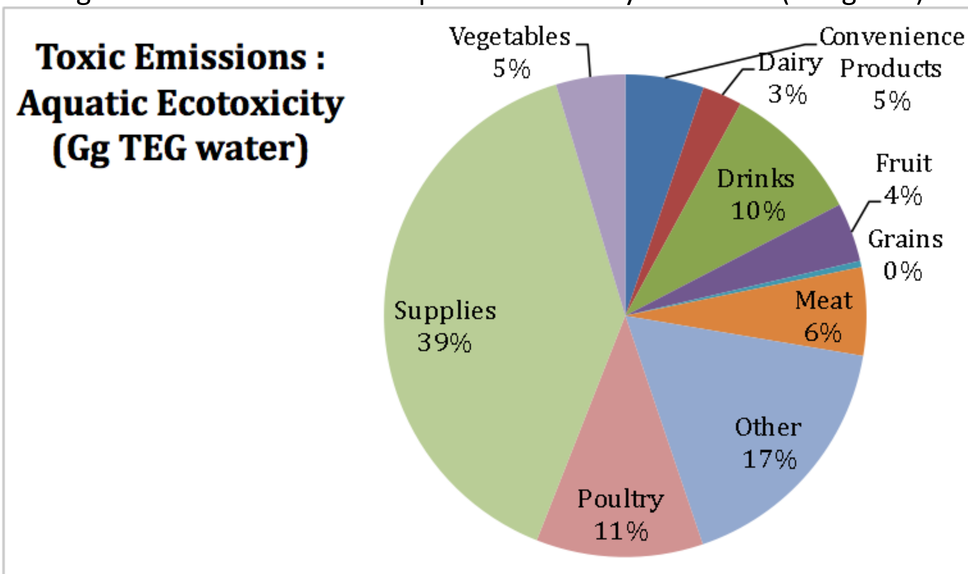
One reason for large emissions associated with these two categories could be their large purchase price relative to other products. Since EIO models are linearly dependent on the price of the product, a large price for a product will reflect large emissions associated with that product. However, it could also be that in the production and supply chain of items belonging to these two categories, there might be more toxic releases associated as compared to the other products. The Supplies category in particluar, includes metal and chemical based products such as aluminum foil, pots & pans and cleaning agents. Toxic releases from production of these products might be more than toxic releases from food production.

One interesting pattern noticed is that while toxic emissions from Supplies dominate the impact categories – Terrestrial Ecotoxicity, Carcinogens, Non-Carcinogens and Ozone Depletion, the category of Other food items results in more emissions from Terrestrial and Aquatic Acidification, Respiratory Organics and Inorganics and Eutrophication. This might again be due to the fact that food production is associated more with ecological impacts such as acidification and eutrophication caused due to fertilizer runoff during food production, while supplies production might be associated more with health impacts such as carcinogen release during metal and chemical production etc.

Ecotoxicity

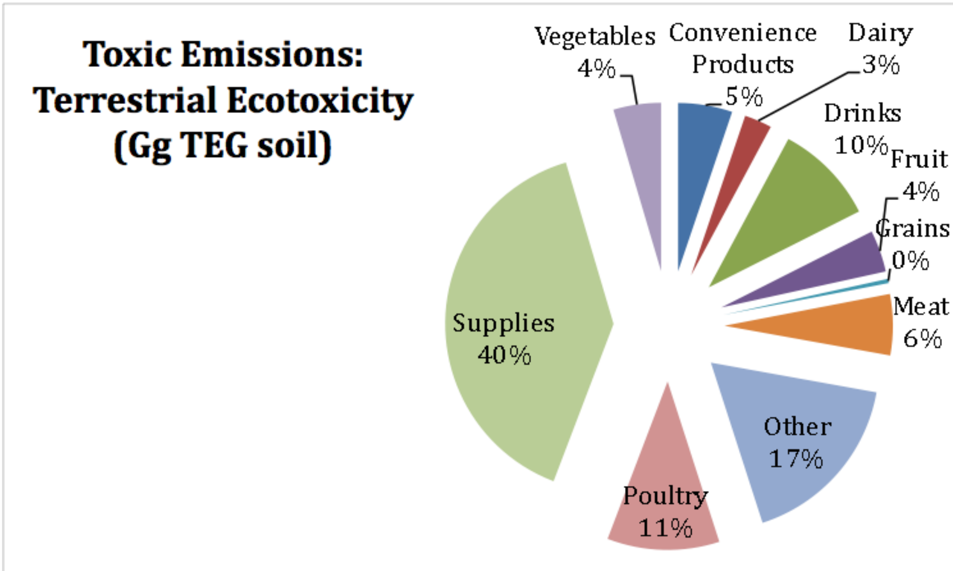
Figure 8.6 and 8.7 illustrate the potential toxicity impacts of water and soil due to chemicals released into air, water and soil from each food type. The values were taken from the IMPACT 2002 model, as used in CMU, and incorporated into our Access database to find results based on spending amounts. Of the food-related categories, soft drink and ice manufacturing is the most polluting to water on a per-dollar basis. In considering substitutions, poultry has 63% greater toxicity than beef and pork, and 166% greater toxicity than seafood.

Figure 8.6: Distribution of aquatic ecotoxicity emissions (in Gg TEG)



Similar to aquatic ecotoxicity, of the food-related categories, soft drink and ice manufacturing is the most toxic to land on a per-dollar basis. In considering substitutions, poultry has 58% greater toxicity than beef and pork, and 158% greater toxicity than seafood. In both of the ecotoxicity categories we find that poultry is among the highest emitters. Wet corn milling and soybean and oilseed processing also have high relative toxicity, which is important to keep in mind for substitutions of grain-based products, soymilk and tofu, and oils. The large portion of ecotoxicity related to production of different supplies should also be considered when determining whether to purchase new or alternative supplies.

Figure 8.7: Distribution of terrestrial ecotoxicity emissions (in Gg TEG)



Acidification

Figure 8.8 illustrates the increased acidity to water, and **Figure 9.7** the increased acidity to terrestrial ecosystems due to chemicals released into air, water and soil from each sector. The values were taken from the CML model, as used in CMU, and incorporated into our Access database to find results based on spending amounts. Of the food-related categories, for both aquatic and terrestrial acidification sugar manufacturing is by far the most toxic on a per-dollar basis. At 11,100 kg SO_2 eq for every one million dollars in spending, sugar production is over 10 times as acidifying to water on a per-dollar basis than the next highest sector, wet corn milling. For terrestrial acidification, sugar production is over six times as high as seasoning and dressing manufacturing, which is the next highest. These environmental implications should complement the dietary health benefits of reduced sugar consumption. For meat substitutions, poultry has 20% greater aquatic acidification and 28% terrestrial acidification than beef and pork, and 4 times greater aquatic acidification and 3 times great terrestrial acidification than seafood. In replacing soy-based products with dairy, there is a 25% increase in both aquatic and terrestrial acidification on a per-dollar basis.

Figure 8.8: Distribution of aquatic acidification emissions (in kg SO_2 equivalent)

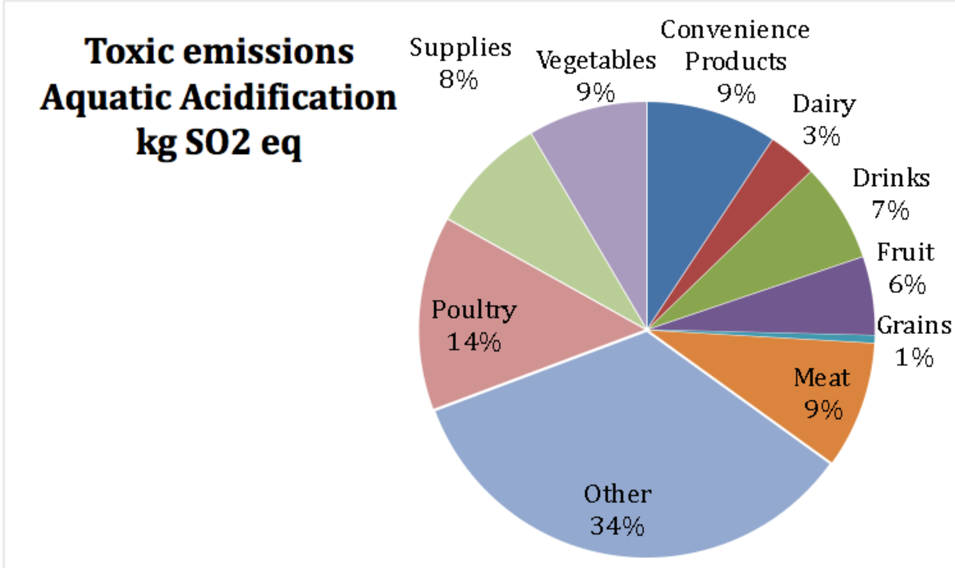
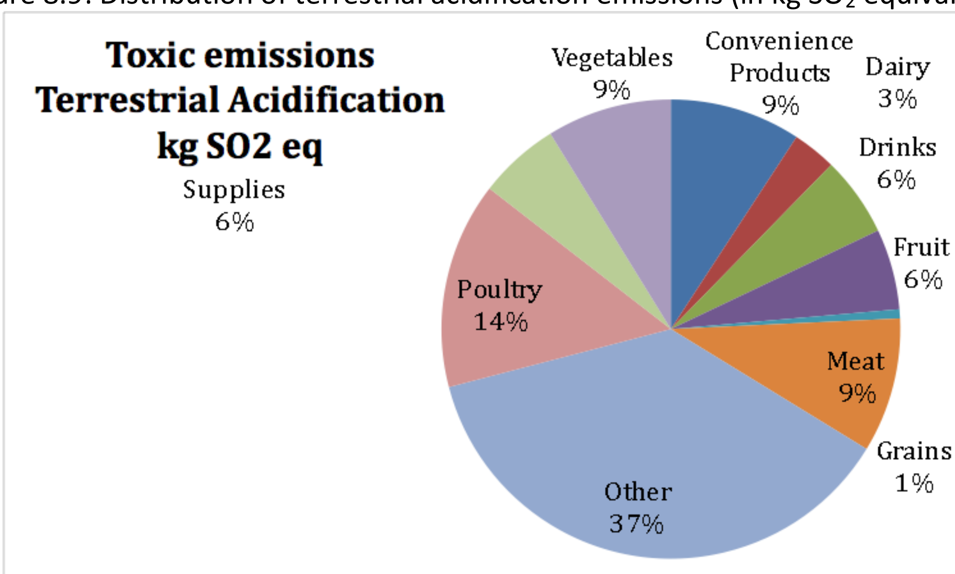


Figure 8.9: Distribution of terrestrial acidification emissions (in kg SO_2 equivalent)



Respiratory Emissions

Respiratory health risks from Kaiser Permanente's food purchases are represented in **Figures 8.10**and **8.11** below, for organic and inorganic emissions, respectively. The values were taken from the Eco-Indicator 99 model, as used in CMU, and incorporated into our Access database to find results based on spending amounts. Sugar manufacturing is by far the most toxic for inorganic emissions, at 89.9 kg $PM_{2.5}$ per million dollars spent, compared with 8 kg $PM_{2.5}$ for seasoning and dressing manufacturing, the next highest. Seasoning and dressing manufacturing is also among the highest emitters for organic emissions, and wet corn milling is the third highest for both organic and inorganic. Poultry production is almost 4 times as great as beef and pork for organic emissions, yet only 20% higher for inorganic emissions. Compared with seafood, poultry is 4 times as high for inorganic emissions and 3.3 times as high for organic emissions. Compared with dairy products, soy-based products have approximately 15 times greater organic emissions, but only 26% greater inorganic emissions.

Figure 8.10: Distribution of respiratory organic emissions (in kg C_2H_4 equivalent)

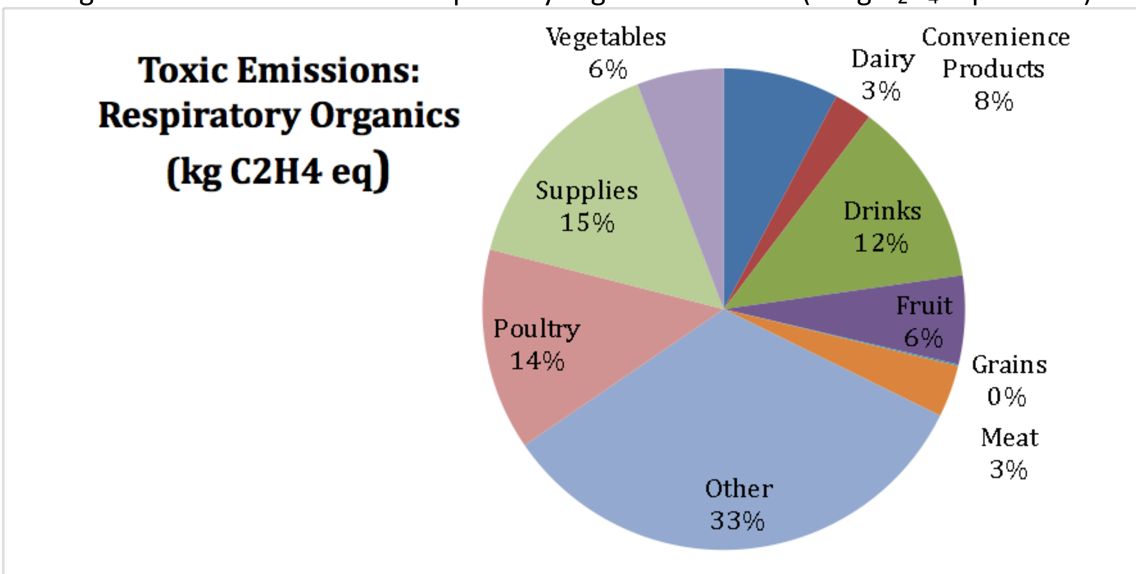
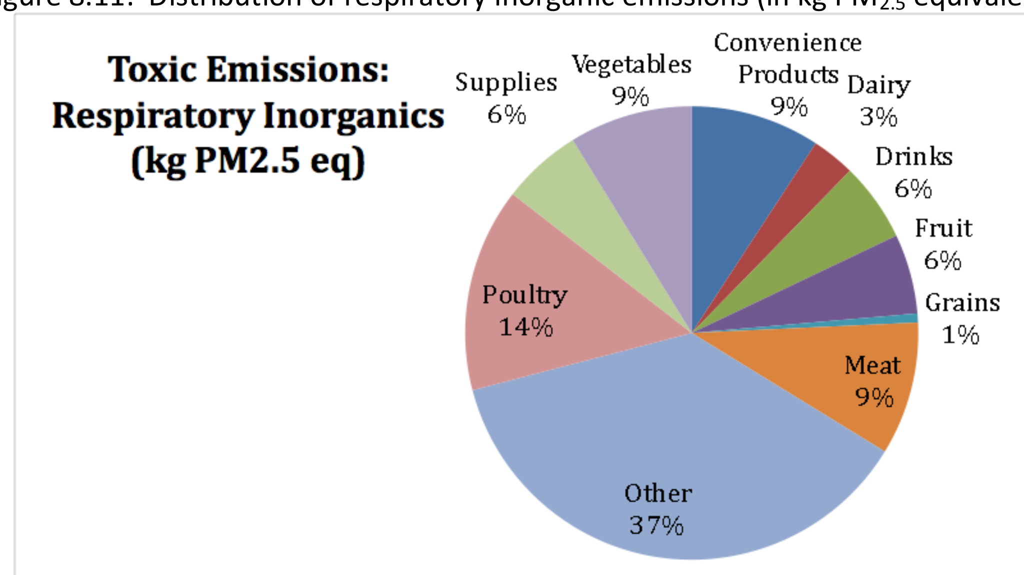


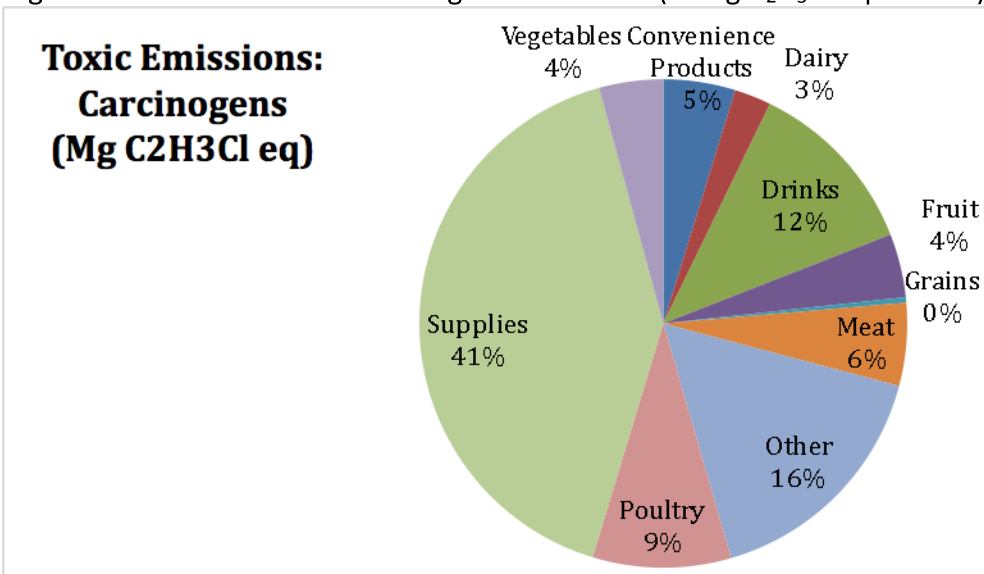
Figure 8.11: Distribution of respiratory inorganic emissions (in kg $PM_{2.5}$ equivalent)



Carcinogenic Emissions

Figure 8.12 illustrates the carcinogenic emissions and the toxicological effects of chemicals released to the air, water and soil for each food type. The values were taken from the IMPACT 2002 model, as used in CMU, and incorporated into our Access database to find results based on spending amounts. Supplies account for a large portion of these emissions, with only soft drink and ice manufacturing in the same range as manufacturing processes for equipment used in food preparation and serving. This is another environmental health-related reason for reductions of soft drink purchases, particularly given the emissions are over 2.5 times higher than those for fruit and vegetable processing associated with juice production. Again we find higher emissions associated with poultry production than beef and pork production, in this case 43% higher.

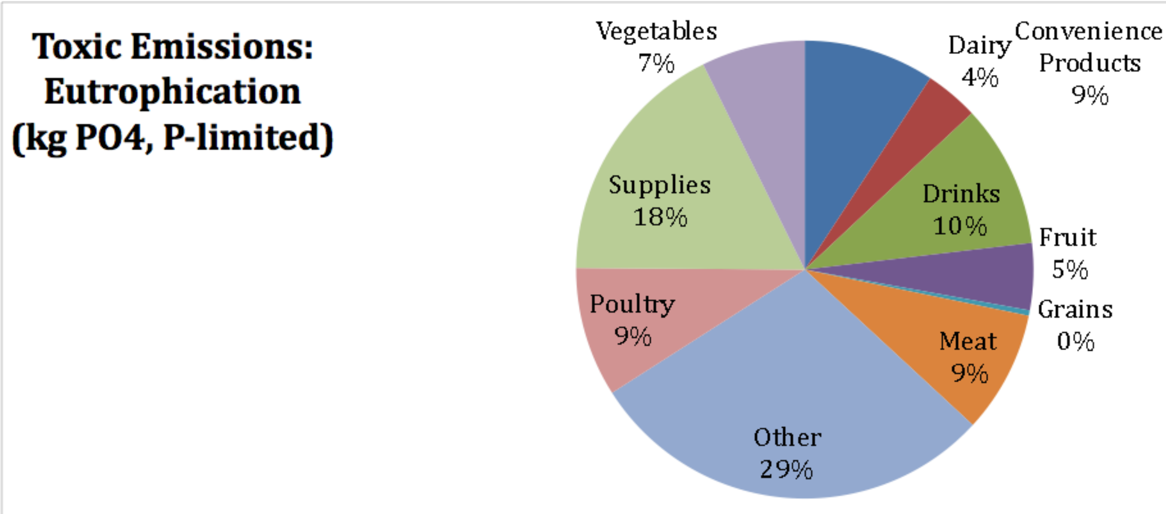
Figure 8.12 Distribution of carcinogenic emissions (in Mg C_2H_3Cl equivalent)



Eutrophication

Emissions of phosphate which lead to eutrophication of water-bodies are shown for different purchase categories in Figure 8.13. The values were taken from the CML model, as used in CMU, and incorporated into our Access database to find results based on spending amounts. Wet corn milling, which is among the top emitters for each of the other categories, is the highest in eutrophication, followed by production of bread and bakery products. In this category, poultry and beef and pork production have equal emissions factors, with seafood processing slightly higher. Seasoning and dressing manufacturing, as well production of fats and oils are also high in this category.

Figure 8.13: Distribution of emissions associated with eutrophication (in kg PO_4)



Assumptions and Limitations of Toxic Release Results

There is a high level of uncertainty associated with Toxic Release Results from the CMU Model and for this reason, caution should be exercised when using the results to inform any kind of formal decision-making process. The high level of uncertainty in the results stems from three main areas:

Limitations of the original data

The original data on toxic release emissions are limited by the scope of industry reporting requirements. For example, emission reports for the Toxic Release Inventory (TRI), on which the CMU model is based, are collected only from those facilities that: 1) employ 10 or more full-time equivalent employees 2) manufacture or process over 25,000 pounds or 3) use over 10,000 pounds of any listed chemical during the given year.[145] While the individual emissions from facilities not meeting these standards may be relatively small, when considered all together they may be significant. Yet this total impact of all small facilities is excluded from the TRI based on current reporting practices. Though other toxic release inventories are also available for public use – namely the National Toxics Inventory (NTI) and the database from the National Center for Food and Agricultural Policy (NCFAP) – they are not utilized in the CMU model. A comparison of completeness between the NTI and TRI databases by Suh suggested that there may be significant "systematic truncations" in the TRI. Suh's study showed that the TRI showed only 17.2% of Hazardous Air Pollutants in comparison to the NTI.[146] Therefore any estimate of toxic releases generated by the CMU model, which only relies on the TRI, is likely to underestimate the amount of toxic releases.

[145] Suh, S. (2009). Developing the Sectoral Environmental Database for Input-Output Analysis: Comprehensive Environmental Data Archive of the US. In S.Suh (Ed.), *Handbook of Input-Output Economics in Industrial Ecology, Eco-Efficiency in Industry and Science,* 23 (8), 689-712. New York: Springer Science+Business Media.

[146] Suh, S. (2009). Developing the Sectoral Environmental Database for Input-Output Analysis: Comprehensive Environmental Data Archive of the US. In S.Suh (Ed.), *Handbook of Input-Output Economics in Industrial Ecology, Eco-Efficiency in Industry and Science,* 23 (8), 689-712. New York: Springer Science+Business Media.

Lack of transparency in the CMU Model

The CMU model gives toxic release results by classifying emissions into one of five major environmental impact categories: ecotoxicity (aquatic and terrestrial), acidification (aquatic and terrestrial), respiratory organics/inorganics, carcinogens and eutrophication(aquatic). Within each impact category, characterization factors are applied to given emissions to produce indicator results in a common equivalency.[147] This equivalency is what allows different chemicals to be compared to each other in regards to a certain environmental impact. For example, eutrophication results are given in kg PO_4e, meaning that they include other chemicals besides PO_4 which have been characterized with PO_4e used as the common base (a more familiar comparison may be the use of CO2e to compare GHG emissions such as methane, nitrous oxide and CFCs). Impact models, such as the one available from Leiden University's CML-IA database, typically provide these characterization factors.

Unfortunately, the impact models are used for the CMU Model are not readily specified in the public version of the model or the Green Design Institute website. A thorough literature review on the formulation of the EIO LCA model also did not result in any information on this topic. Without this information, the full scope of the CMU toxicity results remains unknown. The user is essentially unable to decipher which chemical compounds are accounted for and which are not, and this reduces the overall strength and accountability of the results.

Limitations in Regard to Human Toxicity

Another major limitation of the CMU model is its treatment of human toxicity. The model, which focuses on toxic emissions to environmental media only, virtually neglects the effect of toxics on human welfare. Direct exposure to agriculturally derived chemicals and pathogens has been shown to pose a significant health risk to human life.[148] Those who work on farms are at the highest risk, with studies showing that exposure to pesticides is linked with Parkinson's disease, and organophosphates result in biochemical effects, as well as increased risk of leukemia and lymphoma .[149,150] While acute pesticide intoxications in workers are at "epidemic levels worldwide," knowledge of these risks is relatively unknown because incidence rates are difficult to determine and long-term effects have gone unmonitored.[151] This is true because the diversity of pesticides used make it difficult to attribute symptoms or diseases to particular chemical exposures. Another occupational hazard that cannot be ignored is the mental health of farmers: studies have shown high levels of stress, depression and anxiety, and that farmers have one of

[147] Geyer, R. (2011). "Life Cycle Impact Assessment." ESM 282, Industrial Ecology. Bren School of Environmental Science and Management, University of California, Santa Barbara. January 22, 2011.

[148] Environmental Protection Agency (2011). Human Health Issues. Retrieved March 14, 2011 from http://www.epa.gov/pesticides/health/human.htm

[149] Ascherio, A., Chen, H., Weisskopf, M.G., O'Reilly, E., McCullough, M.L., Calle, E.E., Schwarzchild, M.A., Thun, M.J. (2006). Pesticide Exposure and Risk for Parkinson's Disease. *Annals of Neurology:* 60(2), 197-203. DOI: 10.1002/ana.20904

[150] Lopez, O., Hernandez, A.F., Rodrigo, L., Gil, F., Pena, G., Serrano, J.L., Parron, T., Villanueva, E., and Pla, A. (2007). Changes in antioxidant enzymes in humans with long-term exposure to pesticides. *Toxicology Letters*: 171(3), 146-153.

[151] Fenske, R.A.**,** Lu C, Curl CL, Shirai JH, Kissel JC. (2005). *Biologic monitoring to characterize organophosphorus pesticide exposure among children and workers: an analysis of recent studies in Washington State.* Environmental Health Perspectives: 113(11), 1651-7.

the highest rates of suicide of any industry.[152,153,154] These factors all affect the health of the community directly, and the sustainability of food production systems more generally.

The effect of toxics in food consumption, which are also impactful to human health, is likewise neglected in the CMU model. For example, the nitrogen fertilizer used in production of many foods is not only a primary source of N_2O, it also is a cause of acute nitrate and nitrite toxicity. While the most commonly known side effect of acute nitrate toxicity is methemoglobinemia in babies ("blue baby syndrome"), a review by Rao & Puttanna found the following additional health problems:

> Oral cancer, cancer of the colon, rectum or other gastrointestinal cancers, Alzheimer's disease, vascular dementia of Biswanger type or multiple small infarct type, absorptive and secretive functional disorders of the intestinal mucosa and changes in maturation, differentiation and apoptosis in intestinal crypts, reduced casein digestion, multiple sclerosis, neural tube defects, cytogenetic effect in children, non-Hodkins's lymphoma and hypertrophy of thyroid.[155]

High concentrations of nitrates lead to the formation of carcinogenic nitrosamines, which are capable of both initiating and promoting the cancer process.[156,157] In 1996, Havender and Coulombe tested roughly 300 nitrosamines for carcinogenicity in high-dose animal cancer tests, and found approximately 90% of them to be carcinogenic.[158] Nitrates are useful, however, in countering cardiovascular disease, reducing platelet aggregation and preventing angina attacks.

While the effects of toxics on human welfare are clearly significant, in terms of occupational health hazards and direct food consumption, the CMU model does not account for either of them, instead focusing only on toxic emissions to soil, air and water. Therefore these toxic results cannot be used to judge the impact of changing consumption or purchasing patterns on human health.

Due to these factors, the robustness of the CMU Toxic Release Results is not clear. They are intended to serve as a supplement to the results generated for GHG emissions, not as a main point of research. Ultimately the use of these results is not recommended for decision-making purposes. Rather, they should be utilized to identify issues and as a means to distinguish potential future areas of research.

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[152] Booth, N.J, and Lloyd, K.L. (2000). Stress in Farmers. *International Journal of Social Psychiatry*: 46(1), 67-73. doi: 10.1177/002076400004600108

[153] Eisner, C.S., Neal, R.D. and Scaife, B. Depression and anxiety in farmers. *Primary Care Psychiatry*: 4, 101–105.

[154] Fraser, C.E. (2005). Farming and Mental Health Problems and Mental Illness. *International Journal Social Psychiatry:* 51(4), 340-349. Doi: 10.1177/0020764005060844

[155] Rao, P. and Puttanna, K. (2000). Nitrates, Agriculture and Environment. *Current Science*: 79 (9), 1163-1168.

[156] Bruning-Fann, C.S. and Kaneene, J.B. (1993). The effect of nitrite, nitrate, N-nitroso compounds on human health. *Veterinary Human Toxicology*: 35(3):237-53.

[157] Vermeer, I.T., and vanMaanen, J.M. (2001). Nitrate exposure and the endogenous formation of carcinogenic nitrosamines in humans. *Review of Environmental Health*: 16(2), 105-16.

[158] Havender, W. R. and Coulombe, R. (1996) *Does Nature Know Best? Natural Carcinogens and Anticarcinogens in America's Food.* New York, New York: American Council on Science and Health.

9. Conclusions and Recommendations

9.1 Recommendations from Substitutions and Toxic Analysis

Based on our substitutions analysis, possibly the greatest potential for emissions reductions comes from cutting beef consumption. As an example scenario, if a 30% reduction in beef purchases were divided evenly between substitutions with pork, poultry, and seafood (10% for each), the estimated reduction would be approximately 430 tons. Out of these three substitutions, the switch to chicken would have the greatest effect on both emissions and cost reduction, and it is therefore worthwhile to consider an even larger substitution percentage. A 20% switch from beef to poultry would reduce emissions by almost 500 tons, and save $75,000. Based on the toxic emissions results, however, such a switch would be expected to result in a larger overall impact on ecotoxicity and acidification in both terrestrial and aquatic environments, as well as create larger respiratory health risks. Given these risks the source of poultry products should be taken into account, utilizing sustainability metrics from SYSCO to buy from suppliers known to encourage environmentally-friendly practices.

In the case of substitutions for juice beverages their seem to be clear emissions reductions possibilities in switching to either carbonated beverages or tap water, and in this case the toxic emissions results help to strengthen the case for a switch to tap water. Soft drink manufacturing has the largest toxicity factors for carcinogenic emissions, as well as for ecotoxicity, whereas tap water is relatively neutral. Given that the carbon footprint of the beverages group is so large, a shift to tap water can have large emissions reductions overall—approximately 500 tons if half of all the juice is replaced. This would also have a substantial cost-cutting benefit, estimated at nearly $450,000.

Also of interest in the beverage category is the possibility of replacing coffee with tea, which, although they are derived from the same emissions factor, due to the lower cost of tea, could result in significant emissions reductions and cost savings. With this lower cost, and given that these products both fall under the same category for the toxicity data, we would find that there would also be toxicity reductions with this substitution. Replacing soymilk with milk, on the other hand, we can separate out toxicity data, and find that consistently soybean processing has a higher toxicity factor than milk manufacturing. In this case the appropriateness of applying soymilk into the soybean processing category is somewhat of an issue, and again the environmental health effects of this switch may come down to individual suppliers.

For most of the fruit and vegetable substitutions, whether based on our CEDA emissions factors or process-based emissions factors, the emissions reductions were relatively low. Replacing frozen carrots with canned carrots did show potential for reductions in the tens of tons at moderate substitution percentages, but this is also an example of the difficulty in comparing qualitative aspects of these products—the tastes of those who will be consuming these products must be taken into account. There may be significant savings in both emissions and cost, but whether the change is realistic in a more aesthetic sense is debatable. The analysis provided here serves as a guide for food purchasers, who have years of experience in meeting the demands of these consumers.

In comparing fresh versus frozen versus canned items the capacity of the institutions that serve these foods are also crucial. With supplies, which take into account the items required to get food to the consumer, accounting up such a considerable portion of emissions, it would be expected that there may be substantial costs associated with making shifts between items of the same type. Depending upon the electricity usage of refrigerators and freezers, a shift between products that utilize either of these will cause a higher footprint, particularly when compared with canned foods, which would not. Going forward there should be greater focus on how to incorporate the potential for kitchens to reduce the emissions required to maintain food, as well as how substitutions of items may necessitate increased carbon footprint from energy use.

Even after considering all the potential emissions reductions and resulting costs changes of the substitution scenarios described above, there is the possibility that the overall effect of substitutions would lead to increased emissions. Given this possibility it is worth mentioning the potential for Kaiser Permanente to purchase carbon emissions offsets. Many companies already voluntarily purchase these offsets as part of social corporate responsibility efforts, and this would potentially be an appropriate course of action should food substitutions lead to higher emissions. This is also a relatively low-cost option. In the market for offsets in the U.S., the Chicago Climate Exchange has, since its launch in 2003, traded offsets at an average price of $3.26 per metric ton.[159] At that price, the cost of offsetting all of the emissions associated with purchases from Sysco would be approximately $61,000, or less than 1.3% of the total purchase amount. It is worth considering whether this cost for emissions offsets would be a good annual investment from Kaiser Permanente's perspective, even with the great potential for emissions reductions through food substitutions.

9.2 Limitations of the Models

In recent years Kaiser Permanente has made a conscious effort to purchase more and more of its food from local producers.[160] The benefits of sourcing locally are environmental and social. They include a higher level of freshness, particularly for produce; financial support of the local economy; and lowered fossil fuel use due to reduced transportation, processing and packaging.[161] While the study by Weber and Matthews showed that GHG emissions from "food miles" are relatively small when considered in the context of the entire food production system[162], purchasing more food locally is one way Kaiser

[159] http://www.chicagoclimatex.com/about/pdf/10-21-10_CCX_Fact_Sheet.pdf

[160] Kaiser Permanente (2008). *Farmer's Fill Kaiser Permanente's Patient's Plates.* Retrieved March 14, 2011 from http://xnet.kp.org/newscenter/healthandfitness/2008/012908farmers.html

[161] Pretty, Jules. *Some Benefits and Drawbacks of Local Food Systems.* Briefing Note for TVU/Sustain AgriFood Network, November 2, 2001. Retrieved March 15, 2011 from http://www.sustainweb.org/pdf/afn_m1_p2.pdf

[162] Weber and Matthews found that "although food is transported long distances in general (1640 km delivery and 6760 km life-cycle supply chain on average)the GHG emissions associated with food are dominated by the
production phase, contributing 83% of the average U.S.household's 8.1 t CO2e/yr footprint for food
consumption. Transportation as a whole represents only 11% of life-cycleGHG emissions, and final delivery
from producer to retail contributes only 4%." They suggested that shifts in diet "can be a more effective means
of lowering an average household's food-related climate footprint than 'buying local.' Shifting less than one day
per week's worth of calories from red meat and dairy products to chicken, fish, eggs, or a vegetable-based diet
achieves more GHG reduction than buying all locally sourced food."

Permanente acts upon its desire to achieve greater sustainability in its food sector. The organization has also expressed interest in examining the impacts of sourcing the organic versions of products, likewise due to the positive aspects of organic production.[163,164]

Unfortunately, neither the process-based studies nor the EIO-LCA models utilized for this project are capable of determining the impact purchasing locally or organically (or both) has on GHG emissions or toxic releases. The majority of process-based studies used to determine GHG emissions for this project were conducted outside of the US, mainly in Europe and Australia. The field of food LCAs in the US is not as developed as elsewhere and thus LCA studies specific to US-specific production practices are simply not available. For this reason, the literature emissions method outlined above cannot be used to indicate the changes in GHG emissions from switching to purchasing local or organic food.

The ability of EIO-LCA models to gauge the effect of local and/or organic purchasing is also limited by several factors inherent to the models. First, these types of models are based off of the division of industry sectors as determined by the US Census Bureau, and some sectors may not be treated as separate from other sectors of the same general type. Certain production practices, which may differ in their level of sustainability, cannot be distinguished through an EIO-LCA model. For example, organic agriculture –whether for fruit, vegetables, dairy or meat - is grouped into the same category as conventional agriculture. In addition, EIO-LCA models, as mentioned previously, are based off of national statistics and cannot account for regional, local or purchaser-specific location information. For example, in California, 2,887 commercial farm operations maintain 708,330 acres of certified organic pasture and cropland, which accounts for 14% of all organic cropland in the US.[165] Since the majority of Kaiser Permanente hospitals are located in California, the organization could potentially purchase more from these local, organic operations instead of conventional ones (and in fact has already begun to do so).[166] However, the EIO-LCA model would still be unable to recognize the changes, both because organic agriculture is unrecognized as a unique sector and because the model has no way to discern the location of the purchasing entity or the respective area's economic statistics.

Source: Weber, C.L., Matthews, S.H. (2008).Food-Miles and the Relative Climate Impacts of Food Choices in the
United States. *Environmental Science & Technology 42* (10), 3508-3513.

[163] Reed, K., Kaiser Permanente Sustainable Food Program Manager, personal communication, March 19, 2010.

[164] The benefits of organic production include reduced exposure to toxics for humans; reduced fossil fuel energy use for the production of fertilizers, herbicides, pesticides and insecticides; reduced toxic runoff into environmental media; reduced GHG emission from volatilization in soils; and improved overall soil health. Source: Organic Trade Association (2010). *Benefits of Organic.* Retrieved March 15, 2011 from http://www.ota.com/organic/benefits.html

[165] USDA Economic Research Service (2010). Organic Production. Table 3. *Certified organic and total U.S. acreage, selected crops and livestock, 1995-2008*. Retrieved March 14, 2011 from http://www.ers.usda.gov/Data/Organic/

[166] Kaiser Permanente purchased more than 60 tons of fresh, locally sourced produce in California for patient meals in 2007 alone.
Source: Kaiser Permanente (2008). *Farmer's Fill Kaiser Permanente's Patient's Plates.* Retrieved March 14, 2011 from http://xnet.kp.org/newscenter/healthandfitness/2008/012908farmers.html

The type of data available to this project for use in the EIO-LCA models further limited the ability to judge the impact of purchasing locally or organically. This project determined GHG emissions based on food purchasing data from Kaiser Permanente, not purchasing data related to fuel used for transportation. If purchasing data for fuel had been available, it could have been input into the EIO-LCA model to determine the effect of reduced transportation on GHG emissions and toxic releases.

9.3 Emissions from Transportation

With the limitations of the process-based method and EIO-LCA models in mind, this project can only comment on the effect of purchasing locally by investigating and comparing the GHG emissions associated with the different modes of transportation used to deliver Kaiser Permanente's food. In order to this, first information on the GHG emissions resulting from various forms of transport was obtained from the U.S. National Renewable Energy Laboratory Life Cycle Inventory Database.[167] The NREL database gives emissions factors for transport by Ocean Tanker, Barge, Locomotive, Heavy-Heavy-Duty Truck and Medium-Heavy-Duty truck, by pound (here converted to kg) and according to a reference flow of 1,000 gallons of fuel burned:

Table 9.1: Emissions Factors of Fuel Combustion by Transportation Mode

Mode of Transportation	Type of Fuel	Carbon Dioxide Emissions (kg)	Methane Emissions (kg)	Nitrous Oxide Emissions (kg)
Combination truck	Diesel	11116.19	0.17933	0.300094
Combination truck	Gasoline	8604.208	1.23942	0.250154
Single unit truck	Diesel	11113.012	0.26786	0.40179
Single unit truck	Gasoline	8601.938	1.85232	0.362292
Train	Diesel	11075.784	0.52664	N/A
Barge	Diesel	11117.098	0.2724	N/A
Barge	Residual fuel oil	12340.174	0.2724	0.3178
Ocean freighter	Diesel	11070.79	0.5448	N/A
Ocean freighter	Residual fuel oil	12290.234	0.5902	0.29964

Since sourcing more locally could potentially lead to lowered fuel consumption, based on information such as this Kaiser Permanente could determine the expected emissions reductions from lowered fuel usage. This would depend upon the type of transportation most often used by the organization as well as its suppliers. Kaiser Permanente's own transportation fleet consists mainly of passenger vehicles and combination and single unit trucks.[168] While the emissions from passenger cars are not available through the NREL database, emissions from combination and single unit trucks are. Because a user version of the NREL database was unavailable for public use, linearity in the database was assumed, and the amount of GHG emission reductions to be expected from a reduction in fuel was calculated based on the base value of 1,000 gallons of fuel burned:

167

168 Tomar, S., personal communication, March 14, 2011.

Table 9.2: Expected Emissions Reductions – Combination Truck, Diesel Powered

% Reduction of Fuel	Volume Reduction (gallons)	Carbon Dioxide Emissions Reduction (kg)	Methane Emissions Reduction (kg)	Nitrous Oxide Emissions Reduction (kg)
10.00%	100	1111.619	0.017933	0.0300094
20.00%	200	2223.238	0.035866	0.0600188
30.00%	300	3334.857	0.053799	0.0900282
40.00%	400	4446.476	0.071732	0.1200376
50.00%	500	5558.095	0.089665	0.150047
60.00%	600	6669.714	0.107598	0.1800564
70.00%	700	7781.333	0.125531	0.2100658
80.00%	800	8892.952	0.143464	0.2400752
90.00%	900	10004.571	0.161397	0.2700846
100.00%	1000	11116.19	0.17933	0.300094

Table 9.3: Expected Emissions Results – Combination Truck, Gasoline Powered

% Reduction of Fuel	Volume Reduction (gallons)	Carbon Dioxide Emissions Reduction (kg)	Methane Emissions Reduction (kg)	Nitrous Oxide Emissions Reduction (kg)
10.00%	100	860.4208	0.123942	0.0250154
20.00%	200	1720.8416	0.247884	0.0500308
30.00%	300	2581.2624	0.371826	0.0750462
40.00%	400	3441.6832	0.495768	0.1000616
50.00%	500	4302.104	0.61971	0.125077
60.00%	600	5162.5248	0.743652	0.1500924
70.00%	700	6022.9456	0.867594	0.1751078
80.00%	800	6883.3664	0.991536	0.2001232
90.00%	900	7743.7872	1.115478	0.2251386
100.00%	1000	8604.208	1.23942	0.250154

Table 9.4: Expected Emissions Results – Single Unit Truck, Diesel Powered

% Reduction of Fuel	Volume Reduction (gallons)	Carbon Dioxide Emissions Reduction (kg)	Methane Emissions Reduction (kg)	Nitrous Oxide Emissions Reduction (kg)
10.00%	100	1111.3012	0.026786	0.040179
20.00%	200	2222.6024	0.053572	0.080358
30.00%	300	3333.9036	0.080358	0.120537
40.00%	400	4445.2048	0.107144	0.160716
50.00%	500	5556.506	0.13393	0.200895
60.00%	600	6667.8072	0.160716	0.241074

% Reduction of Fuel	Volume Reduction (gallons)	Carbon Dioxide Emissions Reduction (kg)	Methane Emissions Reduction (kg)	Nitrous Oxide Emissions Reduction (kg)
70.00%	700	7779.1084	0.187502	0.281253
80.00%	800	8890.4096	0.214288	0.321432
90.00%	900	10001.7108	0.241074	0.361611
100.00%	1000	11113.012	0.26786	0.40179

Table 9.5: Expected Emissions Results – Single Unit Truck, Gasoline Powered

% Reduction of Fuel	Volume Reduction (gallons)	Carbon Dioxide Emissions Reduction (kg)	Methane Emissions Reduction (kg)	Nitrous Oxide Emissions Reduction (kg)
10.00%	100	860.1938	0.185232	0.0362292
20.00%	200	1720.3876	0.370464	0.0724584
30.00%	300	2580.5814	0.555696	0.1086876
40.00%	400	3440.7752	0.740928	0.1449168
50.00%	500	4300.969	0.92616	0.181146
60.00%	600	5161.1628	1.111392	0.2173752
70.00%	700	6021.3566	1.296624	0.2536044
80.00%	800	6881.5504	1.481856	0.2898336
90.00%	900	7741.7442	1.667088	0.3260628
100.00%	1000	8601.938	1.85232	0.362292

Based on these results, Kaiser Permanente can now form some idea of potential emissions reductions from altered food transportation patterns. According to the data, combination and single unit trucks powered by diesel emit about the same amount of CO_2 per 1,000 gallons of fuel combusted (11,116 kg and 11,113 kg respectively). Similarly, combination and single unit trucks powered by gasoline emit about the same amount of CO_2 per 1,000 gallons of fuel combusted (8604 kg and 8601 kg). Therefore a change to single unit trucks as a primary mode of transportation could result in greater GHG emissions savings. Reductions in fuel use overall also results in GHG savings. For example, assuming an amount of 1,000 gallons of fuel combusted, if Kaiser Permanente's fleet of single unit diesel powered trucks lowered fuel usage by 50%, the organization could expect reductions of 5,556 kg CO_2, 0.13 kg CH_4 and .200 kg N_2O. If the fleet's combination diesel powered trucks lowered fuel usage by 50%, the organization could expect reductions of 5,558 kg CO_2, 0.089 kg CH_4 and 0.15 kg N_2O.

However, since Kaiser Permanente's current fuel usage rates were not available for the purpose of this project or this particular analysis, these estimations would need to be re-calculated based on the organization's actual fuel usage rates. The results listed here can only serve as an indicator of an area of future study.

Appendix A

Substitution Scenarios

Intensive Beef for Intensive Beef+Lima Beans

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT RE	baseling kg * emissions factor			sum of purchase/product cost	
Intensive Fee	854884.0421	10	Process Based	85488.40422	6.912090715
PRODUCT SUBSTITUTE					
Intensive Fee	672318.9693	1.45+10	CEDA+ Processe	85488.40422	3.11+6.91
Lima	31155.93762	1.457785434	CEDA	21372.10105	1.848790275
Intensive Fee	641163.0316	10		64116.30316	6.912090715
Intensive Fee	672318.9693	1.45+10	CEDA+ Processe	85488.40422	3.11+6.91

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	4274.420211	42744.20211	365413362.8	0.05	33615.94846	365413362.8	-9	0
10	8548.840422	85488.40421	730826725.6	0.1	67231.89693	730826725.6	-18	0
15	12823.26063	128232.6063	1096240088	0.15	100847.8454	1096240088	-27	0
20	17097.68084	170976.8084	1461653451	0.2	134463.7939	1461653451	-37	0
25	21372.10105	213721.0105	1827066814	0.25	168079.7423	1827066814	-46	0
30	25646.52127	256465.2126	2192480177	0.3	201695.6908	2192480177	-55	0
35	29920.94148	299209.4147	2557893540	0.35	235311.6392	2557893540	-64	0
40	34195.36169	341953.6168	2923306902	0.4	268927.5877	2923306902	-73	0
45	38469.7819	384697.819	3288720265	0.45	302543.5362	3288720265	-82	0
50	42744.20211	427442.0211	3654133628	0.5	336159.4846	3654133628	-91	0
55	47018.62232	470186.2232	4019546991	0.55	369775.4331	4019546991	-100	0
60	51293.04253	512930.4253	4384960354	0.6	403391.3816	4384960354	-110	0
65	55567.46274	555674.6274	4750373716	0.65	437007.33	4750373716	-119	0
70	59841.88295	598418.8295	5115787079	0.7	470623.2785	5115787079	-128	0
75	64116.30316	641163.0316	5481200442	0.75	504239.2269	5481200442	-137	0
80	68390.72337	683907.2337	5846613805	0.8	537855.1754	5846613805	-146	0
85	72665.14359	726651.4358	6212027167	0.85	571471.1239	6212027167	-155	0
90	76939.5638	769395.6379	6577440530	0.9	605087.0723	6577440530	-164	0
95	81213.98401	812139.84	6942853893	0.95	638703.0208	6942853893	-173	0
100	85488.40422	854884.0421	7308267256	1	672318.9693	7308267256	-183	0

Intensive Beef for Intensive beef+ refried beans

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED	baseling kg * emissions factor			sum of purchase/product cost	
Intensive Feedlot Beef	854884.0421	10	Process Based	85488.40422	6.912090715
PRODUCT SUBSTITUTE					
Intensive Feed Lot Beef + Refried Beans	665458.3581	1.13+10	CEDA+ Processed Base	85488.40422	1.84+6.91
25% Changes	#VALUE!	1.136777631	CEDA	21372.10105	1.848790275
Intensive Feed Lot Beef + Refried Beans	641163.0316	10		64116.30316	6.912090715
Intensive Feed Lot Beef + Refried Beans	#VALUE!	1.13+10	CEDA+ Processed Base	85488.40422	1.84+6.91

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE % CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISS CHANC (TONS
0	0	0	0	0	0	0	
5	4274.4	42744.2	365413362.8	0.1	33272.9	365413362.8	
10	8548.8	85488.4	730826725.6	0.1	66545.8	730826725.6	
15	12823.3	128232.6	1096240088.4	0.2	99818.8	1096240088.4	
20	17097.7	170976.8	1461653451.2	0.2	133091.7	1461653451.2	
25	21372.1	213721.0	1827066814.0	0.3	166364.6	1827066814.0	
30	25646.5	256465.2	2192480176.8	0.3	199637.5	2192480176.8	
35	29920.9	299209.4	2557893539.5	0.4	232910.4	2557893539.5	
40	34195.4	341953.6	2923306902.3	0.4	266183.3	2923306902.3	
45	38469.8	384697.8	3288720265.1	0.5	299456.3	3288720265.1	
50	42744.2	427442.0	3654133627.9	0.5	332729.2	3654133627.9	
55	47018.6	470186.2	4019546990.7	0.6	366002.1	4019546990.7	
60	51293.0	512930.4	4384960353.5	0.6	399275.0	4384960353.5	
65	55567.5	555674.6	4750373716.3	0.7	432547.9	4750373716.3	
70	59841.9	598418.8	5115787079.1	0.7	465820.9	5115787079.1	
75	64116.3	641163.0	5481200441.9	0.8	499093.8	5481200441.9	
80	68390.7	683907.2	5846613804.7	0.8	532366.7	5846613804.7	
85	72665.1	726651.4	6212027167.5	0.9	565639.6	6212027167.5	
90	76939.6	769395.6	6577440530.3	0.9	598912.5	6577440530.3	
95	81214.0	812139.8	6942853893.1	1.0	632185.4	6942853893.1	
100	85488.4	854884.0	7308267255.9	1.0	665458.4	7308267255.9	

0

Cheese Cubes for Cheese Snacks

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED	baseling kg * emissions factor			sum of purchase/product cost	
Cheese Snacks	4197.339591	1.140758104	CEDA	614.7365873	5.985376625
PRODUCT SUBSTITUTE					
Cheese Cubes	12129.91794	2.513946579	CEDA	514.756165	9.373467144

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	30.73682936	209.8669795	18895.05359	0.059711435	724.2948086	15821.97241	1	-3
10	61.47365873	419.7339591	37790.10717	0.11942287	1448.589617	31643.94482	1	-6
15	92.21048809	629.6009386	56685.16076	0.179134305	2172.884426	47465.91722	2	-9
20	122.9473175	839.4679182	75580.21435	0.238845741	2897.179235	63287.88963	2	-12
25	153.6841468	1049.334898	94475.26793	0.298557176	3621.474043	79109.86204	3	-15
30	184.4209762	1259.201877	113370.3215	0.358268611	4345.768852	94931.83445	3	-18
35	215.1578055	1469.068857	132265.3751	0.417980046	5070.06366	110753.8069	4	-22
40	245.8946349	1678.935836	151160.4287	0.477691481	5794.358469	126575.7793	4	-25
45	276.6314643	1888.802816	170055.4823	0.537402916	6518.653278	142397.7517	5	-28
50	307.3682936	2098.669795	188950.5359	0.597114351	7242.948086	158219.7241	5	-31
55	338.105123	2308.536775	207845.5895	0.656825787	7967.242895	174041.6965	6	-34
60	368.8419524	2518.403754	226740.643	0.716537222	8691.537704	189863.6689	6	-37
65	399.5787817	2728.270734	245635.6966	0.776248657	9415.832512	205685.6413	7	-40
70	430.3156111	2938.137714	264530.7502	0.835960092	10140.12732	221507.6137	7	-43
75	461.0524405	3148.004693	283425.8038	0.895671527	10864.42213	237329.5861	8	-46
80	491.7892698	3357.871673	302320.8574	0.955382962	11588.71694	253151.5585	8	-49
85	522.5260992	3567.738652	321215.911	1.015094398	12313.01175	268973.5309	9	-52
90	553.2629285	3777.605632	340110.9646	1.074805833	13037.30656	284795.5033	9	-55
95	583.9997579	3987.472611	359006.0181	1.134517268	13761.60136	300617.4757	10	-58
100	614.7365873	4197.339591	377901.0717	1.194228703	14485.89617	316439.4482	10	-61

Hot Cereal for Cereal Bars

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Cereal Bar	8136.289473	1.079143596	CEDA	700.6345626	10.76107346
PRODUCT SUBSTITUTE					
CEREAL HOT	70219.3772	0.989387133	CEDA	64084.27054	1.05237285

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	35.03172813	406.8144737	24544.43952	0.000546651	38.38549009	2244982.743	0	2220
10	70.06345626	813.6289473	49088.87903	0.001093302	76.77098018	4489965.486	-1	4441
15	105.0951844	1220.443421	73633.31855	0.001639953	115.1564703	6734948.229	-1	6661
20	140.1269125	1627.257895	98177.75807	0.002186604	153.5419604	8979930.972	-1	8882
25	175.1586407	2034.072368	122722.1976	0.002733255	191.9274504	11224913.72	-2	11102
30	210.1903688	2440.886842	147266.6371	0.003279906	230.3129405	13469896.46	-2	13323
35	245.2220969	2847.701316	171811.0766	0.003826557	268.6984306	15714879.2	-3	15543
40	280.253825	3254.515789	196355.5161	0.004373208	307.0839207	17959861.94	-3	17764
45	315.2855532	3661.330263	220899.9556	0.004919859	345.4694108	20204844.69	-3	19984
50	350.3172813	4068.144737	245444.3952	0.00546651	383.8549009	22449827.43	-4	22204
55	385.3490094	4474.95921	269988.8347	0.006013161	422.240391	24694810.17	-4	24425
60	420.3807376	4881.773684	294533.2742	0.006559812	460.6258811	26939792.92	-4	26645
65	455.4124657	5288.588158	319077.7137	0.007106463	499.0113712	29184775.66	-5	28866
70	490.4441938	5695.402631	343622.1532	0.007653113	537.3968612	31429758.4	-5	31086
75	525.475922	6102.217105	368166.5927	0.008199764	575.7823513	33674741.15	-6	33307
80	560.5076501	6509.031579	392711.0323	0.008746415	614.1678414	35919723.89	-6	35527
85	595.5393782	6915.846052	417255.4718	0.009293066	652.5533315	38164706.63	-6	37747
90	630.5711064	7322.660526	441799.9113	0.009839717	690.9388216	40409689.38	-7	39968
95	665.6028345	7729.474999	466344.3508	0.010386368	729.3243117	42654672.12	-7	42188
100	700.6345626	8136.289473	490888.7903	0.010933019	767.7098018	44899654.86	-7	44409

Hot Cereal for Breakfast Items

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Breakfast Iter	210307.7947	1.457785434	CEDA	28692.74949	5.027934324
PRODUCT SUBSTITUTE					
CEREAL HOT	70219.3772	0.989387133	CEDA	67440.54641	1.05237285

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	1434.637474	10515.4	41163693.7	0.0	1493.8	96752735.2	-9	55589
10	2869.274949	21030.8	82327387.3	0.0	2987.5	193505470.3	-18	111178
15	4303.912423	31546.2	123491081.0	0.1	4481.3	290258205.5	-27	166767
20	5738.549897	42061.6	164654774.6	0.1	5975.0	387010940.7	-36	222356
25	7173.187372	52576.9	205818468.3	0.1	7468.8	483763675.8	-45	277945
30	8607.824846	63092.3	246982161.9	0.1	8962.5	580516411.0	-54	333534
35	10042.46232	73607.7	288145855.6	0.1	10456.3	677269146.2	-63	389123
40	11477.09979	84123.1	329309549.3	0.2	11950.0	774021881.3	-72	444712
45	12911.73727	94638.5	370473242.9	0.2	13443.8	870774616.5	-81	500301
50	14346.37474	105153.9	411636936.6	0.2	14937.5	967527351.7	-90	555890
55	15781.01222	115669.3	452800630.2	0.2	16431.3	1064280086.8	-99	611479
60	17215.64969	126184.7	493964323.9	0.3	17925.0	1161032822.0	-108	667068
65	18650.28717	136700.1	535128017.5	0.3	19418.8	1257785557.2	-117	722658
70	20084.92464	147215.5	576291711.2	0.3	20912.5	1354538292.3	-126	778247
75	21519.56212	157730.8	617455404.9	0.3	22406.3	1451291027.5	-135	833836
80	22954.19959	168246.2	658619098.5	0.3	23900.0	1548043762.6	-144	889425
85	24388.83706	178761.6	699782792.2	0.4	25393.8	1644796497.8	-153	945014
90	25823.47454	189277.0	740946485.8	0.4	26887.5	1741549233.0	-162	1000603
95	27258.11201	199792.4	782110179.5	0.4	28381.3	1838301968.1	-171	1056192
100	28692.74949	210307.8	823273873.1	0.4	29875.0	1935054703.3	-180	1111781

Hot Cereal for Cold Cereal

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
CEREAL COLD	285707.5781	0.989387133	CEDA	43490.9636	6.639822531
PRODUCT SUBSTITUTE					
CEREAL HOT	70219.3772	0.989387133	CEDA	67440.54641	1.05237285

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
5	2174.5	14285.4	14438.6	0.0	2264.1	2288.4	-12	-12
10	4349.1	28570.8	28877.2	0.1	4528.3	4576.9	-24	-24
15	6523.6	42856.1	43315.8	0.1	6792.4	6865.3	-36	-36
20	8698.2	57141.5	57754.5	0.1	9056.6	9153.7	-48	-49
25	10872.7	71426.9	72193.1	0.2	11320.7	11442.2	-60	-61
30	13047.3	85712.3	86631.7	0.2	13584.9	13730.6	-72	-73
35	15221.8	99997.7	101070.3	0.2	15849.0	16019.0	-84	-85
40	17396.4	114283.0	115508.9	0.3	18113.2	18307.5	-96	-97
45	19570.9	128568.4	129947.5	0.3	20377.3	20595.9	-108	-109
50	21745.5	142853.8	144386.1	0.3	22641.5	22884.4	-120	-122
55	23920.0	157139.2	158824.8	0.4	24905.6	25172.8	-132	-134
60	26094.6	171424.5	173263.4	0.4	27169.8	27461.2	-144	-146
65	28269.1	185709.9	187702.0	0.4	29433.9	29749.7	-156	-158
70	30443.7	199995.3	202140.6	0.5	31698.1	32038.1	-168	-170
75	32618.2	214280.7	216579.2	0.5	33962.2	34326.5	-180	-182
80	34792.8	228566.1	231017.8	0.5	36226.4	36615.0	-192	-194
85	36967.3	242851.4	245456.4	0.5	38490.5	38903.4	-204	-207
90	39141.9	257136.8	259895.1	0.6	40754.7	41191.8	-216	-219
95	41316.4	271422.2	274333.7	0.6	43018.8	43480.3	-228	-231
100	43491.0	285707.6	288772.3	0.6	45283.0	45768.7	-240	-243

Fresh Pork for Bacon

PRODUCT REDUCED	baseling kg * emissions factor			sum of purchase/product cost	
Bacon	**395508.7705**	**3.200676428**	**CEDA**	**12250.20481**	**10.08720849**
PRODUCT SUBSTITUTE					
Fresh Pork	61583.54301	3.200676428	CEDA	2051.304472	9.379782603

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
5	612.5	19775.4	7503375.9	0.3	18388.6	1256445.0	-1	-6247
10	1225.0	39550.9	15006751.8	0.6	36777.1	2512890.0	-3	-12494
15	1837.5	59326.3	22510127.7	0.9	55165.7	3769335.0	-4	-18741
20	2450.0	79101.8	30013503.6	1.2	73554.3	5025780.0	-6	-24988
25	3062.6	98877.2	37516879.5	1.5	91942.8	6282225.0	-7	-31235
30	3675.1	118652.6	45020255.4	1.8	110331.4	7538670.0	-8	-37482
35	4287.6	138428.1	52523631.3	2.1	128720.0	8795115.0	-10	-43729
40	4900.1	158203.5	60027007.1	2.4	147108.5	10051560.0	-11	-49975
45	5512.6	177978.9	67530383.0	2.7	165497.1	11308005.0	-12	-56222
50	6125.1	197754.4	75033758.9	3.0	183885.7	12564450.0	-14	-62469
55	6737.6	217529.8	82537134.8	3.3	202274.2	13820894.9	-15	-68716
60	7350.1	237305.3	90040510.7	3.6	220662.8	15077339.9	-17	-74963
65	7962.6	257080.7	97543886.6	3.9	239051.4	16333784.9	-18	-81210
70	8575.1	276856.1	105047262.5	4.2	257439.9	17590229.9	-19	-87457
75	9187.7	296631.6	112550638.4	4.5	275828.5	18846674.9	-21	-93704
80	9800.2	316407.0	120054014.3	4.8	294217.1	20103119.9	-22	-99951
85	10412.7	336182.5	127557390.2	5.1	312605.6	21359564.9	-24	-106198
90	11025.2	355957.9	135060766.1	5.4	330994.2	22616009.9	-25	-112445
95	11637.7	375733.3	142564142.0	5.7	349382.8	23872454.9	-26	-118692
100	12250.2	395508.8	150067517.9	6.0	367771.3	25128899.9	-28	-124939

PERCENTAGE CH	KG REDUCT	EMISSIONS	COST REDU	EQUIVALENT SUB	SUBSTITUTE EM	SUBSTITUTE COST INC	EMISSIONS CHA	COST CHANGE ($1000s
0	#VALUE!	#REF!	#VALUE!	#VALUE!	#REF!	#VALUE!	#REF!	#VALUE!

)

Fresh Pork for Franks

PRODUCT REDUCED

Franks	78660.2	3.200676428	CEDA	4437.425401	5.538375922
SUBSTITUTE					
Fresh Pork	61583.543	3.200676428	CEDA	2051.304472	9.379782603

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	**221.87127**	**3933.011999**	**984537.2096**	**0.108161062**	**6660.94141**	**455125.5285**	**2.727929411**	**-529.4116811**
10	443.7	7866.0	1969074.4	0.2	13321.9	910251.1	5	-1059
15	665.6	11799.0	2953611.6	0.3	19982.8	1365376.6	8	-1588
20	887.5	15732.0	3938148.8	0.4	26643.8	1820502.1	11	-2118
25	1109.4	19665.1	4922686.0	0.5	33304.7	2275627.6	14	-2647
30	1331.2	23598.1	5907223.3	0.6	39965.6	2730753.2	16	-3176
35	1553.1	27531.1	6891760.5	0.8	46626.6	3185878.7	19	-3706
40	1775.0	31464.1	7876297.7	0.9	53287.5	3641004.2	22	-4235
45	1996.8	35397.1	8860834.9	1.0	59948.5	4096129.8	25	-4765
50	2218.7	39330.1	9845372.1	1.1	66609.4	4551255.3	27	-5294
55	2440.6	43263.1	10829909.3	1.2	73270.4	5006380.8	30	-5824
60	2662.5	47196.1	11814446.5	1.3	79931.3	5461506.3	33	-6353
65	2884.3	51129.2	12798983.7	1.4	86592.2	5916631.9	35	-6882
70	3106.2	55062.2	13783520.9	1.5	93253.2	6371757.4	38	-7412
75	3328.1	58995.2	14768058.1	1.6	99914.1	6826882.9	41	-7941
80	3549.9	62928.2	15752595.4	1.7	106575.1	7282008.5	44	-8471
85	3771.8	66861.2	16737132.6	1.8	113236.0	7737134.0	46	-9000
90	3993.7	70794.2	17721669.8	1.9	119896.9	8192259.5	49	-9529
95	4215.6	74727.2	18706207.0	2.1	126557.9	8647385.0	52	-10059
100	4437.4	78660.2	19690744.2	2.2	133218.8	9102510.6	55	-10588

PERCENTA(	KG REDUC	EMISSIONS RED	COST REDUC	EQUIVALENT SUBST	SUBSTITUTE EMISSI	SUBSTITUTE COST I	EMISSIONS CHANGE	COST CHANGE ($
0	#VALUE!	#REF!	#VALUE!	#VALUE!	#REF!	#VALUE!	#REF!	#VALUE!

1000s)

Tap Water for Carbonated Beverages

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
CARBONATED	444605.1525	1.031523232	CEDA	662923.2709	0.650177915
PRODUCT SUBSTITUTE					
TAP WATER	39042775.22	0.023	CEDA	1697511966	0.000529

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0.0	0.0	0.0	0.000000	0.0	0.0	0	0
5	33146.2	22230.3	21550.9	0.000020	762.4	17.5	-21	-22
10	66292.3	44460.5	43101.8	0.000039	1524.7	35.1	-43	-43
15	99438.5	66690.8	64652.7	0.000059	2287.1	52.6	-64	-65
20	132584.7	88921.0	86203.6	0.000078	3049.4	70.1	-86	-86
25	165730.8	111151.3	107754.5	0.000098	3811.8	87.7	-107	-108
30	198877.0	133381.5	129305.4	0.000117	4574.2	105.2	-129	-129
35	232023.1	155611.8	150856.3	0.000137	5336.5	122.7	-150	-151
40	265169.3	177842.1	172407.2	0.000156	6098.9	140.3	-172	-172
45	298315.5	200072.3	193958.1	0.000176	6861.3	157.8	-193	-194
50	331461.6	222302.6	215509.0	0.000195	7623.6	175.3	-215	-215
55	364607.8	244532.8	237059.9	0.000215	8386.0	192.9	-236	-237
60	397754.0	266763.1	258610.8	0.000234	9148.3	210.4	-258	-258
65	430900.1	288993.3	280161.7	0.000254	9910.7	227.9	-279	-280
70	464046.3	311223.6	301712.6	0.000273	10673.1	245.5	-301	-301
75	497192.5	333453.9	323263.6	0.000293	11435.4	263.0	-322	-323
80	530338.6	355684.1	344814.5	0.000312	12197.8	280.5	-343	-345
85	563484.8	377914.4	366365.4	0.000332	12960.1	298.1	-365	-366
90	596630.9	400144.6	387916.3	0.000351	13722.5	315.6	-386	-388
95	629777.1	422374.9	409467.2	0.000371	14484.9	333.2	-408	-409
100	662923.3	444605.2	431018.1	0.000391	15247.2	350.7	-429	-431

Fresh Pork for Pizza Meat Top

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Pizza Meat T	11536.19805	3.200676428	CEDA	285.5282866	12.62326771
PRODUCT SUBSTITUTE					
Fresh Pork	61583.54301	3.200676428	CEDA	2051.304472	9.379782603

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	14.27641433	576.8099025	180.215	0.006959676	428.601501	133.9096627	0	0
10	28.55282866	1153.619805	360.43	0.013919352	857.2030021	267.8193255	0	0
15	42.82924298	1730.429707	540.645	0.020879028	1285.804503	401.7289882	0	0
20	57.10565731	2307.23961	720.86	0.027838704	1714.406004	535.638651	-1	0
25	71.38207164	2884.049512	901.075	0.03479838	2143.007505	669.5483137	-1	0
30	85.65848597	3460.859415	1081.29	0.041758055	2571.609006	803.4579765	-1	0
35	99.9349003	4037.669317	1261.505	0.048717731	3000.210507	937.3676392	-1	0
40	114.2113146	4614.47922	1441.72	0.055677407	3428.812008	1071.277302	-1	0
45	128.487729	5191.289122	1621.935	0.062637083	3857.413509	1205.186965	-1	0
50	142.7641433	5768.099025	1802.15	0.069596759	4286.01501	1339.096627	-1	0
55	157.0405576	6344.908927	1982.365	0.076556435	4714.616511	1473.00629	-2	-1
60	171.3169719	6921.71883	2162.58	0.083516111	5143.218012	1606.915953	-2	-1
65	185.5933863	7498.528732	2342.795	0.090475787	5571.819514	1740.825616	-2	-1
70	199.8698006	8075.338635	2523.01	0.097435463	6000.421015	1874.735278	-2	-1
75	214.1462149	8652.148537	2703.225	0.104395139	6429.022516	2008.644941	-2	-1
80	228.4226292	9228.958439	2883.44	0.111354815	6857.624017	2142.554604	-2	-1
85	242.6990436	9805.768342	3063.655	0.118314491	7286.225518	2276.464267	-3	-1
90	256.9754579	10382.57824	3243.87	0.125274166	7714.827019	2410.373929	-3	-1
95	271.2518722	10959.38815	3424.085	0.132233842	8143.42852	2544.283592	-3	-1
100	285.5282866	11536.19805	3604.3	0.139193518	8572.030021	2678.193255	-3	-1

PERCENTAGI	KG REDUCTION	EMISSIONS REDU(	COST REDUCTION	EQUIVALENT SUBSTITUTE P	SUBSTITUTE EMISSIONS IN(	SUBSTITUTE COST INCREAS	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0

Fresh Pork for Ham

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Ham	116047.5334	3.200676428	CEDA	7225.973107	5.01762039
PRODUCT SUBSTITUTE					
Fresh Pork	61583.54301	3.200676428	CEDA	2051.304472	9.379782603

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	361.2986553	5802.376669	1812.8595	0.176131169	10846.78144	3388.902842	5	2
10	722.5973107	11604.75334	3625.719	0.352262339	21693.56288	6777.805684	10	3
15	1083.895966	17407.13001	5438.5785	0.528393508	32540.34433	10166.70853	15	5
20	1445.194621	23209.50668	7251.438	0.704524677	43387.12577	13555.61137	20	6
25	1806.493277	29011.88334	9064.2975	0.880655847	54233.90721	16944.51421	25	8
30	2167.791932	34814.26001	10877.157	1.056787016	65080.68865	20333.41705	30	9
35	2529.090587	40616.63668	12690.0165	1.232918185	75927.4701	23722.31989	35	11
40	2890.389243	46419.01335	14502.876	1.409049355	86774.25154	27111.22273	40	13
45	3251.687898	52221.39002	16315.7355	1.585180524	97621.03298	30500.12558	45	14
50	3612.986553	58023.76669	18128.595	1.761311693	108467.8144	33889.02842	50	16
55	3974.285209	63826.14336	19941.4545	1.937442863	119314.5959	37277.93126	55	17
60	4335.583864	69628.52003	21754.314	2.113574032	130161.3773	40666.8341	61	19
65	4696.882519	75430.8967	23567.1735	2.289705201	141008.1588	44055.73694	66	20
70	5058.181175	81233.27336	25380.033	2.465836371	151854.9402	47444.63979	71	22
75	5419.47983	87035.65003	27192.8925	2.64196754	162701.7216	50833.54263	76	24
80	5780.778485	92838.0267	29005.752	2.81809871	173548.5031	54222.44547	81	25
85	6142.077141	98640.40337	30818.6115	2.994229879	184395.2845	57611.34831	86	27
90	6503.375796	104442.78	32631.471	3.170361048	195242.066	61000.25115	91	28
95	6864.674451	110245.1567	34444.3305	3.346492218	206088.8474	64389.15399	96	30
100	7225.973107	116047.5334	36257.19	3.522623387	216935.6288	67778.05684	101	32

Fresh Pasta for Pasta Entrees

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Pasta Entrée	844.5388422	1.102732669	CEDA	213.477894	3.587537733
PRODUCT SUBSTITUTE					
Pasta	65804.12838	1.457785434	CEDA	61267.12032	0.736770225

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMIS CHA (TON
0	0	0	0	0	0	0	
5	10.6738947	42.22694211	38.293	0.000174219	11.46432758	7.864207798	
10	21.3477894	84.45388422	76.586	0.000348438	22.92865516	15.7284156	
15	32.02168411	126.6808263	114.879	0.000522657	34.39298274	23.59262339	
20	42.69557881	168.9077684	153.172	0.000696876	45.85731032	31.45683119	
25	53.36947351	211.1347105	191.465	0.000871095	57.32163791	39.32103899	
30	64.04336821	253.3616527	229.758	0.001045314	68.78596549	47.18524679	
35	74.71726292	295.5885948	268.051	0.001219533	80.25029307	55.04945458	
40	85.39115762	337.8155369	306.344	0.001393752	91.71462065	62.91366238	
45	96.06505232	380.042479	344.637	0.001567971	103.1789482	70.77787018	
50	106.738947	422.2694211	382.93	0.00174219	114.6432758	78.64207798	
55	117.4128417	464.4963632	421.223	0.001916409	126.1076034	86.50628578	
60	128.0867364	506.7233053	459.516	0.002090628	137.571931	94.37049357	
65	138.7606311	548.9502474	497.809	0.002264847	149.0362586	102.2347014	
70	149.4345258	591.1771895	536.102	0.002439066	160.5005861	110.0989092	
75	160.1084205	633.4041316	574.395	0.002613285	171.9649137	117.963117	
80	170.7823152	675.6310737	612.688	0.002787504	183.4292413	125.8273248	
85	181.4562099	717.8580158	650.981	0.002961723	194.8935689	133.6915326	
90	192.1301046	760.084958	689.274	0.003135941	206.3578965	141.5557404	
95	202.8039993	802.3119001	727.567	0.00331016	217.822224	149.4199482	
100	213.477894	844.5388422	765.86	0.003484379	229.2865516	157.284156	

Fresh Apples for Candy

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Candy	8397.3451	1.079143596	CEDA	641.6013409	12.12823213
PRODUCT SUBSTITUTE					
Fresh Apples	100329.3776	1.564179911	CEDA	29099.69522	2.181228

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	32.08006705	419.867255	389.0745	0.001102419	110.6050471	69.97394048	0	0
10	64.16013409	839.73451	778.149	0.002204839	221.2100942	139.947881	-1	-1
15	96.24020114	1259.601765	1167.2235	0.003307258	331.8151413	209.9218214	-1	-1
20	128.3202682	1679.46902	1556.298	0.004409677	442.4201884	279.8957619	-1	-1
25	160.4003352	2099.336275	1945.3725	0.005512097	553.0252354	349.8697024	-2	-2
30	192.4804023	2519.20353	2334.447	0.006614516	663.6302825	419.8436429	-2	-2
35	224.5604693	2939.070785	2723.5215	0.007716935	774.2353296	489.8175834	-2	-2
40	256.6405364	3358.93804	3112.596	0.008819355	884.8403767	559.7915239	-2	-3
45	288.7206034	3778.805295	3501.6705	0.009921774	995.4454238	629.7654643	-3	-3
50	320.8006705	4198.67255	3890.745	0.011024193	1106.050471	699.7394048	-3	-3
55	352.8807375	4618.539805	4279.8195	0.012126613	1216.655518	769.7133453	-3	-4
60	384.9608045	5038.40706	4668.894	0.013229032	1327.260565	839.6872858	-4	-4
65	417.0408716	5458.274315	5057.9685	0.014331452	1437.865612	909.6612263	-4	-4
70	449.1209386	5878.14157	5447.043	0.015433871	1548.470659	979.6351667	-4	-4
75	481.2010057	6298.008825	5836.1175	0.01653629	1659.075706	1049.609107	-5	-5
80	513.2810727	6717.87608	6225.192	0.01763871	1769.680753	1119.583048	-5	-5
85	545.3611398	7137.743335	6614.2665	0.018741129	1880.2858	1189.556988	-5	-5
90	577.4412068	7557.61059	7003.341	0.019843548	1990.890848	1259.530929	-6	-6
95	609.5212739	7977.477845	7392.4155	0.020945968	2101.495895	1329.504869	-6	-6
100	641.6013409	8397.3451	7781.49	0.022048387	2212.100942	1399.47881	-6	-6

Potatoes for Chips

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Chips	398648.9004	1.140758104	CEDA	28559.31588	8.212937627
PRODUCT SUBSTITUTE					
Potatoes	97216.87157	1.539808537	CEDA	66578.53197	0.839795176

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	1427.965794	19932.44502	11727.794	0.021447841	2085.092042	1199.198786	-18	-11
10	2855.931588	39864.89004	23455.588	0.042895683	4170.184085	2398.397572	-36	-21
15	4283.897382	59797.33505	35183.382	0.064343524	6255.276127	3597.596358	-54	-32
20	5711.863176	79729.78007	46911.176	0.085791366	8340.36817	4796.795144	-71	-42
25	7139.82897	99662.22509	58638.97	0.107239207	10425.46021	5995.99393	-89	-53
30	8567.794764	119594.6701	70366.764	0.128687048	12510.55225	7195.192716	-107	-63
35	9995.760558	139527.1151	82094.558	0.15013489	14595.6443	8394.391502	-125	-74
40	11423.72635	159459.5601	93822.352	0.171582731	16680.73634	9593.590288	-143	-84
45	12851.69215	179392.0052	105550.146	0.193030573	18765.82838	10792.78907	-161	-95
50	14279.65794	199324.4502	117277.94	0.214478414	20850.92042	11991.98786	-178	-105
55	15707.62373	219256.8952	129005.734	0.235926255	22936.01247	13191.18665	-196	-116
60	17135.58953	239189.3402	140733.528	0.257374097	25021.10451	14390.38543	-214	-126
65	18563.55532	259121.7852	152461.322	0.278821938	27106.19655	15589.58422	-232	-137
70	19991.52112	279054.2302	164189.116	0.30026978	29191.28859	16788.783	-250	-147
75	21419.48691	298986.6753	175916.91	0.321717621	31276.38064	17987.98179	-268	-158
80	22847.45271	318919.1203	187644.704	0.343165462	33361.47268	19187.18058	-286	-168
85	24275.4185	338851.5653	199372.498	0.364613304	35446.56472	20386.37936	-303	-179
90	25703.38429	358784.0103	211100.292	0.386061145	37531.65676	21585.57815	-321	-190
95	27131.35009	378716.4553	222828.086	0.407508987	39616.74881	22784.77693	-339	-200
100	28559.31588	398648.9004	234555.88	0.428956828	41701.84085	23983.97572	-357	-211

Beef for Beef Entrees

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Beef Entrees	24966.65243	3.200676428	CEDA	2150.474654	3.627306178
PRODUCT SUBSTITUTE					
BEEF	1275278.764	3.200676428	CEDA	38981.61124	10.22123964

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	107.5237327	1248.332621	390.0215	0.002758319	3517.626097	1099.025839	2	1
10	215.0474654	2496.665243	780.043	0.005516639	7035.252194	2198.051679	5	1
15	322.5711981	3744.997864	1170.0645	0.008274958	10552.87829	3297.077518	7	2
20	430.0949309	4993.330486	1560.086	0.011033277	14070.50439	4396.103357	9	3
25	537.6186636	6241.663107	1950.1075	0.013791597	17588.13048	5495.129197	11	4
30	645.1423963	7489.995729	2340.129	0.016549916	21105.75658	6594.155036	14	4
35	752.666129	8738.32835	2730.1505	0.019308235	24623.38268	7693.180876	16	5
40	860.1898617	9986.660972	3120.172	0.022066555	28141.00877	8792.206715	18	6
45	967.7135944	11234.99359	3510.1935	0.024824874	31658.63487	9891.232554	20	6
50	1075.237327	12483.32621	3900.215	0.027583194	35176.26097	10990.25839	23	7
55	1182.76106	13731.65884	4290.2365	0.030341513	38693.88706	12089.28423	25	8
60	1290.284793	14979.99146	4680.258	0.033099832	42211.51316	13188.31007	27	9
65	1397.808525	16228.32408	5070.2795	0.035858152	45729.13926	14287.33591	30	9
70	1505.332258	17476.6567	5460.301	0.038616471	49246.76535	15386.36175	32	10
75	1612.855991	18724.98932	5850.3225	0.04137479	52764.39145	16485.38759	34	11
80	1720.379723	19973.32194	6240.344	0.04413311	56282.01755	17584.41343	36	11
85	1827.903456	21221.65456	6630.3655	0.046891429	59799.64365	18683.43927	39	12
90	1935.427189	22469.98719	7020.387	0.049649748	63317.26974	19782.46511	41	13
95	2042.950922	23718.31981	7410.4085	0.052408068	66834.89584	20881.49095	43	13
100	2150.474654	24966.65243	7800.43	0.055166387	70352.52194	21980.51679	45	14

Fresh Apples for Cake

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Cakes	69850.33192	0.954289177	CEDA	20784.82389	3.521617041
PRODUCT SUBSTITUTE					
Fresh Apples	100329.3776	1.564179911	CEDA	29099.69522	2.181228

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	1039.241194	3492.516596	3659.8095	0.03571313	3583.076092	2266.821992	0	-1
10	2078.482389	6985.033192	7319.619	0.07142626	7166.152183	4533.643984	0	-3
15	3117.723583	10477.54979	10979.4285	0.10713939	10749.22828	6800.465977	0	-4
20	4156.964778	13970.06638	14639.238	0.142852519	14332.30437	9067.287969	0	-6
25	5196.205972	17462.58298	18299.0475	0.178565649	17915.38046	11334.10996	0	-7
30	6235.447167	20955.09957	21958.857	0.214278779	21498.45655	13600.93195	1	-8
35	7274.688361	24447.61617	25618.6665	0.249991909	25081.53264	15867.75395	1	-10
40	8313.929556	27940.13277	29278.476	0.285705039	28664.60873	18134.57594	1	-11
45	9353.17075	31432.64936	32938.2855	0.321418169	32247.68483	20401.39793	1	-13
50	10392.41194	34925.16596	36598.095	0.357131299	35830.76092	22668.21992	1	-14
55	11431.65314	38417.68255	40257.9045	0.392844429	39413.83701	24935.04191	1	-15
60	12470.89433	41910.19915	43917.714	0.428557558	42996.9131	27201.86391	1	-17
65	13510.13553	45402.71575	47577.5235	0.464270688	46579.98919	29468.6859	1	-18
70	14549.37672	48895.23234	51237.333	0.499983818	50163.06528	31735.50789	1	-20
75	15588.61792	52387.74894	54897.1425	0.535696948	53746.14138	34002.32988	1	-21
80	16627.85911	55880.26553	58556.952	0.571410078	57329.21747	36269.15187	1	-22
85	17667.10031	59372.78213	62216.7615	0.607123208	60912.29356	38535.97387	2	-24
90	18706.3415	62865.29872	65876.571	0.642836338	64495.36965	40802.79586	2	-25
95	19745.5827	66357.81532	69536.3805	0.678549467	68078.44574	43069.61785	2	-26
100	20784.82389	69850.33192	73196.19	0.714262597	71661.52183	45336.43984	2	-28

Soup Base for Soups

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Soups	950875.5543	1.136777631	CEDA	315629.197	2.32226767
PRODUCT SUBSTITUTE					
Soup Base	93938.14249	1.136777631	CEDA	51808.16485	1.595027738

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	15781.45985	47543.77772	36648.774	0.304613373	28614.81445	25171.86621	-19	-11
10	31562.9197	95087.55543	73297.548	0.609226746	57229.6289	50343.73242	-38	-23
15	47344.37955	142631.3331	109946.322	0.913840119	85844.44335	75515.59863	-57	-34
20	63125.8394	190175.1109	146595.096	1.218453493	114459.2578	100687.4648	-76	-46
25	78907.29926	237718.8886	183243.87	1.523066866	143074.0723	125859.3311	-95	-57
30	94688.75911	285262.6663	219892.644	1.827680239	171688.8867	151031.1973	-114	-69
35	110470.219	332806.444	256541.418	2.132293612	200303.7012	176203.0635	-133	-80
40	126251.6788	380350.2217	293190.192	2.436906985	228918.5156	201374.9297	-151	-92
45	142033.1387	427893.9994	329838.966	2.741520358	257533.3301	226546.7959	-170	-103
50	157814.5985	475437.7772	366487.74	3.046133731	286148.1445	251718.6621	-189	-115
55	173596.0584	522981.5549	403136.514	3.350747104	314762.959	276890.5283	-208	-126
60	189377.5182	570525.3326	439785.288	3.655360478	343377.7734	302062.3945	-227	-138
65	205158.9781	618069.1103	476434.062	3.959973851	371992.5879	327234.2607	-246	-149
70	220940.4379	665612.888	513082.836	4.264587224	400607.4023	352406.127	-265	-161
75	236721.8978	713156.6657	549731.61	4.569200597	429222.2168	377577.9932	-284	-172
80	252503.3576	760700.4435	586380.384	4.87381397	457837.0312	402749.8594	-303	-184
85	268284.8175	808244.2212	623029.158	5.178427343	486451.8457	427921.7256	-322	-195
90	284066.2773	855787.9989	659677.932	5.483040716	515066.6601	453093.5918	-341	-207
95	299847.7372	903331.7766	696326.706	5.78765409	543681.4746	478265.458	-360	-218
100	315629.197	950875.5543	732975.48	6.092267463	572296.289	503437.3242	-379	-230

Cheese Cubes for Processed Cheese

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT RI	baseling kg * emissions factor			sum of purchase/product cost	
Processed Ch	113174.7577	2.513946579	CEDA	5019.542961	8.968697021
PRODUCT SUBSTITUTE					
Cheese Cube	12129.91794	2.513946579	CEDA	514.756165	9.373467144

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	250.9771481	5658.737886	1259790.577	0.487565114	5914.12482	129192.0342	0	-1131
10	501.9542961	11317.47577	2519581.154	0.975130227	11828.24964	258384.0685	1	-2261
15	752.9314442	16976.21366	3779371.731	1.462695341	17742.37446	387576.1027	1	-3392
20	1003.908592	22634.95154	5039162.308	1.950260454	23656.49928	516768.1369	1	-4522
25	1254.88574	28293.68943	6298952.885	2.437825568	29570.6241	645960.1712	1	-5653
30	1505.862888	33952.42731	7558743.462	2.925390681	35484.74892	775152.2054	2	-6784
35	1756.840036	39611.1652	8818534.038	3.412955795	41398.87374	904344.2397	2	-7914
40	2007.817184	45269.90309	10078324.62	3.900520909	47312.99856	1033536.274	2	-9045
45	2258.794332	50928.64097	11338115.19	4.388086022	53227.12338	1162728.308	2	-10175
50	2509.771481	56587.37886	12597905.77	4.875651136	59141.2482	1291920.342	3	-11306
55	2760.748629	62246.11674	13857696.35	5.363216249	65055.37302	1421112.377	3	-12437
60	3011.725777	67904.85463	15117486.92	5.850781363	70969.49784	1550304.411	3	-13567
65	3262.702925	73563.59251	16377277.5	6.338346477	76883.62266	1679496.445	3	-14698
70	3513.680073	79222.3304	17637068.08	6.82591159	82797.74748	1808688.479	4	-15828
75	3764.657221	84881.06829	18896858.65	7.313476704	88711.8723	1937880.514	4	-16959
80	4015.634369	90539.80617	20156649.23	7.801041817	94625.99712	2067072.548	4	-18090
85	4266.611517	96198.54406	21416439.81	8.288606931	100540.1219	2196264.582	4	-19220
90	4517.588665	101857.2819	22676230.38	8.776172044	106454.2468	2325456.616	5	-20351
95	4768.565813	107516.0198	23936020.96	9.263737158	112368.3716	2454648.65	5	-21481
100	5019.542961	113174.7577	25195811.54	9.751302272	118282.4964	2583840.685	5	-22612

Fresh Pork for Pork Deli Slices

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Pork Deli Slices (	4616.911734	3.200676428	CEDA	228.9962901	6.299141349
PRODUCT SUBSTITUTE					
Fresh Pork	61583.54301	3.200676428	CEDA	2051.304472	9.379782603

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	11.44981451	230.8455867	72.124	0.005581724	343.7423131	107.3967709	0	0
10	22.89962901	461.6911734	144.248	0.011163447	687.4846262	214.7935418	0	0
15	34.34944352	692.5367601	216.372	0.016745171	1031.226939	322.1903128	0	0
20	45.79925803	923.3823468	288.496	0.022326894	1374.969252	429.5870837	0	0
25	57.24907253	1154.227933	360.62	0.027908618	1718.711566	536.9838546	1	0
30	68.69888704	1385.07352	432.744	0.033490341	2062.453879	644.3806255	1	0
35	80.14870155	1615.919107	504.868	0.039072065	2406.196192	751.7773964	1	0
40	91.59851605	1846.764694	576.992	0.044653789	2749.938505	859.1741673	1	0
45	103.0483306	2077.61028	649.116	0.050235512	3093.680818	966.5709383	1	0
50	114.4981451	2308.455867	721.24	0.055817236	3437.423131	1073.967709	1	0
55	125.9479596	2539.301454	793.364	0.061398959	3781.165444	1181.36448	1	0
60	137.3977741	2770.14704	865.488	0.066980683	4124.907757	1288.761251	1	0
65	148.8475886	3000.992627	937.612	0.072562406	4468.650071	1396.158022	1	0
70	160.2974031	3231.838214	1009.736	0.07814413	4812.392384	1503.554793	2	0
75	171.7472176	3462.6838	1081.86	0.083725853	5156.134697	1610.951564	2	1
80	183.1970321	3693.529387	1153.984	0.089307577	5499.87701	1718.348335	2	1
85	194.6468466	3924.374974	1226.108	0.094889301	5843.619323	1825.745106	2	1
90	206.0966611	4155.22056	1298.232	0.100471024	6187.361636	1933.141877	2	1
95	217.5464756	4386.066147	1370.356	0.106052748	6531.103949	2040.538647	2	1
100	228.9962901	4616.911734	1442.48	0.111634471	6874.846262	2147.935418	2	1

Egg Liquid Fresh for Egg Entrees

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Egg Entrees	161765.5901	2.438845751	CEDA	15864.51053	4.180951558
PRODUCT SUBSTITUTE					
Eggs Liquid Fresh	297247.2274	2.438845751	CEDA	54515.04018	2.235718613

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	793.2255263	8088.279507	3316.4375	0.014550581	4325.11996	1773.429073	-4	-2
10	1586.451053	16176.55901	6632.875	0.029101163	8650.23992	3546.858146	-8	-3
15	2379.676579	24264.83852	9949.3125	0.043651744	12975.35988	5320.287219	-11	-5
20	3172.902105	32353.11803	13265.75	0.058202325	17300.47984	7093.716292	-15	-6
25	3966.127631	40441.39753	16582.1875	0.072752907	21625.5998	8867.145365	-19	-8
30	4759.353158	48529.67704	19898.625	0.087303488	25950.71976	10640.57444	-23	-9
35	5552.578684	56617.95655	23215.0625	0.101854069	30275.83972	12414.00351	-26	-11
40	6345.80421	64706.23605	26531.5	0.116404651	34600.95968	14187.43258	-30	-12
45	7139.029736	72794.51556	29847.9375	0.130955232	38926.07964	15960.86166	-34	-14
50	7932.255263	80882.79507	33164.375	0.145505813	43251.1996	17734.29073	-38	-15
55	8725.480789	88971.07457	36480.8125	0.160056395	47576.31956	19507.7198	-41	-17
60	9518.706315	97059.35408	39797.25	0.174606976	51901.43952	21281.14888	-45	-19
65	10311.93184	105147.6336	43113.6875	0.189157557	56226.55948	23054.57795	-49	-20
70	11105.15737	113235.9131	46430.125	0.203708139	60551.67944	24828.00702	-53	-22
75	11898.38289	121324.1926	49746.5625	0.21825872	64876.7994	26601.4361	-56	-23
80	12691.60842	129412.4721	53063	0.232809301	69201.91936	28374.86517	-60	-25
85	13484.83395	137500.7516	56379.4375	0.247359883	73527.03932	30148.29424	-64	-26
90	14278.05947	145589.0311	59695.875	0.261910464	77852.15928	31921.72331	-68	-28
95	15071.285	153677.3106	63012.3125	0.276461045	82177.27924	33695.15239	-72	-29
100	15864.51053	161765.5901	66328.75	0.291011627	86502.3992	35468.58146	-75	-31

Fresh Turkey for Lunch Meat

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Lunch Meat	4025.202683	3.200676428	CEDA	178.7179652	7.036841531
PRODUCT SUBSTITUTE					
Turkey Fresh	281810.554	1.539808537	CEDA	37750.89301	4.8480077

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	8.935898262	201.2601341	62.8805	0.000236707	66.7065131	43.32130358	0	0
10	17.87179652	402.5202683	125.761	0.000473414	133.4130262	86.64260715	0	0
15	26.80769478	603.7804024	188.6415	0.000710121	200.1195393	129.9639107	0	0
20	35.74359305	805.0405365	251.522	0.000946828	266.8260524	173.2852143	-1	0
25	44.67949131	1006.300671	314.4025	0.001183535	333.5325655	216.6065179	-1	0
30	53.61538957	1207.560805	377.283	0.001420242	400.2390786	259.9278215	-1	0
35	62.55128783	1408.820939	440.1635	0.001656949	466.9455917	303.249125	-1	0
40	71.48718609	1610.081073	503.044	0.001893655	533.6521048	346.5704286	-1	0
45	80.42308435	1811.341207	565.9245	0.002130362	600.3586179	389.8917322	-1	0
50	89.35898262	2012.601341	628.805	0.002367069	667.065131	433.2130358	-1	0
55	98.29488088	2213.861475	691.6855	0.002603776	733.7716441	476.5343393	-1	0
60	107.2307791	2415.12161	754.566	0.002840483	800.4781572	519.8556429	-2	0
65	116.1666774	2616.381744	817.4465	0.00307719	867.1846703	563.1769465	-2	0
70	125.1025757	2817.641878	880.327	0.003313897	933.8911834	606.4982501	-2	0
75	134.0384739	3018.902012	943.2075	0.003550604	1000.597696	649.8195536	-2	0
80	142.9743722	3220.162146	1006.088	0.003787311	1067.30421	693.1408572	-2	0
85	151.9102704	3421.42228	1068.9685	0.004024018	1134.010723	736.4621608	-2	0
90	160.8461687	3622.682414	1131.849	0.004260725	1200.717236	779.7834644	-2	0
95	169.782067	3823.942548	1194.7295	0.004497432	1267.423749	823.1047679	-3	0
100	178.7179652	4025.202683	1257.61	0.004734139	1334.130262	866.4260715	-3	0

Fresh Chicken for Poultry Entrees

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Poultry Entrees	3418.020797	1.539808537	CEDA	374.8916887	5.921096857
PRODUCT SUBSTITUTE					
CHICKEN	1333242.822	1.539808537	CEDA	238837.5019	6.141400151

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	18.74458444	170.9010399	110.9885	7.84826E-05	104.6363425	115.1179937	0	0
10	37.48916887	341.8020797	221.977	0.000156965	209.272685	230.2359874	0	0
15	56.23375331	512.7031196	332.9655	0.000235448	313.9090275	345.3539811	0	0
20	74.97833775	683.6041594	443.954	0.00031393	418.54537	460.4719747	0	0
25	93.72292218	854.5051993	554.9425	0.000392413	523.1817125	575.5899684	0	0
30	112.4675066	1025.406239	665.931	0.000470896	627.818055	690.7079621	0	0
35	131.2120911	1196.307279	776.9195	0.000549378	732.4543975	805.8259558	0	0
40	149.9566755	1367.208319	887.908	0.000627861	837.09074	920.9439495	-1	0
45	168.7012599	1538.109359	998.8965	0.000706343	941.7270825	1036.061943	-1	0
50	187.4458444	1709.010399	1109.885	0.000784826	1046.363425	1151.179937	-1	0
55	206.1904288	1879.911438	1220.8735	0.000863308	1150.999768	1266.297931	-1	0
60	224.9350132	2050.812478	1331.862	0.000941791	1255.63611	1381.415924	-1	0
65	243.6795977	2221.713518	1442.8505	0.001020274	1360.272453	1496.533918	-1	0
70	262.4241821	2392.614558	1553.839	0.001098756	1464.908795	1611.651912	-1	0
75	281.1687665	2563.515598	1664.8275	0.001177239	1569.545138	1726.769905	-1	0
80	299.913351	2734.416638	1775.816	0.001255721	1674.18148	1841.887899	-1	0
85	318.6579354	2905.317678	1886.8045	0.001334204	1778.817823	1957.005893	-1	0
90	337.4025199	3076.218717	1997.793	0.001412687	1883.454165	2072.123886	-1	0
95	356.1471043	3247.119757	2108.7815	0.001491169	1988.090508	2187.24188	-1	0
100	374.8916887	3418.020797	2219.77	0.001569652	2092.72685	2302.359874	-1	0

Tap Water for Juice Beverages

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
JUICE BEVERAGES	1021955.727	1.031523232	CEDA	941230.6228	0.954052926
PRODUCT SUBSTITUTE					
TAP WATER	39042775.22	0.023	CEDA	1697511966	0.000529

PERCENTAGE CHANGE	KG REDUCTION	EMISSIONS REDUCTION (kg)	COST REDUCTION ($)	EQUIVALENT SUBSTITUTE PERCENTAGE CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (TONS)	COST CHANGE ($1000s)
0	0	0	0	0	0	0	0	0
5	47061.53114	51097.78635	44899.1915	2.77238E-05	1082.415216	24.89554997	-50	-45
10	94123.06228	102195.5727	89798.383	5.54477E-05	2164.830432	49.79109994	-100	-90
15	141184.5934	153293.359	134697.5745	8.31715E-05	3247.245649	74.68664992	-150	-135
20	188246.1246	204391.1454	179596.766	0.000110895	4329.660865	99.58219989	-200	-179
25	235307.6557	255488.9317	224495.9575	0.000138619	5412.076081	124.4777499	-250	-224
30	282369.1868	306586.7181	269395.149	0.000166343	6494.491297	149.3732998	-300	-269
35	329430.718	357684.5044	314294.3405	0.000194067	7576.906513	174.2688498	-350	-314
40	376492.2491	408782.2908	359193.532	0.000221791	8659.321729	199.1643998	-400	-359
45	423553.7802	459880.0771	404092.7235	0.000249514	9741.736946	224.0599497	-450	-404
50	470615.3114	510977.8635	448991.915	0.000277238	10824.15216	248.9554997	-500	-449
55	517676.8425	562075.6498	493891.1065	0.000304962	11906.56738	273.8510497	-550	-494
60	564738.3737	613173.4362	538790.298	0.000332686	12988.98259	298.7465997	-600	-538
65	611799.9048	664271.2225	583689.4895	0.00036041	14071.39781	323.6421496	-650	-583
70	658861.4359	715369.0088	628588.681	0.000388134	15153.81303	348.5376996	-700	-628
75	705922.9671	766466.7952	673487.8725	0.000415857	16236.22824	373.4332496	-750	-673
80	752984.4982	817564.5815	718387.064	0.000443581	17318.64346	398.3287996	-800	-718
85	800046.0293	868662.3679	763286.2555	0.000471305	18401.05867	423.2243495	-850	-763
90	847107.5605	919760.1542	808185.447	0.000499029	19483.47389	448.1198995	-900	-808
95	894169.0916	970857.9406	853084.6385	0.000526753	20565.88911	473.0154495	-950	-853
100	941230.6228	1021955.727	897983.83	0.000554477	21648.30432	497.9109994	-1000	-897

Organic Chicken for Intensive Feedlot Chicken

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Intensive Feedlot Chicken	92438.38808	3.1	Process Based	5488.90828	5.432562058
PRODUCT SUBSTITUTE					
Organic Chicken	357119.5577	4.1	Process Based	16033.35205	5.432562058

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.00
5	274.4454	4621.9194	1506405.7053	0.0171	6112.8718	4400279.9408	1.49	2893.87
10	548.8908	9243.8388	3012811.4106	0.0342	12225.7435	8800559.8816	2.98	5787.75
15	823.3362	13865.7582	4519217.1159	0.0514	18338.6153	13200839.8224	4.47	8681.62
20	1097.7817	18487.6776	6025622.8212	0.0685	24451.4870	17601119.7633	5.96	11575.50
25	1372.2271	23109.5970	7532028.5265	0.0856	30564.3588	22001399.7041	7.45	14469.37
30	1646.6725	27731.5164	9038434.2319	0.1027	36677.2305	26401679.6449	8.95	17363.25
35	1921.1179	32353.4358	10544839.9372	0.1198	42790.1023	30801959.5857	10.44	20257.12
40	2195.5633	36975.3552	12051245.6425	0.1369	48902.9740	35202239.5265	11.93	23150.99
45	2470.0087	41597.2746	13557651.3478	0.1541	55015.8458	39602519.4673	13.42	26044.87
50	2744.4541	46219.1940	15064057.0531	0.1712	61128.7175	44002799.4082	14.91	28938.74
55	3018.8996	50841.1134	16570462.7584	0.1883	67241.5893	48403079.3490	16.40	31832.62
60	3293.3450	55463.0328	18076868.4637	0.2054	73354.4611	52803359.2898	17.89	34726.49
65	3567.7904	60084.9522	19583274.1690	0.2225	79467.3328	57203639.2306	19.38	37620.37
70	3842.2358	64706.8717	21089679.8743	0.2396	85580.2046	61603919.1714	20.87	40514.24
75	4116.6812	69328.7911	22596085.5796	0.2568	91693.0763	66004199.1122	22.36	43408.11
80	4391.1266	73950.7105	24102491.2850	0.2739	97805.9481	70404479.0531	23.86	46301.99
85	4665.5720	78572.6299	25608896.9903	0.2910	103918.8198	74804758.9939	25.35	49195.86
90	4940.0175	83194.5493	27115302.6956	0.3081	110031.6916	79205038.9347	26.84	52089.74
95	5214.4629	87816.4687	28621708.4009	0.3252	116144.5633	83605318.8755	28.33	54983.61
100	5488.9083	92438.3881	30128114.1062	0.3423	122257.4351	88005598.8163	29.82	57877.48

Extensive Feedlot Chicken for Intensive Feedlot Chicken

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Intensive Feedlot Chicker	92438.38808	3.1	Process Based	5488.90828	5.432562058
PRODUCT SUBSTITUTE					
Extensive Chicken	322278.066	3.7	Process Based	16033.35205	5.432562058

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.00
5	274.4454	4,621.9194	1,506,405.7053	0.0171	5,516.4844	4,400,279.9408	0.89	2,893.87
10	548.8908	9,243.8388	3,012,811.4106	0.0342	11,032.9689	8,800,559.8816	1.79	5,787.75
15	823.3362	13,865.7582	4,519,217.1159	0.0514	16,549.4533	13,200,839.8224	2.68	8,681.62
20	1,097.7817	18,487.6776	6,025,622.8212	0.0685	22,065.9378	17,601,119.7633	3.58	11,575.50
25	1,372.2271	23,109.5970	7,532,028.5265	0.0856	27,582.4222	22,001,399.7041	4.47	14,469.37
30	1,646.6725	27,731.5164	9,038,434.2319	0.1027	33,098.9067	26,401,679.6449	5.37	17,363.25
35	1,921.1179	32,353.4358	10,544,839.9372	0.1198	38,615.3911	30,801,959.5857	6.26	20,257.12
40	2,195.5633	36,975.3552	12,051,245.6425	0.1369	44,131.8756	35,202,239.5265	7.16	23,150.99
45	2,470.0087	41,597.2746	13,557,651.3478	0.1541	49,648.3600	39,602,519.4673	8.05	26,044.87
50	2,744.4541	46,219.1940	15,064,057.0531	0.1712	55,164.8445	44,002,799.4082	8.95	28,938.74
55	3,018.8996	50,841.1134	16,570,462.7584	0.1883	60,681.3289	48,403,079.3490	9.84	31,832.62
60	3,293.3450	55,463.0328	18,076,868.4637	0.2054	66,197.8134	52,803,359.2898	10.73	34,726.49
65	3,567.7904	60,084.9522	19,583,274.1690	0.2225	71,714.2978	57,203,639.2306	11.63	37,620.37
70	3,842.2358	64,706.8717	21,089,679.8743	0.2396	77,230.7823	61,603,919.1714	12.52	40,514.24
75	4,116.6812	69,328.7911	22,596,085.5796	0.2568	82,747.2667	66,004,199.1122	13.42	43,408.11
80	4,391.1266	73,950.7105	24,102,491.2850	0.2739	88,263.7512	70,404,479.0531	14.31	46,301.99
85	4,665.5720	78,572.6299	25,608,896.9903	0.2910	93,780.2356	74,804,758.9939	15.21	49,195.86
90	4,940.0175	83,194.5493	27,115,302.6956	0.3081	99,296.7201	79,205,038.9347	16.10	52,089.74
95	5,214.4629	87,816.4687	28,621,708.4009	0.3252	104,813.2045	83,605,318.8755	17.00	54,983.61
100	5,488.9083	92,438.3881	30,128,114.1062	0.3423	110,329.6890	88,005,598.8163	17.89	57,877.48

Organic Suckler Beef for Intensive Feedlot Beef

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Intensive Feedlot Beef	854884.0421	10	Process Based	85488.40422	6.912090715
PRODUCT SUBSTITUTE					
Organic Suckler Beef	2735628.93	32	Process Based	85488.40422	6.912090715

PERCENTAGE CHANGE	PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.00
5	4274.4202	42744.2021	365413362.7926	0.0500	136781.4467	365413362.7926	94.0372	94.04	0.00
10	8548.8404	85488.4042	730826725.5852	0.1000	273562.8935	730826725.5852	188.0745	188.07	0.00
15	12823.2606	128232.6063	1096240088.3778	0.1500	410344.3402	1096240088.3778	282.1117	282.11	0.00
20	17097.6808	170976.8084	1461653451.1704	0.2000	547125.7870	1461653451.1704	376.1490	376.15	0.00
25	21372.1011	213721.0105	1827066813.9630	0.2500	683907.2337	1827066813.9630	470.1862	470.19	0.00
30	25646.5213	256465.2126	2192480176.7556	0.3000	820688.6804	2192480176.7556	564.2235	564.22	0.00
35	29920.9415	299209.4147	2557893539.5482	0.3500	957470.1272	2557893539.5482	658.2607	658.26	0.00
40	34195.3617	341953.6168	2923306902.3408	0.4000	1094251.5739	2923306902.3408	752.2980	752.30	0.00
45	38469.7819	384697.8190	3288720265.1334	0.4500	1231033.0206	3288720265.1334	846.3352	846.34	0.00
50	42744.2021	427442.0211	3654133627.9261	0.5000	1367814.4674	3654133627.9261	940.3724	940.37	0.00
55	47018.6223	470186.2232	4019546990.7187	0.5500	1504595.9141	4019546990.7187	1034.4097	1034.41	0.00
60	51293.0425	512930.4253	4384960353.5113	0.6000	1641377.3609	4384960353.5113	1128.4469	1128.45	0.00
65	55567.4627	555674.6274	4750373716.3039	0.6500	1778158.8076	4750373716.3039	1222.4842	1222.48	0.00
70	59841.8830	598418.8295	5115787079.0965	0.7000	1914940.2543	5115787079.0965	1316.5214	1316.52	0.00
75	64116.3032	641163.0316	5481200441.8891	0.7500	2051721.7011	5481200441.8891	1410.5587	1410.56	0.00
80	68390.7234	683907.2337	5846613804.6817	0.8000	2188503.1478	5846613804.6817	1504.5959	1504.60	0.00
85	72665.1436	726651.4358	6212027167.4743	0.8500	2325284.5946	6212027167.4743	1598.6332	1598.63	0.00
90	76939.5638	769395.6379	6577440530.2669	0.9000	2462066.0413	6577440530.2669	1692.6704	1692.67	0.00
95	81213.9840	812139.8400	6942853893.0595	0.9500	2598847.4880	6942853893.0595	1786.7076	1786.71	0.00
100	85488.4042	854884.0421	7308267255.8521	1.0000	2735628.9348	7308267255.8521	1880.7449	1880.74	0.00

Extensive Feedlot Beef for Intensive Feedlot Beef

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Intensive Feedlot Beef	854884.0421	10	Process Based	85488.40422	6.912090715
PRODUCT SUBSTITUTE					
Extensive Feedlot Beef	2564652.13	30	Process Based	85488.40422	6.912090715

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0.00	0.00
5	4274.420211	42744.20211	365413362.8	0.05	128232.6063	365413362.8	85.49	0.00
10	8548.840422	85488.40421	730826725.6	0.1	256465.2126	730826725.6	170.98	0.00
15	12823.26063	128232.6063	1096240088	0.15	384697.819	1096240088	256.47	0.00
20	17097.68084	170976.8084	1461653451	0.2	512930.4253	1461653451	341.95	0.00
25	21372.10105	213721.0105	1827066814	0.25	641163.0316	1827066814	427.44	0.00
30	25646.52127	256465.2126	2192480177	0.3	769395.6379	2192480177	512.93	0.00
35	29920.94148	299209.4147	2557893540	0.35	897628.2442	2557893540	598.42	0.00
40	34195.36169	341953.6168	2923306902	0.4	1025860.851	2923306902	683.91	0.00
45	38469.7819	384697.819	3288720265	0.45	1154093.457	3288720265	769.40	0.00
50	42744.20211	427442.0211	3654133628	0.5	1282326.063	3654133628	854.88	0.00
55	47018.62232	470186.2232	4019546991	0.55	1410558.669	4019546991	940.37	0.00
60	51293.04253	512930.4253	4384960354	0.6	1538791.276	4384960354	1025.86	0.00
65	55567.46274	555674.6274	4750373716	0.65	1667023.882	4750373716	1111.35	0.00
70	59841.88295	598418.8295	5115787079	0.7	1795256.488	5115787079	1196.84	0.00
75	64116.30316	641163.0316	5481200442	0.75	1923489.095	5481200442	1282.33	0.00
80	68390.72337	683907.2337	5846613805	0.8	2051721.701	5846613805	1367.81	0.00
85	72665.14359	726651.4358	6212027167	0.85	2179954.307	6212027167	1453.30	0.00
90	76939.5638	769395.6379	6577440530	0.9	2308186.914	6577440530	1538.79	0.00
95	81213.98401	812139.84	6942853893	0.95	2436419.52	6942853893	1624.28	0.00
100	85488.40422	854884.0421	7308267256	1	2564652.126	7308267256	1709.77	0.00

Extensive Feedlot Pork for Intensive Feedlot Pork

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Intensive Feedlot Pork	71430.43042	5.5	Process Based	12987.35098	9.636847166
PRODUCT SUBSTITUTE					
Extensive Feedlot Pork	1155.874238	8.9	Process Based	12987.35098	9.636847166

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0.00	0.00
5	649.3675491	3571.521521	8433564.276	0.05	57.79371189	8433564.276	-3.51	0.00
10	1298.735098	7143.043042	16867128.55	0.1	115.5874238	16867128.55	-7.03	0.00
15	1948.102647	10714.56456	25300692.83	0.15	173.3811357	25300692.83	-10.54	0.00
20	2597.470196	14286.08608	33734257.1	0.2	231.1748476	33734257.1	-14.05	0.00
25	3246.837745	17857.60761	42167821.38	0.25	288.9685594	42167821.38	-17.57	0.00
30	3896.205294	21429.12913	50601385.65	0.3	346.7622713	50601385.65	-21.08	0.00
35	4545.572843	25000.65065	59034949.93	0.35	404.5559832	59034949.93	-24.60	0.00
40	5194.940393	28572.17217	67468514.2	0.4	462.3496951	67468514.2	-28.11	0.00
45	5844.307942	32143.69369	75902078.48	0.45	520.143407	75902078.48	-31.62	0.00
50	6493.675491	35715.21521	84335642.76	0.5	577.9371189	84335642.76	-35.14	0.00
55	7143.04304	39286.73673	92769207.03	0.55	635.7308308	92769207.03	-38.65	0.00
60	7792.410589	42858.25825	101202771.3	0.6	693.5245427	101202771.3	-42.16	0.00
65	8441.778138	46429.77978	109636335.6	0.65	751.3182546	109636335.6	-45.68	0.00
70	9091.145687	50001.3013	118069899.9	0.7	809.1119664	118069899.9	-49.19	0.00
75	9740.513236	53572.82282	126503464.1	0.75	866.9056783	126503464.1	-52.71	0.00
80	10389.88079	57144.34434	134937028.4	0.8	924.6993902	134937028.4	-56.22	0.00
85	11039.24833	60715.86586	143370592.7	0.85	982.4931021	143370592.7	-59.73	0.00
90	11688.61588	64287.38738	151804157	0.9	1040.286814	151804157	-63.25	0.00
95	12337.98343	67858.9089	160237721.2	0.95	1098.080526	160237721.2	-66.76	0.00
100	12987.35098	71430.43042	168671285.5	1	1155.874238	168671285.5	-70.27	0.00

Hot Cereal for Cold Cereal

	EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
CEREAL COLD	285707.5781	0.989387133	CEDA	43490.9636	6.639822531
PRODUCT SUBSTITUTE					
CEREAL HOT	70219.3772	0.989387133	CEDA	67440.54641	1.05237285

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.00
5	2174.5482	14285.3789	14438.6140	0.0322	2264.1486	2288.4355	-12.02	-12.15
10	4349.0964	28570.7578	28877.2280	0.0645	4528.2972	4576.8709	-24.04	-24.30
15	6523.6445	42856.1367	43315.8420	0.0967	6792.4458	6865.3064	-36.06	-36.45
20	8698.1927	57141.5156	57754.4560	0.1290	9056.5944	9153.7419	-48.08	-48.60
25	10872.7409	71426.8945	72193.0700	0.1612	11320.7430	11442.1773	-60.11	-60.75
30	13047.2891	85712.2734	86631.6840	0.1935	13584.8916	13730.6128	-72.13	-72.90
35	15221.8373	99997.6523	101070.2980	0.2257	15849.0402	16019.0483	-84.15	-85.05
40	17396.3854	114283.0312	115508.9120	0.2580	18113.1888	18307.4837	-96.17	-97.20
45	19570.9336	128568.4101	129947.5260	0.2902	20377.3374	20595.9192	-108.19	-109.35
50	21745.4818	142853.7890	144386.1400	0.3224	22641.4860	22884.3546	-120.21	-121.50
55	23920.0300	157139.1679	158824.7540	0.3547	24905.6346	25172.7901	-132.23	-133.65
60	26094.5782	171424.5468	173263.3680	0.3869	27169.7832	27461.2256	-144.25	-145.80
65	28269.1263	185709.9257	187701.9820	0.4192	29433.9318	29749.6610	-156.28	-157.95
70	30443.6745	199995.3047	202140.5960	0.4514	31698.0804	32038.0965	-168.30	-170.10
75	32618.2227	214280.6836	216579.2100	0.4837	33962.2290	34326.5320	-180.32	-182.25
80	34792.7709	228566.0625	231017.8240	0.5159	36226.3776	36614.9674	-192.34	-194.40
85	36967.3191	242851.4414	245456.4380	0.5481	38490.5262	38903.4029	-204.36	-206.55
90	39141.8672	257136.8203	259895.0520	0.5804	40754.6748	41191.8384	-216.38	-218.70
95	41316.4154	271422.1992	274333.6660	0.6126	43018.8234	43480.2738	-228.40	-230.85
100	43490.9636	285707.5781	288772.2800	0.6449	45282.9721	45768.7093	-240.42	-243.00

Carbonated Beverages for Juice Beverages

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
JUICE BEVERAGES	1021955.727	1.031523232	CEDA	941230.6228	0.954052926
PRODUCT SUBSTITUTE					
CARBONATED BEVERAGES	444605.1525	1.031523232	CEDA	662923.2709	0.650177915

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0.00	0.00
5	47061.53114	51097.78635	44899.1915	0.070990917	31562.92764	30598.36819	-19.53	-14.30
10	94123.06228	102195.5727	89798.383	0.141981835	63125.85528	61196.73637	-39.07	-28.60
15	141184.5934	153293.359	134697.5745	0.212972752	94688.78291	91795.10456	-58.60	-42.90
20	188246.1246	204391.1454	179596.766	0.283963669	126251.7106	122393.4727	-78.14	-57.20
25	235307.6557	255488.9317	224495.9575	0.354954587	157814.6382	152991.8409	-97.67	-71.50
30	282369.1868	306586.7181	269395.149	0.425945504	189377.5658	183590.2091	-117.21	-85.80
35	329430.718	357684.5044	314294.3405	0.496936421	220940.4935	214188.5773	-136.74	-100.11
40	376492.2491	408782.2908	359193.532	0.567927339	252503.4211	244786.9455	-156.28	-114.41
45	423553.7802	459880.0771	404092.7235	0.638918256	284066.3487	275385.3137	-175.81	-128.71
50	470615.3114	510977.8635	448991.915	0.709909174	315629.2764	305983.6819	-195.35	-143.01
55	517676.8425	562075.6498	493891.1065	0.780900091	347192.204	336582.05	-214.88	-157.31
60	564738.3737	613173.4362	538790.298	0.851891008	378755.1317	367180.4182	-234.42	-171.61
65	611799.9048	664271.2225	583689.4895	0.922881926	410318.0593	397778.7864	-253.95	-185.91
70	658861.4359	715369.0088	628588.681	0.993872843	441880.9869	428377.1546	-273.49	-200.21
75	705922.9671	766466.7952	673487.8725	1.06486376	473443.9146	458975.5228	-293.02	-214.51
80	752984.4982	817564.5815	718387.064	1.135854678	505006.8422	489573.891	-312.56	-228.81
85	800046.0293	868662.3679	763286.2555	1.206845595	536569.7698	520172.2591	-332.09	-243.11
90	847107.5605	919760.1542	808185.447	1.277836512	568132.6975	550770.6273	-351.63	-257.41
95	894169.0916	970857.9406	853084.6385	1.34882743	599695.6251	581368.9955	-371.16	-271.72
100	941230.6228	1021955.727	897983.83	1.419818347	631258.5528	611967.3637	-390.70	-286.02

Tea for Coffee

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Coffe	379946.4884	1.060442275	CEDA	516255.422	0.699
PRODUCT SUBSTITUTE					
Tea	155121.1461	1.060442275	CEDA	392453.9402	0.368

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0.00	0.00
5	25812.7711	18997.32442	18043.127	0.06577274	10202.74286	9499.099765	-8.79	-8.54
10	51625.5422	37994.64884	36086.254	0.131545481	20405.48572	18998.19953	-17.59	-17.09
15	77438.3133	56991.97326	54129.381	0.197318221	30608.22858	28497.2993	-26.38	-25.63
20	103251.0844	75989.29769	72172.508	0.263090961	40810.97144	37996.39906	-35.18	-34.18
25	129063.8555	94986.62211	90215.635	0.328863702	51013.7143	47495.49883	-43.97	-42.72
30	154876.6266	113983.9465	108258.762	0.394636442	61216.45716	56994.59859	-52.77	-51.26
35	180689.3977	132981.271	126301.889	0.460409182	71419.20002	66493.69836	-61.56	-59.81
40	206502.1688	151978.5954	144345.016	0.526181923	81621.94288	75992.79812	-70.36	-68.35
45	232314.9399	170975.9198	162388.143	0.591954663	91824.68574	85491.89789	-79.15	-76.90
50	258127.711	189973.2442	180431.27	0.657727403	102027.4286	94990.99765	-87.95	-85.44
55	283940.4821	208970.5686	198474.397	0.723500144	112230.1715	104490.0974	-96.74	-93.98
60	309753.2532	227967.8931	216517.524	0.789272884	122432.9143	113989.1972	-105.53	-102.53
65	335566.0243	246965.2175	234560.651	0.855045624	132635.6572	123488.2969	-114.33	-111.07
70	361378.7954	265962.5419	252603.778	0.920818365	142838.4	132987.3967	-123.12	-119.62
75	387191.5665	284959.8663	270646.905	0.986591105	153041.1429	142486.4965	-131.92	-128.16
80	413004.3376	303957.1907	288690.032	1.052363845	163243.8858	151985.5962	-140.71	-136.70
85	438817.1087	322954.5152	306733.159	1.118136586	173446.6286	161484.696	-149.51	-145.25
90	464629.8798	341951.8396	324776.286	1.183909326	183649.3715	170983.7958	-158.30	-153.79
95	490442.6509	360949.164	342819.413	1.249682066	193852.1143	180482.8955	-167.10	-162.34
100	516255.422	379946.4884	360862.54	1.315454807	204054.8572	189981.9953	-175.89	-170.88

Pork for Beef

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
BEEF	3007826.519	3.200676428	CEDA	91940.62294	10.22123964
PRODUCT SUBSTITUTE					
PORK	1120020.512	3.200676428	CEDA	36866.1994	9.44307511

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0.00	0.00
5	4597.031147	150391.326	46987.357	0.124695011	139660.9703	43410.11041	-10.73	-3.58
10	9194.062294	300782.6519	93974.714	0.249390022	279321.9406	86820.22081	-21.46	-7.15
15	13791.09344	451173.9779	140962.071	0.374085034	418982.9109	130230.3312	-32.19	-10.73
20	18388.12459	601565.3039	187949.428	0.498780045	558643.8811	173640.4416	-42.92	-14.31
25	22985.15574	751956.6298	234936.785	0.623475056	698304.8514	217050.552	-53.65	-17.89
30	27582.18688	902347.9558	281924.142	0.748170067	837965.8217	260460.6624	-64.38	-21.46
35	32179.21803	1052739.282	328911.499	0.872865078	977626.792	303870.7728	-75.11	-25.04
40	36776.24918	1203130.608	375898.856	0.99756009	1117287.762	347280.8833	-85.84	-28.62
45	41373.28032	1353521.934	422886.213	1.122255101	1256948.733	390690.9937	-96.57	-32.20
50	45970.31147	1503913.26	469873.57	1.246950112	1396609.703	434101.1041	-107.30	-35.77
55	50567.34262	1654304.586	516860.927	1.371645123	1536270.673	477511.2145	-118.03	-39.35
60	55164.37376	1804695.912	563848.284	1.496340134	1675931.643	520921.3249	-128.76	-42.93
65	59761.40491	1955087.238	610835.641	1.621035145	1815592.614	564331.4353	-139.49	-46.50
70	64358.43606	2105478.563	657822.998	1.745730157	1955253.584	607741.5457	-150.22	-50.08
75	68955.46721	2255869.889	704810.355	1.870425168	2094914.554	651151.6561	-160.96	-53.66
80	73552.49835	2406261.215	751797.712	1.995120179	2234575.525	694561.7665	-171.69	-57.24
85	78149.5295	2556652.541	798785.069	2.11981519	2374236.495	737971.8769	-182.42	-60.81
90	82746.56065	2707043.867	845772.426	2.244510201	2513897.465	781381.9873	-193.15	-64.39
95	87343.59179	2857435.193	892759.783	2.369205213	2653558.435	824792.0977	-203.88	-67.97
100	91940.62294	3007826.519	939747.14	2.493900224	2793219.406	868202.2081	-214.61	-71.54

Seafood for Beef

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
BEEF	3007826.519	3.200676428	CEDA	91940.62294	10.22123964
PRODUCT SUBSTITUTE					
SEAFOOD	211912.4415	1.056296561	CEDA	13711.12878	14.80269665

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0	0
5	4597.031147	150391.326	46987.357	0.335277366	71049.44528	68048.45755	-79	21
10	9194.062294	300782.6519	93974.714	0.670554733	142098.8906	136096.9151	-159	42
15	13791.09344	451173.9779	140962.071	1.005832099	213148.3358	204145.3726	-238	63
20	18388.12459	601565.3039	187949.428	1.341109466	284197.7811	272193.8302	-317	84
25	22985.15574	751956.6298	234936.785	1.676386832	355247.2264	340242.2877	-397	105
30	27582.18688	902347.9558	281924.142	2.011664198	426296.6717	408290.7453	-476	126
35	32179.21803	1052739.282	328911.499	2.346941565	497346.1169	476339.2028	-555	147
40	36776.24918	1203130.608	375898.856	2.682218931	568395.5622	544387.6604	-635	168
45	41373.28032	1353521.934	422886.213	3.017496297	639445.0075	612436.1179	-714	190
50	45970.31147	1503913.26	469873.57	3.352773664	710494.4528	680484.5755	-793	211
55	50567.34262	1654304.586	516860.927	3.68805103	781543.8981	748533.033	-873	232
60	55164.37376	1804695.912	563848.284	4.023328397	852593.3433	816581.4906	-952	253
65	59761.40491	1955087.238	610835.641	4.358605763	923642.7886	884629.9481	-1031	274
70	64358.43606	2105478.563	657822.998	4.693883129	994692.2339	952678.4057	-1111	295
75	68955.46721	2255869.889	704810.355	5.029160496	1065741.679	1020726.863	-1190	316
80	73552.49835	2406261.215	751797.712	5.364437862	1136791.124	1088775.321	-1269	337
85	78149.5295	2556652.541	798785.069	5.699715228	1207840.57	1156823.778	-1349	358
90	82746.56065	2707043.867	845772.426	6.034992595	1278890.015	1224872.236	-1428	379
95	87343.59179	2857435.193	892759.783	6.370269961	1349939.46	1292920.693	-1507	400
100	91940.62294	3007826.519	939747.14	6.705547328	1420988.906	1360969.151	-1587	421

Chicken for Beef

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
BEEF	3007826.519	3.200676428	CEDA	91940.62294	10.22123964
PRODUCT SUBSTITUTE					
Chicken	1333242.822	1.539808537	CEDA	238837.5019	6.141400151

PERCENTAGE CHANGE	KG REDUCTION (CO^{2}e kg)	EMISSIONS REDUCTION (CO^{2}e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^{2}e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0.00	0.00
5	4597.031147	150391.326	46987.357	0.019247527	25661.62655	28232.20778	-124.73	-18.76
10	9194.062294	300782.6519	93974.714	0.038495053	51323.25309	56464.41556	-249.46	-37.51
15	13791.09344	451173.9779	140962.071	0.05774258	76984.87964	84696.62334	-374.19	-56.27
20	18388.12459	601565.3039	187949.428	0.076990106	102646.5062	112928.8311	-498.92	-75.02
25	22985.15574	751956.6298	234936.785	0.096237633	128308.1327	141161.0389	-623.65	-93.78
30	27582.18688	902347.9558	281924.142	0.115485159	153969.7593	169393.2467	-748.38	-112.53
35	32179.21803	1052739.282	328911.499	0.134732686	179631.3858	197625.4545	-873.11	-131.29
40	36776.24918	1203130.608	375898.856	0.153980212	205293.0124	225857.6622	-997.84	-150.04
45	41373.28032	1353521.934	422886.213	0.173227739	230954.6389	254089.87	-1122.57	-168.80
50	45970.31147	1503913.26	469873.57	0.192475265	256616.2655	282322.0778	-1247.30	-187.55
55	50567.34262	1654304.586	516860.927	0.211722792	282277.892	310554.2856	-1372.03	-206.31
60	55164.37376	1804695.912	563848.284	0.230970318	307939.5186	338786.4934	-1496.76	-225.06
65	59761.40491	1955087.238	610835.641	0.250217845	333601.1451	367018.7011	-1621.49	-243.82
70	64358.43606	2105478.563	657822.998	0.269465371	359262.7717	395250.9089	-1746.22	-262.57
75	68955.46721	2255869.889	704810.355	0.288712898	384924.3982	423483.1167	-1870.95	-281.33
80	73552.49835	2406261.215	751797.712	0.307960424	410586.0248	451715.3245	-1995.68	-300.08
85	78149.5295	2556652.541	798785.069	0.327207951	436247.6513	479947.5323	-2120.40	-318.84
90	82746.56065	2707043.867	845772.426	0.346455477	461909.2778	508179.74	-2245.13	-337.59
95	87343.59179	2857435.193	892759.783	0.365703004	487570.9044	536411.9478	-2369.86	-356.35
100	91940.62294	3007826.519	939747.14	0.38495053	513232.5309	564644.1556	-2494.59	-375.10

Chicken for Pork

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
PORK	1120020.512	3.200676428	CEDA	36866.1994	9.44307511
PRODUCT SUBSTITUTE					
CHICKEN	1333242.822	1.539808537	CEDA	238837.5019	6.141400151

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0	0
5	1843.30997	56001.0256	17406.5145	0.007717841	10289.7567	11320.50413	-46	-6
10	3686.61994	112002.0512	34813.029	0.015435683	20579.51341	22641.00826	-91	-12
15	5529.92991	168003.0768	52219.5435	0.023153524	30869.27011	33961.51239	-137	-18
20	7373.239881	224004.1024	69626.058	0.030871366	41159.02682	45282.01652	-183	-24
25	9216.549851	280005.128	87032.5725	0.038589207	51448.78352	56602.52064	-229	-30
30	11059.85982	336006.1536	104439.087	0.046307049	61738.54023	67923.02477	-274	-37
35	12903.16979	392007.1792	121845.6015	0.05402489	72028.29693	79243.5289	-320	-43
40	14746.47976	448008.2048	139252.116	0.061742732	82318.05363	90564.03303	-366	-49
45	16589.78973	504009.2304	156658.6305	0.069460573	92607.81034	101884.5372	-411	-55
50	18433.0997	560010.256	174065.145	0.077178414	102897.567	113205.0413	-457	-61
55	20276.40967	616011.2816	191471.6595	0.084896256	113187.3237	124525.5454	-503	-67
60	22119.71964	672012.3073	208878.174	0.092614097	123477.0805	135846.0495	-549	-73
65	23963.02961	728013.3329	226284.6885	0.100331939	133766.8372	147166.5537	-594	-79
70	25806.33958	784014.3585	243691.203	0.10804978	144056.5939	158487.0578	-640	-85
75	27649.64955	840015.3841	261097.7175	0.115767622	154346.3506	169807.5619	-686	-91
80	29492.95952	896016.4097	278504.232	0.123485463	164636.1073	181128.0661	-731	-97
85	31336.26949	952017.4353	295910.7465	0.131203305	174925.864	192448.5702	-777	-103
90	33179.57946	1008018.461	313317.261	0.138921146	185215.6207	203769.0743	-823	-110
95	35022.88943	1064019.486	330723.7755	0.146638987	195505.3774	215089.5784	-869	-116
100	36866.1994	1120020.512	348130.29	0.154356829	205795.1341	226410.0826	-914	-122

Canned Carrots for Frozen Carrots

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Frozen Carro	93168.831	1.457785434	CEDA	25319.18313	2.524220851
PRODUCT SUBSTITUTE					
Canned Carrots	431.804983	1.136777631	CEDA	279.4787146	1.359137495

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0	0
5	1265.959157	4658.441552	3195.5605	4.529715827	1955.953867	1720.612557	-3	-1
10	2531.918313	9316.883104	6391.121	9.059431653	3911.907734	3441.225113	-5	-3
15	3797.87747	13975.32466	9586.6815	13.58914748	5867.861601	5161.83767	-8	-4
20	5063.836626	18633.76621	12782.242	18.11886331	7823.815467	6882.450227	-11	-6
25	6329.795783	23292.20776	15977.8025	22.64857913	9779.769334	8603.062784	-14	-7
30	7595.75494	27950.64931	19173.363	27.17829496	11735.7232	10323.67534	-16	-9
35	8861.714096	32609.09086	22368.9235	31.70801079	13691.67707	12044.2879	-19	-10
40	10127.67325	37267.53241	25564.484	36.23772661	15647.63093	13764.90045	-22	-12
45	11393.63241	41925.97397	28760.0445	40.76744244	17603.5848	15485.51301	-24	-13
50	12659.59157	46584.41552	31955.605	45.29715827	19559.53867	17206.12557	-27	-15
55	13925.55072	51242.85707	35151.1655	49.82687409	21515.49254	18926.73812	-30	-16
60	15191.50988	55901.29862	38346.726	54.35658992	23471.4464	20647.35068	-32	-18
65	16457.46904	60559.74017	41542.2865	58.88630575	25427.40027	22367.96324	-35	-19
70	17723.42819	65218.18173	44737.847	63.41602157	27383.35414	24088.57579	-38	-21
75	18989.38735	69876.62328	47933.4075	67.9457374	29339.308	25809.18835	-41	-22
80	20255.34651	74535.06483	51128.968	72.47545322	31295.26187	27529.80091	-43	-24
85	21521.30566	79193.50638	54324.5285	77.00516905	33251.21574	29250.41346	-46	-25
90	22787.26482	83851.94793	57520.089	81.53488488	35207.1696	30971.02602	-49	-27
95	24053.22398	88510.38949	60715.6495	86.0646007	37163.12347	32691.63858	-51	-28
100	25319.18313	93168.83104	63911.21	90.59431653	39119.07734	34412.25113	-54	-29

Fresh Carrots for Frozen Carrots

PRODUCT REDUCED					
Frozen Carrot	18938.16456	1.756054019	CEDA	4464.213929	2.415766845
PRODUCT SUBSTITUTE					
Fresh Carrots	93168.83104	1.457785434	CEDA	25319.18313	2.524220851

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0.00	0.00
5	223.2106965	946.9082282	539.225	0.008815873	821.3645581	563.4330942	-0.13	0.02
10	446.4213929	1893.816456	1078.45	0.017631745	1642.729116	1126.866188	-0.25	0.05
15	669.6320894	2840.724684	1617.675	0.026447618	2464.093674	1690.299283	-0.38	0.07
20	892.8427858	3787.632913	2156.9	0.035263491	3285.458232	2253.732377	-0.50	0.10
25	1116.053482	4734.541141	2696.125	0.044079364	4106.82279	2817.165471	-0.63	0.12
30	1339.264179	5681.449369	3235.35	0.052895236	4928.187348	3380.598565	-0.75	0.15
35	1562.474875	6628.357597	3774.575	0.061711109	5749.551906	3944.03166	-0.88	0.17
40	1785.685572	7575.265825	4313.8	0.070526982	6570.916465	4507.464754	-1.00	0.19
45	2008.896268	8522.174053	4853.025	0.079342855	7392.281023	5070.897848	-1.13	0.22
50	2232.106965	9469.082282	5392.25	0.088158727	8213.645581	5634.330942	-1.26	0.24
55	2455.317661	10415.99051	5931.475	0.0969746	9035.010139	6197.764037	-1.38	0.27
60	2678.528357	11362.89874	6470.7	0.105790473	9856.374697	6761.197131	-1.51	0.29
65	2901.739054	12309.80697	7009.925	0.114606346	10677.73925	7324.630225	-1.63	0.31
70	3124.94975	13256.71519	7549.15	0.123422218	11499.10381	7888.063319	-1.76	0.34
75	3348.160447	14203.62342	8088.375	0.132238091	12320.46837	8451.496413	-1.88	0.36
80	3571.371143	15150.53165	8627.6	0.141053964	13141.83293	9014.929508	-2.01	0.39
85	3794.58184	16097.43988	9166.825	0.149869837	13963.19749	9578.362602	-2.13	0.41
90	4017.792536	17044.34811	9706.05	0.158685709	14784.56205	10141.7957	-2.26	0.44
95	4241.003233	17991.25633	10245.275	0.167501582	15605.9266	10705.22879	-2.39	0.46
100	4464.213929	18938.16456	10784.5	0.176317455	16427.29116	11268.66188	-2.51	0.48

Frozen Broccoli for Fresh Broccoli

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDU	baseling kg * emissions factor			sum of purchase/product cost	
Fresh Broccoli	25071.49931	1.756054019	CEDA	2845.57423	5.01732826
PRODUCT SUBSTITUTE					
Frozen Brocolli	9474.132961	1.457785434	CEDA	2182.184573	2.978203623

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0.00	0.00
5	142.2787115	1253.574966	404864.6349	0.065200127	617.7146732	310478.4093	-0.64	-94.39
10	284.557423	2507.149931	809729.2698	0.130400254	1235.429346	620956.8186	-1.27	-188.77
15	426.8361345	3760.724897	1214593.905	0.195600381	1853.144019	931435.2279	-1.91	-283.16
20	569.114846	5014.299863	1619458.54	0.260800508	2470.858693	1241913.637	-2.54	-377.54
25	711.3935575	6267.874828	2024323.175	0.326000635	3088.573366	1552392.046	-3.18	-471.93
30	853.672269	7521.449794	2429187.81	0.391200763	3706.288039	1862870.456	-3.82	-566.32
35	995.9509805	8775.024759	2834052.444	0.45640089	4324.002712	2173348.865	-4.45	-660.70
40	1138.229692	10028.59973	3238917.079	0.521601017	4941.717385	2483827.274	-5.09	-755.09
45	1280.508403	11282.17469	3643781.714	0.586801144	5559.432058	2794305.684	-5.72	-849.48
50	1422.787115	12535.74966	4048646.349	0.652001271	6177.146732	3104784.093	-6.36	-943.86
55	1565.065826	13789.32462	4453510.984	0.717201398	6794.861405	3415262.502	-6.99	-1038.25
60	1707.344538	15042.89959	4858375.619	0.782401525	7412.576078	3725740.911	-7.63	-1132.63
65	1849.623249	16296.47455	5263240.254	0.847601652	8030.290751	4036219.321	-8.27	-1227.02
70	1991.901961	17550.04952	5668104.889	0.912801779	8648.005424	4346697.73	-8.90	-1321.41
75	2134.180672	18803.62448	6072969.524	0.978001906	9265.720097	4657176.139	-9.54	-1415.79
80	2276.459384	20057.19945	6477834.159	1.043202034	9883.434771	4967654.549	-10.17	-1510.18
85	2418.738095	21310.77442	6882698.794	1.108402161	10501.14944	5278132.958	-10.81	-1604.57
90	2561.016807	22564.34938	7287563.429	1.173602288	11118.86412	5588611.367	-11.45	-1698.95
95	2703.295518	23817.92435	7692428.064	1.238802415	11736.57879	5899089.776	-12.08	-1793.34
100	2845.57423	25071.49931	8097292.698	1.304002542	12354.29346	6209568.186	-12.72	-1887.72

Margarine for Butter

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Butter	18504.3884	1.649858894	CEDA	1834.410723	6.114083317
PRODUCT SUBSTITUTE					
Margarine	180161.537	2.380323403	CEDA	25504.76285	2.967596305

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0.00	0.00
5	91.7205362	925.2194194	560.787	0.003596212	647.8990945	272.1895242	-0.28	-0.29
10	183.441072	1850.438839	1121.574	0.007192424	1295.798189	544.3790484	-0.55	-0.58
15	275.161608	2775.658258	1682.361	0.010788636	1943.697283	816.5685726	-0.83	-0.87
20	366.882145	3700.877678	2243.148	0.014384848	2591.596378	1088.758097	-1.11	-1.15
25	458.602681	4626.097097	2803.935	0.01798106	3239.495472	1360.947621	-1.39	-1.44
30	550.323217	5551.316516	3364.722	0.021577272	3887.394567	1633.137145	-1.66	-1.73
35	642.043753	6476.535936	3925.509	0.025173485	4535.293661	1905.326669	-1.94	-2.02
40	733.764289	7401.755355	4486.296	0.028769697	5183.192756	2177.516194	-2.22	-2.31
45	825.484825	8326.974775	5047.083	0.032365909	5831.09185	2449.705718	-2.50	-2.60
50	917.205362	9252.194194	5607.87	0.035962121	6478.990945	2721.895242	-2.77	-2.89
55	1008.9259	10177.41361	6168.657	0.039558333	7126.890039	2994.084766	-3.05	-3.17
60	1100.64643	11102.63303	6729.444	0.043154545	7774.789134	3266.27429	-3.33	-3.46
65	1192.36697	12027.85245	7290.231	0.046750757	8422.688228	3538.463815	-3.61	-3.75
70	1284.08751	12953.07187	7851.018	0.050346969	9070.587323	3810.653339	-3.88	-4.04
75	1375.80804	13878.29129	8411.805	0.053943181	9718.486417	4082.842863	-4.16	-4.33
80	1467.52858	14803.51071	8972.592	0.057539393	10366.38551	4355.032387	-4.44	-4.62
85	1559.24911	15728.73013	9533.379	0.061135605	11014.28461	4627.221911	-4.71	-4.91
90	1650.96965	16653.94955	10094.166	0.064731817	11662.1837	4899.411436	-4.99	-5.19
95	1742.69019	17579.16897	10654.953	0.068328029	12310.0828	5171.60096	-5.27	-5.48
100	1834.41072	18504.38839	11215.74	0.071924242	12957.98189	5443.790484	-5.55	-5.77

Frozen Blueberries for Fresh Blueberries

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Fresh Blueberrie	21869.92555	1.564179911	CEDA	2162.265504	6.466236444
PRODUCT SUBSTITUTE					
Frozen Blueberr	21703.32004	1.457785434	CEDA	3352.267802	5.823893303

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0.00	0.00
5	108.1132752	1093.496278	699.086	0.032250787	699.9491539	629.6401793	-0.39	-0.07
10	216.2265504	2186.992555	1398.172	0.064501574	1399.898308	1259.280359	-0.79	-0.14
15	324.3398255	3280.488833	2097.258	0.096752361	2099.847462	1888.920538	-1.18	-0.21
20	432.4531007	4373.98511	2796.344	0.129003148	2799.796616	2518.560717	-1.57	-0.28
25	540.5663759	5467.481388	3495.43	0.161253936	3499.74577	3148.200896	-1.97	-0.35
30	648.6796511	6560.977665	4194.516	0.193504723	4199.694923	3777.841076	-2.36	-0.42
35	756.7929262	7654.473943	4893.602	0.22575551	4899.644077	4407.481255	-2.75	-0.49
40	864.9062014	8747.97022	5592.688	0.258006297	5599.593231	5037.121434	-3.15	-0.56
45	973.0194766	9841.466498	6291.774	0.290257084	6299.542385	5666.761614	-3.54	-0.63
50	1081.132752	10934.96278	6990.86	0.322507871	6999.491539	6296.401793	-3.94	-0.69
55	1189.246027	12028.45905	7689.946	0.354758658	7699.440693	6926.041972	-4.33	-0.76
60	1297.359302	13121.95533	8389.032	0.387009445	8399.389847	7555.682152	-4.72	-0.83
65	1405.472577	14215.45161	9088.118	0.419260232	9099.339001	8185.322331	-5.12	-0.90
70	1513.585852	15308.94789	9787.204	0.451511019	9799.288155	8814.96251	-5.51	-0.97
75	1621.699128	16402.44416	10486.29	0.483761807	10499.23731	9444.602689	-5.90	-1.04
80	1729.812403	17495.94044	11185.376	0.516012594	11199.18646	10074.24287	-6.30	-1.11
85	1837.925678	18589.43672	11884.462	0.548263381	11899.13562	10703.88305	-6.69	-1.18
90	1946.038953	19682.933	12583.548	0.580514168	12599.08477	11333.52323	-7.08	-1.25
95	2054.152228	20776.42927	13282.634	0.612764955	13299.03392	11963.16341	-7.48	-1.32
100	2162.265504	21869.92555	13981.72	0.645015742	13998.98308	12592.80359	-7.87	-1.39

Fresh Spinach for Frozen Spinach

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Frozen Spinach	11345.128	1.457785434	CEDA	1350.539266	3.196641601
PRODUCT SUBSTITUTE					
Fresh Spinach	7581.2188	1.756054019	CEDA	1264.776876	6.153211802

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0.00	0.00
5	67.52696328	567.2563838	215.8595	0.053390416	404.7644265	415.5077074	-0.16	0.20
10	135.0539266	1134.512768	431.719	0.106780832	809.5288529	831.0154148	-0.32	0.40
15	202.5808898	1701.769151	647.5785	0.160171247	1214.293279	1246.523122	-0.49	0.60
20	270.1078531	2269.025535	863.438	0.213561663	1619.057706	1662.03083	-0.65	0.80
25	337.6348164	2836.281919	1079.2975	0.266952079	2023.822132	2077.538537	-0.81	1.00
30	405.1617797	3403.538303	1295.157	0.320342495	2428.586559	2493.046244	-0.97	1.20
35	472.6887429	3970.794687	1511.0165	0.37373291	2833.350985	2908.553952	-1.14	1.40
40	540.2157062	4538.051071	1726.876	0.427123326	3238.115412	3324.061659	-1.30	1.60
45	607.7426695	5105.307454	1942.7355	0.480513742	3642.879838	3739.569367	-1.46	1.80
50	675.2696328	5672.563838	2158.595	0.533904158	4047.644265	4155.077074	-1.62	2.00
55	742.796596	6239.820222	2374.4545	0.587294574	4452.408691	4570.584781	-1.79	2.20
60	810.3235593	6807.076606	2590.314	0.640684989	4857.173117	4986.092489	-1.95	2.40
65	877.8505226	7374.33299	2806.1735	0.694075405	5261.937544	5401.600196	-2.11	2.60
70	945.3774859	7941.589374	3022.033	0.747465821	5666.70197	5817.107904	-2.27	2.80
75	1012.904449	8508.845757	3237.8925	0.800856237	6071.466397	6232.615611	-2.44	2.99
80	1080.431412	9076.102141	3453.752	0.854246653	6476.230823	6648.123318	-2.60	3.19
85	1147.958376	9643.358525	3669.6115	0.907637068	6880.99525	7063.631026	-2.76	3.39
90	1215.485339	10210.61491	3885.471	0.961027484	7285.759676	7479.138733	-2.92	3.59
95	1283.012302	10777.87129	4101.3305	1.0144179	7690.524103	7894.646441	-3.09	3.79
100	1350.539266	11345.12768	4317.19	1.067808316	8095.288529	8310.154148	-3.25	3.99

Fresh Apples for Canned Apples

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Canned Apples	4147.578659	1.136777631	CEDA	1022.598545	3.657769728
PRODUCT SUBSTITUTE					
Fresh Apples	100329.3776	1.564179911	CEDA	29099.69522	2.181228

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0.00	0.00
5	51.12992723	207.378933	187.0215	0.001757061	176.284794	111.5260289	-0.03	-0.08
10	102.2598545	414.7578659	374.043	0.003514121	352.569588	223.0520578	-0.06	-0.15
15	153.3897817	622.1367989	561.0645	0.005271182	528.8543819	334.5780867	-0.09	-0.23
20	204.5197089	829.5157319	748.086	0.007028242	705.1391759	446.1041157	-0.12	-0.30
25	255.6496362	1036.894665	935.1075	0.008785303	881.4239699	557.6301446	-0.16	-0.38
30	306.7795634	1244.273598	1122.129	0.010542363	1057.708764	669.1561735	-0.19	-0.45
35	357.9094906	1451.652531	1309.1505	0.012299424	1233.993558	780.6822024	-0.22	-0.53
40	409.0394178	1659.031464	1496.172	0.014056485	1410.278352	892.2082313	-0.25	-0.60
45	460.1693451	1866.410397	1683.1935	0.015813545	1586.563146	1003.73426	-0.28	-0.68
50	511.2992723	2073.78933	1870.215	0.017570606	1762.84794	1115.260289	-0.31	-0.75
55	562.4291995	2281.168263	2057.2365	0.019327666	1939.132734	1226.786318	-0.34	-0.83
60	613.5591268	2488.547196	2244.258	0.021084727	2115.417528	1338.312347	-0.37	-0.91
65	664.689054	2695.926129	2431.2795	0.022841787	2291.702322	1449.838376	-0.40	-0.98
70	715.8189812	2903.305062	2618.301	0.024598848	2467.987116	1561.364405	-0.44	-1.06
75	766.9489085	3110.683995	2805.3225	0.026355909	2644.27191	1672.890434	-0.47	-1.13
80	818.0788357	3318.062928	2992.344	0.028112969	2820.556704	1784.416463	-0.50	-1.21
85	869.2087629	3525.441861	3179.3655	0.02987003	2996.841498	1895.942492	-0.53	-1.28
90	920.3386902	3732.820793	3366.387	0.03162709	3173.126292	2007.46852	-0.56	-1.36
95	971.4686174	3940.199726	3553.4085	0.033384151	3349.411086	2118.994549	-0.59	-1.43
100	1022.598545	4147.578659	3740.43	0.035141212	3525.69588	2230.520578	-0.62	-1.51

Soymilk for Regular Milk

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Regular Milk	18096.24274	2.258422512	CEDA	21531.53494	1.054521661
PRODUCT SUBSTITUTE					
Soy Milk	138932.0402	2.258422512	CEDA	33492.42514	1.835978128

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0	0
5	1076.576747	904.8121368	1135.2735	0.032143888	4465.815874	1976.57136	3.56	0.84
10	2153.153494	1809.624274	2270.547	0.064287775	8931.631748	3953.142721	7.12	1.68
15	3229.730241	2714.436411	3405.8205	0.096431663	13397.44762	5929.714081	10.68	2.52
20	4306.306988	3619.248547	4541.094	0.12857555	17863.2635	7906.285442	14.24	3.37
25	5382.883735	4524.060684	5676.3675	0.160719438	22329.07937	9882.856802	17.81	4.21
30	6459.460482	5428.872821	6811.641	0.192863325	26794.89524	11859.42816	21.37	5.05
35	7536.037229	6333.684958	7946.9145	0.225007213	31260.71112	13835.99952	24.93	5.89
40	8612.613976	7238.497095	9082.188	0.2571511	35726.52699	15812.57088	28.49	6.73
45	9689.190724	8143.309232	10217.4615	0.289294988	40192.34287	17789.14224	32.05	7.57
50	10765.76747	9048.121368	11352.735	0.321438875	44658.15874	19765.7136	35.61	8.41
55	11842.34422	9952.933505	12488.0085	0.353582763	49123.97461	21742.28496	39.17	9.25
60	12918.92096	10857.74564	13623.282	0.38572665	53589.79049	23718.85633	42.73	10.10
65	13995.49771	11762.55778	14758.5555	0.417870538	58055.60636	25695.42769	46.29	10.94
70	15072.07446	12667.36992	15893.829	0.450014426	62521.42224	27671.99905	49.85	11.78
75	16148.65121	13572.18205	17029.1025	0.482158313	66987.23811	29648.57041	53.42	12.62
80	17225.22795	14476.99419	18164.376	0.514302201	71453.05399	31625.14177	56.98	13.46
85	18301.8047	15381.80633	19299.6495	0.546446088	75918.86986	33601.71313	60.54	14.30
90	19378.38145	16286.61846	20434.923	0.578589976	80384.68573	35578.28449	64.10	15.14
95	20454.95819	17191.4306	21570.1965	0.610733863	84850.50161	37554.85585	67.66	15.98
100	21531.53494	18096.24274	22705.47	0.642877751	89316.31748	39531.42721	71.22	16.83

Regular Milk for Soymilk

	BASELINE EMISSIONS (kg)	EMISSIONS FACTOR	EMISSIONS MODEL	BASELINE KG	PRODUCT COST ($/kg)
PRODUCT REDUCED					
Soy Milk	138932.0402	2.258422512	CEDA	33492.42514	1.835978128
PRODUCT SUBSTITUTE					
Regular Milk	21289.08756	2.258422512	CEDA	21531.53494	1.054521661

PERCENTAGE CHANGE	KG REDUCTION (kg)	EMISSIONS REDUCTION (CO^2e kg)	COST REDUCTION (US$)	EQUIVALENT SUBSTITUTE PERCENTAGE (%) CHANGE (1/100)	SUBSTITUTE EMISSIONS INCREASE (CO^2e kg)	SUBSTITUTE COST INCREASE ($)	EMISSIONS CHANGE (CO^2e TONS)	COST CHANGE (US$1000s)
0	0	0	0	0	0	0	0	0
5	1674.621257	6946.602008	3074.568	0.077775285	1655.764843	1765.92439	-5	-1
10	3349.242514	13893.20402	6149.136	0.155550569	3311.529686	3531.84878	-11	-3
15	5023.863771	20839.80602	9223.704	0.233325854	4967.294529	5297.773171	-16	-4
20	6698.485028	27786.40803	12298.272	0.311101138	6623.059373	7063.697561	-21	-5
25	8373.106285	34733.01004	15372.84	0.388876423	8278.824216	8829.621951	-26	-7
30	10047.72754	41679.61205	18447.408	0.466651707	9934.589059	10595.54634	-32	-8
35	11722.3488	48626.21405	21521.976	0.544426992	11590.3539	12361.47073	-37	-9
40	13396.97006	55572.81606	24596.544	0.622202276	13246.11875	14127.39512	-42	-10
45	15071.59131	62519.41807	27671.112	0.699977561	14901.88359	15893.31951	-48	-12
50	16746.21257	69466.02008	30745.68	0.777752846	16557.64843	17659.2439	-53	-13
55	18420.83383	76412.62208	33820.248	0.85552813	18213.41327	19425.16829	-58	-14
60	20095.45508	83359.22409	36894.816	0.933303415	19869.17812	21191.09268	-63	-16
65	21770.07634	90305.8261	39969.384	1.011078699	21524.94296	22957.01707	-69	-17
70	23444.6976	97252.42811	43043.952	1.088853984	23180.7078	24722.94146	-74	-18
75	25119.31885	104199.0301	46118.52	1.166629268	24836.47265	26488.86585	-79	-20
80	26793.94011	111145.6321	49193.088	1.244404553	26492.23749	28254.79024	-85	-21
85	28468.56137	118092.2341	52267.656	1.322179837	28148.00233	30020.71463	-90	-22
90	30143.18263	125038.8361	55342.224	1.399955122	29803.76718	31786.63902	-95	-24
95	31817.80388	131985.4381	58416.792	1.477730407	31459.53202	33552.56341	-101	-25
100	33492.42514	138932.0402	61491.36	1.555505691	33115.29686	35318.4878	-106	-26

Appendix B

CMU Toxic Data

Categories	Item Major Description	Aq Ecotoxcity	Terr Ecotoxicity
Drinks	ALCOHOLIC BEV	0.006732457	0.005519682
Supplies	APPAREL DISP	8.308089361	7.038797931
Other	BABY/STRND FOOD	5.050141041	4.226359169
Supplies	BAGS	29.70868019	24.74713716
Other	BAKERY PRODUCT	63.5665634	53.65646301
Other	BAKING NEEDS	4.251020073	3.560412231
Supplies	BAR MAINT	0.050206052	0.039806227
Supplies	BAR SUPPLIES	1.749007196	1.458708722
Other	BATTER/BRD/STUF	3.200367495	2.694380423
Meat	BEEF FRESH	152.5779959	126.2236148
Meat	BEEF FROZEN	71.3903129	59.05925885
Supplies	BOXS CTN CIR SQ	6.576380124	5.49065699
Other	BREAD AND ROLLS	0.066081017	0.055782676
Dairy	BUTTER	2.843022137	2.322870217
Other	CANDY AND NUTS	2.055311131	1.680553546
Other	CAPP&OTHER MIX	1.897492563	1.600410394
Drinks	CARBONATED BEVR	46.35078647	39.73791249
Dairy	CHEESE	95.16351444	78.95374732
Other	CHINESE/ORIENTL	6.381232251	5.319251897
Supplies	CLEANING SYSTEM	5.708653043	4.526146341
Other	COCOA	6.594943741	5.376076251
Other	COFFEE	83.64293415	70.71629887
Other	COFFEE/TEA/COCO	4.229868192	3.575899463
Other	CONDIMENTS	9.405984676	7.962060903
Supplies	CONTAINERS PANS	179.2758628	148.802511
Convenience Products	CONVENIENCE PRD	326.2955166	269.6393103
Other	COOKIE/CRK/CONE	90.98005414	75.3275717
Supplies	COOKING AREA	27.31544502	21.65724569
Dairy	CREAM	8.392877805	6.857338758
Supplies	CUPS	622.8598188	520.0129701
Supplies	CUTLERY PLASTIC	257.8202849	237.9879553
Dairy	DAIRY SPECLTIES	27.31611218	22.71991345
Other	DESSERTS/TOP FZ	0.799826856	0.665252814
Other	DIET KITS	38.43748711	35.48075733
Other	DIETARY FOODS	57.03142364	48.04968771
Supplies	DINING RM SUPPL	49.72976595	45.42683201
Supplies	DINING ROOM	2.012469065	1.595600473
Supplies	DINNERWARE	27.30105379	27.15502037
Supplies	DISNFCTNT CLNRS	1.565749789	1.241415904
Drinks	DISP DRNK MX FF	6.542009566	5.474873254
Drinks	DISP JCE BSE FF	1.304267413	1.125250317
Drinks	DISP JUICE	17.41333563	15.02326995
Drinks	DISP JUICE CONC	0.031587304	0.025844158
Supplies	DISPENSERS	1.919718747	1.772048075
Other	DOILIES	0.870907657	0.727125732
Supplies	DRAIN CLNR/MANT	0.710057021	0.562973781

Poultry	EGGS	108.6971513	87.69754262
Other	ENTREE PREP CAN	7.687048692	6.49466082
Supplies	EQUIPMENT	155.1534843	119.3193374
Supplies	EQUIPMENT CHRGS	-0.082790795	-0.069122503
Supplies	EXTRACTS/FD COL	0.286429805	0.23816401
Supplies	FILTERS	2.809771326	2.345893984
Meat	FISH DRIED, CAN	17.27543884	14.62425763
Supplies	FLATWARE	19.73247651	18.2145937
Supplies	FLOOR CARE	7.813589517	6.19506026
Supplies	FOOD WRAPS	35.15876232	29.35424967
Other	FOODS MISC FZ	0.500372697	0.409395843
Supplies	FOUNTAIN ITEMS	2.02769848	1.710230536
Meat	FRESH FINFISH	0.388091224	0.32853267
Meat	FRESH OTHER	0.087477086	0.074052384
Meat	FROZEN FINFISH	31.27678526	26.47688257
Meat	FROZEN SURIMI	0.938061081	0.794101212
Meat	FRSH SHELLFISH	0.022494108	0.019042042
Fruit	FRUIT FRESH	73.85932528	60.51402663
Fruit	FRUITS CANNED	155.6715741	134.3048875
Fruit	FRUITS FROZEN	7.466810387	6.109208498
Meat	FRZN PREPRD SFD	0.36696692	0.310650214
Meat	FRZN SFD OTHER	0.546624915	0.462736933
Meat	FRZN SHELLFISH	3.429808498	2.903451748
Other	GEL/PUDD/TOPPNG	107.4367354	89.91159417
Supplies	GLASSWARE	15.52237806	14.32834897
Other	GRAVIES & BASES	12.76332435	10.61259842
Supplies	HAND/BODY CARE	0.436975143	0.346458863
Other	ICE	0.057409311	0.049218716
Supplies	IMPORT SPECLTY	11.33321396	9.397176272
Supplies	INDUSTRIAL SUPP	0.198012021	0.161799018
Other	JAM/JELL/P-BTTR	0.577534676	0.49064039
Supplies	JANITORIAL MANT	0.132207856	0.104821943
Drinks	JUICE & DRNK FZ	9.461040128	7.740851014
Drinks	JUICE/DRINK REF	0.170924885	0.147464607
Drinks	JUICES/DRINKS	504.6001828	433.8080466
Supplies	KITCHEN SUPPLIE	49.87016593	42.80583852
Supplies	LABELS	0.623836817	0.52084489
Supplies	LAUNDRY	4.760739015	3.774585933
Supplies	LIDS	168.3374756	140.5459113
Supplies	LINERS TRASH	19.44548011	16.23514141
Supplies	MAINT SUPPLIES	6.397010508	5.340900283
Supplies	MAINTENANCE SUP	4.720691277	3.917410821
Supplies	MATCHES	0.020866482	0.017421544
Meat	MEAT PRE-FAB FR	0.299724014	0.247953502
Meat	MEAT SPCLTY FR	0.192802803	0.1595005
Meat	MEAT SPCLTY FZ	1.637663164	1.354794072
Meat	MEATS CANNED	1.809549011	1.456963011

Supplies	MEDICAL	1.656963648	1.331712806
Other	MEXICAN FOODS	21.33954919	18.23196182
Dairy	MILK	23.33517945	19.06583584
Dairy	MILK & NONDAIRY	8.027887635	6.625047359
Other	MISC	-1.108401762	-0.878771851
Drinks	MISC BEVERAGES	0.158136688	0.133697381
Supplies	NAPKINS	76.34323837	63.74533958
Other	NUTRITIONAL	44.80440413	37.49588431
Supplies	OFFICE SUPPLIES	2.055835682	1.716428848
Fruit	OLIVES	7.671191881	6.618283191
Other	PASTA PRODUCTS	10.80072753	8.953466967
Other	PICKLE,REL,PROD	7.927711197	6.839593973
Supplies	PICKS-STIRRERS	3.815329736	3.185440393
Supplies	PLACEMAT COVERS	10.12609722	8.454335889
Supplies	PLANTS/FLOWERS	0.074679914	0.061459068
Supplies	PLATES BOWLS	228.9251296	191.1308865
Meat	PORK FRESH	33.43566623	27.66041479
Meat	PORK FROZEN	49.9631263	41.33313176
Other	PORTION PAKS/PC	104.4751936	87.5582318
Supplies	POT AND PAN	59.65424532	47.29729451
Vegetables	POTATO-CAN/DEHY	15.6727533	13.52159108
Vegetables	POTATOES FROZEN	45.67041228	37.36670096
Poultry	POULTRY FRESH	78.59606032	63.25668052
Poultry	POULTRY FROZEN	505.7733866	407.0629673
Other	PROD PREP FRESH	6.726613846	5.511213214
Other	REFRG/MANUFACTR	31.89307011	26.20962306
Supplies	RESTROOM	0.38211771	0.302964756
Grains	RICE AND GRAINS	26.12558918	21.13429762
Other	SALAD DRES/MAYO	20.80301799	17.29753706
Other	SALT/SEASN/SPCE	32.7201473	27.07950717
Supplies	SANITIZER	7.623188476	6.044099435
Other	SAUCES/SAUC MIX	25.73233692	21.56071856
Other	SHORTENING, OIL	20.24172826	16.52052165
Other	SNACKS	41.23590264	33.69270758
Other	SOUP,CHOWDR,BAS	106.3526473	90.38515918
Supplies	STRAWS	22.0449997	18.40549503
Other	SUGAR	6.180213063	5.074439647
Other	SYRUPS	0.772079055	0.64565342
Supplies	TBL COVER SKIRT	10.97286714	9.161308882
Other	TEA	29.92776794	25.30256744
Supplies	TISSUES	0.02234203	0.018653488
Supplies	TOWELS	6.42720357	5.366108641
Supplies	TRAYS CARRIERS	174.6027447	145.7768199
Vegetables	VEG/FRUIT DRIED	9.01710711	7.779464958
Vegetables	VEGETABLE CAN	21.34261441	18.41323596
Vegetables	VEGETABLE FRESH	66.13338233	54.00143202
Vegetables	VEGETABLES FRZN	129.6603631	106.0857517

Supplies	WAREWASH	82.65936285	65.53706626
Supplies	WASHANTIMICROBL	0.653493516	0.518127002
Other	WINE/LIQ COOKNG	0.831681899	0.681863913
Supplies	WIPERS	23.8886209	19.94474481
Other	YOGURT	41.69312449	34.14009851
	Grand Total	6194.481179	5180.02581

Categories	Item Major Description	Terr Acidification	Aq Acidification
Drinks	ALCOHOLIC BEV	0.004633423	0.002207873
Supplies	APPAREL DISP	4.1713532	2.821288679
Other	BABY/STRND FOOD	11.67621262	4.315900676
Supplies	BAGS	3.242132591	2.0517949
Other	BAKERY PRODUCT	82.65716383	35.805115
Other	BAKING NEEDS	8.900187604	3.324086155
Supplies	BAR MAINT	0.014954231	0.005953003
Supplies	BAR SUPPLIES	0.310972572	0.16900698
Other	BATTER/BRD/STUF	5.077041482	2.053758614
Meat	BEEF FRESH	276.4898228	99.86923365
Meat	BEEF FROZEN	129.3679003	46.72820481
Supplies	BOXS CTN CIR SQ	0.725883466	0.459105782
Other	BREAD AND ROLLS	0.085819502	0.037188451
Dairy	BUTTER	4.004457246	1.524828916
Other	CANDY AND NUTS	2.740414841	1.106705993
Other	CAPP&OTHER MIX	1.629160281	0.709163887
Drinks	CARBONATED BEVR	16.44118211	9.524965283
Dairy	CHEESE	102.2805878	48.07180351
Other	CHINESE/ORIENTL	17.07703837	6.07739676
Supplies	CLEANING SYSTEM	1.700363085	0.676883146
Other	COCOA	10.46920112	4.048381306
Other	COFFEE	133.0683043	50.43922393
Other	COFFEE/TEA/COCO	6.729305919	2.550832374
Other	CONDIMENTS	17.37119553	6.581385423
Supplies	CONTAINERS PANS	19.21698506	12.17307129
Convenience Products	CONVENIENCE PRD	594.1878837	233.990406
Other	COOKIE/CRK/CONE	305.8755942	102.719416
Supplies	COOKING AREA	8.136100409	3.238831338
Dairy	CREAM	11.82154718	4.501443234
Supplies	CUPS	68.73904888	43.4763266
Supplies	CUTLERY PLASTIC	46.36477057	29.74849441
Dairy	DAIRY SPECLTIES	38.24264658	16.56236748
Other	DESSERTS/TOP FZ	1.119757599	0.484974379
Other	DIET KITS	6.91235475	4.435094666
Other	DIETARY FOODS	113.3580674	42.74573234
Supplies	DINING RM SUPPL	17.70909158	8.790887805
Supplies	DINING ROOM	0.599428286	0.238621332
Supplies	DINNERWARE	2.793096991	1.648893476
Supplies	DISNFCTNT CLNRS	0.466369759	0.185653189
Drinks	DISP DRNK MX FF	15.12549729	5.590866331
Drinks	DISP JCE BSE FF	1.114290086	0.511477417
Drinks	DISP JUICE	14.8769394	6.828759069
Drinks	DISP JUICE CONC	0.064389505	0.024960597
Supplies	DISPENSERS	0.345230087	0.221506009
Other	DOILIES	0.096128487	0.060799214
Supplies	DRAIN CLNR/MANT	0.211495556	0.084192475

Poultry	EGGS	156.5478553	58.49572222
Other	ENTREE PREP CAN	10.0009706	3.972113926
Supplies	EQUIPMENT	14.34291443	8.4391677
Supplies	EQUIPMENT CHRGS	-0.009138229	-0.005779735
Supplies	EXTRACTS/FD COL	0.791242557	0.28168235
Supplies	FILTERS	0.310135137	0.196153847
Meat	FISH DRIED, CAN	15.13738948	7.517381555
Supplies	FLATWARE	3.548563863	2.276824213
Supplies	FLOOR CARE	2.327333449	0.926468471
Supplies	FOOD WRAPS	3.880731312	2.454479634
Other	FOODS MISC FZ	1.019990497	0.395399404
Supplies	FOUNTAIN ITEMS	1.74095324	0.757826705
Meat	FRESH FINFISH	0.340060132	0.16887732
Meat	FRESH OTHER	0.076650714	0.038065524
Meat	FROZEN FINFISH	27.405896	13.61004666
Meat	FROZEN SURIMI	0.821964412	0.408195886
Meat	FRSH SHELLFISH	0.019710183	0.009788278
Fruit	FRUIT FRESH	211.2238648	70.40795494
Fruit	FRUITS CANNED	132.996723	61.04767612
Fruit	FRUITS FROZEN	15.22080579	5.900346669
Meat	FRZN PREPRD SFD	0.321550222	0.15968511
Meat	FRZN SFD OTHER	0.478973317	0.23786302
Meat	FRZN SHELLFISH	3.005327248	1.492476074
Other	GEL/PUDD/TOPPNG	248.399828	91.81650083
Supplies	GLASSWARE	2.791446365	1.791043622
Other	GRAVIES & BASES	35.25780206	12.55177753
Supplies	HAND/BODY CARE	0.130156168	0.051812767
Other	ICE	0.020363774	0.011797463
Supplies	IMPORT SPECLTY	21.92417162	10.9351779
Supplies	INDUSTRIAL SUPP	0.074922914	0.039880028
Other	JAM/JELL/P-BTTR	0.923125121	0.362808613
Supplies	JANITORIAL MANT	0.039379054	0.015676074
Drinks	JUICE & DRNK FZ	19.28596642	7.476206535
Drinks	JUICE/DRINK REF	0.146028263	0.067029367
Drinks	JUICES/DRINKS	294.8741872	146.929991
Supplies	KITCHEN SUPPLIE	9.050171258	5.425367639
Supplies	LABELS	0.06885746	0.043550872
Supplies	LAUNDRY	1.418020121	0.564487626
Supplies	LIDS	18.5806459	11.75186151
Supplies	LINERS TRASH	2.146340729	1.357514649
Supplies	MAINT SUPPLIES	0.706085122	0.446583752
Supplies	MAINTENANCE SUP	1.598800105	0.731150588
Supplies	MATCHES	0.002303187	0.001456717
Meat	MEAT PRE-FAB FR	0.543136243	0.196182991
Meat	MEAT SPCLTY FR	0.349382049	0.126198198
Meat	MEAT SPCLTY FZ	2.967644158	1.07192498
Meat	MEATS CANNED	2.430606746	0.898813923

Supplies	MEDICAL	0.605391579	0.260448813
Other	MEXICAN FOODS	29.48403999	11.8190607
Dairy	MILK	32.86809738	12.51561003
Dairy	MILK & NONDAIRY	9.818341007	3.997594913
Other	MISC	-0.330023657	-0.131293051
Drinks	MISC BEVERAGES	0.251581094	0.095361215
Supplies	NAPKINS	8.58524135	5.398373735
Other	NUTRITIONAL	103.5903244	38.29028864
Supplies	OFFICE SUPPLIES	0.226917712	0.143520604
Fruit	OLIVES	6.553819394	3.008310541
Other	PASTA PRODUCTS	35.52430903	11.9628712
Other	PICKLE,REL,PROD	6.772974552	3.108906352
Supplies	PICKS-STIRRERS	0.421126018	0.266353208
Supplies	PLACEMAT COVERS	1.117691863	0.706916221
Supplies	PLANTS/FLOWERS	0.17330028	0.057885867
Supplies	PLATES BOWLS	25.26815109	15.98156565
Meat	PORK FRESH	60.58948002	21.88516335
Meat	PORK FROZEN	90.539241	32.70313722
Other	PORTION PAKS/PC	418.9006313	136.7670023
Supplies	POT AND PAN	17.76844307	7.073289088
Vegetables	POTATO-CAN/DEHY	13.38988727	6.146177763
Vegetables	POTATOES FROZEN	93.09737888	36.08920691
Poultry	POULTRY FRESH	105.0382293	38.85976217
Poultry	POULTRY FROZEN	675.9313475	250.0663956
Other	PROD PREP FRESH	19.23685829	6.412286097
Other	REFRG/MANUFACTR	82.98117306	28.11908227
Supplies	RESTROOM	0.113816489	0.045308243
Grains	RICE AND GRAINS	41.4591966	13.31011084
Other	SALAD DRES/MAYO	57.46690053	20.45821659
Other	SALT/SEASN/SPCE	88.09454233	31.29752156
Supplies	SANITIZER	2.270621139	0.903892348
Other	SAUCES/SAUC MIX	41.61013422	21.18309026
Other	SHORTENING, OIL	28.99269765	11.32718935
Other	SNACKS	57.93420271	22.12065786
Other	SOUP,CHOWDR,BAS	127.2664164	53.94477124
Supplies	STRAWS	2.433268835	1.538990545
Other	SUGAR	168.1381495	48.32078351
Other	SYRUPS	2.547079729	0.872991966
Supplies	TBL COVER SKIRT	1.211156089	0.766030347
Other	TEA	47.61235809	18.04735097
Supplies	TISSUES	0.002466054	0.001559727
Supplies	TOWELS	0.709417753	0.44869157
Supplies	TRAYS CARRIERS	19.27218975	12.18924822
Vegetables	VEG/FRUIT DRIED	7.703690949	3.536120435
Vegetables	VEGETABLE CAN	18.23388626	8.369652708
Vegetables	VEGETABLE FRESH	170.3306247	56.70008131
Vegetables	VEGETABLES FRZN	264.3076633	102.4588884

Supplies	WAREWASH	24.62068165	9.801038738
Supplies	WASHANTIMICROBL	0.194647712	0.07748566
Other	WINE/LIQ COOKNG	0.572381538	0.272745565
Supplies	WIPERS	2.636762873	1.667696176
Other	YOGURT	58.6821653	22.7190158
	Grand Total	6441.71291	2515.052808

Categories	Item Major Description	Respiratory Organics	Respiratory Inorganics
Drinks	ALCOHOLIC BEV	0.000234781	3.76271E-05
Supplies	APPAREL DISP	0.871195482	0.033867003
Other	BABY/STRND FOOD	0.510386595	0.094734915
Supplies	BAGS	0.513184281	0.026269848
Other	BAKERY PRODUCT	6.904247865	0.669526782
Other	BAKING NEEDS	0.485039455	0.072169785
Supplies	BAR MAINT	0.00151694	0.000121212
Supplies	BAR SUPPLIES	0.095447522	0.002519766
Other	BATTER/BRD/STUF	0.355557742	0.041143549
Meat	BEEF FRESH	5.178404708	2.247057757
Meat	BEEF FROZEN	2.422943953	1.051384608
Supplies	BOXS CTN CIR SQ	0.112294793	0.005881517
Other	BREAD AND ROLLS	0.007180232	0.000695138
Dairy	BUTTER	0.128969175	0.032491682
Other	CANDY AND NUTS	0.292193805	0.022251232
Other	CAPP&OTHER MIX	0.2041242	0.013224948
Drinks	CARBONATED BEVR	2.438876461	0.133470851
Dairy	CHEESE	6.042810532	0.829677847
Other	CHINESE/ORIENTL	1.079261799	0.138941345
Supplies	CLEANING SYSTEM	0.172482874	0.013782319
Other	COCOA	0.624669589	0.085103069
Other	COFFEE	7.679942136	1.079754241
Other	COFFEE/TEA/COCO	0.3884039	0.054603712
Other	CONDIMENTS	1.453472417	0.141367396
Supplies	CONTAINERS PANS	3.152107799	0.155710869
Convenience Products	CONVENIENCE PRD	31.34435928	4.821688016
Other	COOKIE/CRK/CONE	11.47848712	2.481570652
Supplies	COOKING AREA	0.82531666	0.065947289
Dairy	CREAM	0.380729545	0.095918603
Supplies	CUPS	10.63730805	0.556962624
Supplies	CUTLERY PLASTIC	6.753712245	0.375206236
Dairy	DAIRY SPECLTIES	2.150251317	0.31045045
Other	DESSERTS/TOP FZ	0.062970495	0.009090096
Other	DIET KITS	1.006886357	0.055938131
Other	DIETARY FOODS	7.068296438	0.920771459
Supplies	DINING RM SUPPL	2.247577804	0.143657741
Supplies	DINING ROOM	0.060805315	0.004858675
Supplies	DINNERWARE	0.272049626	0.022663344
Supplies	DISNFCTNT CLNRS	0.047308011	0.003780167
Drinks	DISP DRNK MX FF	0.661160541	0.122720676
Drinks	DISP JCE BSE FF	0.167326183	0.009060457
Drinks	DISP JUICE	2.233979753	0.120966589
Drinks	DISP JUICE CONC	0.002805306	0.000522405
Supplies	DISPENSERS	0.050287851	0.002793769
Other	DOILIES	0.014871159	0.000778887
Supplies	DRAIN CLNR/MANT	0.021453866	0.001714281

Poultry	EGGS	8.744395871	1.271242209
Other	ENTREE PREP CAN	0.751748742	0.081262551
Supplies	EQUIPMENT	5.402607567	0.11632492
Supplies	EQUIPMENT CHRGS	-0.001413692	-7.40431E-05
Supplies	EXTRACTS/FD COL	0.051193393	0.006440714
Supplies	FILTERS	0.047978171	0.00251289
Meat	FISH DRIED, CAN	1.103233471	0.123151643
Supplies	FLATWARE	0.516900632	0.028716702
Supplies	FLOOR CARE	0.236082026	0.018864238
Supplies	FOOD WRAPS	0.600352451	0.031443874
Other	FOODS MISC FZ	0.044438694	0.008275395
Supplies	FOUNTAIN ITEMS	0.2181312	0.014132444
Meat	FRESH FINFISH	0.024784044	0.002766591
Meat	FRESH OTHER	0.005586408	0.000623599
Meat	FROZEN FINFISH	1.997378861	0.222963222
Meat	FROZEN SURIMI	0.059905881	0.006687168
Meat	FRSH SHELLFISH	0.001436505	0.000160354
Fruit	FRUIT FRESH	2.461977509	1.714180602
Fruit	FRUITS CANNED	19.97131119	1.081415977
Fruit	FRUITS FROZEN	0.663136307	0.123489556
Meat	FRZN PREPRD SFD	0.023435016	0.002616002
Meat	FRZN SFD OTHER	0.034908225	0.003896732
Meat	FRZN SHELLFISH	0.219032325	0.02445012
Other	GEL/PUDD/TOPPNG	10.85796794	2.015391242
Supplies	GLASSWARE	0.406615309	0.022589739
Other	GRAVIES & BASES	2.281179793	0.286998509
Supplies	HAND/BODY CARE	0.013202892	0.001054983
Other	ICE	0.003020752	0.000165315
Supplies	IMPORT SPECLTY	8.170125777	0.178299578
Supplies	INDUSTRIAL SUPP	0.011712828	0.000607959
Other	JAM/JELL/P-BTTR	0.066066418	0.007494037
Supplies	JANITORIAL MANT	0.003994566	0.000319188
Drinks	JUICE & DRNK FZ	0.840246221	0.156471048
Drinks	JUICE/DRINK REF	0.021928179	0.001187377
Drinks	JUICES/DRINKS	44.04035731	2.396367698
Supplies	KITCHEN SUPPLIE	1.834073482	0.07336175
Supplies	LABELS	0.010652308	0.000557922
Supplies	LAUNDRY	0.143842329	0.011493784
Supplies	LIDS	2.874441801	0.150550874
Supplies	LINERS TRASH	0.332040745	0.017390863
Supplies	MAINT SUPPLIES	0.109231972	0.0057211
Supplies	MAINTENANCE SUP	0.427654716	0.012962254
Supplies	MATCHES	0.000356305	1.86617E-05
Meat	MEAT PRE-FAB FR	0.010172451	0.004414117
Meat	MEAT SPCLTY FR	0.00654361	0.002839459
Meat	MEAT SPCLTY FZ	0.055581295	0.024118312
Meat	MEATS CANNED	0.141785543	0.019742561

Supplies	MEDICAL	0.070572507	0.004911179
Other	MEXICAN FOODS	2.973268073	0.239799083
Dairy	MILK	1.058563278	0.266687765
Dairy	MILK & NONDAIRY	0.577062188	0.079702423
Other	MISC	-0.033445076	-0.002675008
Drinks	MISC BEVERAGES	0.014519823	0.002041401
Supplies	NAPKINS	1.327317465	0.069567677
Other	NUTRITIONAL	4.528104673	0.84047978
Supplies	OFFICE SUPPLIES	0.035104364	0.001838615
Fruit	OLIVES	0.984147306	0.053290072
Other	PASTA PRODUCTS	1.363340482	0.288213815
Other	PICKLE,REL,PROD	1.017056506	0.055072055
Supplies	PICKS-STIRRERS	0.065148555	0.003412201
Supplies	PLACEMAT COVERS	0.172907887	0.00905617
Supplies	PLANTS/FLOWERS	0.002422631	0.001407841
Supplies	PLATES BOWLS	3.909004571	0.204736814
Meat	PORK FRESH	1.134786248	0.492416175
Meat	PORK FROZEN	1.695718226	0.735820587
Other	PORTION PAKS/PC	13.81100371	3.398792095
Supplies	POT AND PAN	1.802410412	0.144022392
Vegetables	POTATO-CAN/DEHY	2.010678154	0.108875149
Vegetables	POTATOES FROZEN	4.056043608	0.755318357
Poultry	POULTRY FRESH	6.208796587	0.853161696
Poultry	POULTRY FROZEN	39.95421734	5.490179513
Other	PROD PREP FRESH	0.224220462	0.156116116
Other	REFRG/MANUFACTR	1.593183262	0.673236016
Supplies	RESTROOM	0.011545414	0.000922541
Grains	RICE AND GRAINS	0.446518245	0.336799764
Other	SALAD DRES/MAYO	3.718108464	0.46778057
Other	SALT/SEASN/SPCE	5.537660092	0.71651001
Supplies	SANITIZER	0.230329195	0.018404555
Other	SAUCES/SAUC MIX	15.76520133	0.338025887
Other	SHORTENING, OIL	10.42755698	0.235131187
Other	SNACKS	2.060430789	0.470086222
Other	SOUP,CHOWDR,BAS	12.43033303	1.03369769
Supplies	STRAWS	0.376428768	0.019715717
Other	SUGAR	0.243876055	1.361767535
Other	SYRUPS	0.076143624	0.020653734
Supplies	TBL COVER SKIRT	0.187366882	0.00981347
Other	TEA	2.747913239	0.386340277
Supplies	TISSUES	0.000381501	1.99814E-05
Supplies	TOWELS	0.109747533	0.005748103
Supplies	TRAYS CARRIERS	2.981424226	0.156154153
Vegetables	VEG/FRUIT DRIED	1.156816542	0.062639848
Vegetables	VEGETABLE CAN	2.7380721	0.148262419
Vegetables	VEGETABLE FRESH	2.108891344	1.381773381
Vegetables	VEGETABLES FRZN	11.51529099	2.144382929

Supplies	WAREWASH	2.497493606	0.199563319
Supplies	WASHANTIMICROBL	0.01974484	0.00157772
Other	WINE/LIQ COOKNG	0.029003226	0.004648199
Supplies	WIPERS	0.40790947	0.02136454
Other	YOGURT	2.061630522	0.476168818
	Grand Total	404.8861986	52.29194391

Categories	Item Major Description	Non-carcinogens	Carcinogens
Drinks	ALCOHOLIC BEV	0.025032925	0.002378905
Supplies	APPAREL DISP	28.09749666	2.700129042
Other	BABY/STRND FOOD	17.08451969	1.626073782
Supplies	BAGS	109.0014223	10.37303441
Other	BAKERY PRODUCT	200.0801468	19.0447061
Other	BAKING NEEDS	13.72925947	1.305940151
Supplies	BAR MAINT	0.144880321	0.01369908
Supplies	BAR SUPPLIES	6.399418171	0.610083319
Other	BATTER/BRD/STUF	10.14082302	0.964995741
Meat	BEEF FRESH	550.2055002	52.24640464
Meat	BEEF FROZEN	257.437795	24.44577381
Supplies	BOXS CTN CIR SQ	24.25815687	2.307937175
Other	BREAD AND ROLLS	0.20796926	0.019795698
Dairy	BUTTER	10.04676996	0.954799414
Other	CANDY AND NUTS	7.026704721	0.667536948
Other	CAPP&OTHER MIX	8.462050165	0.808830163
Drinks	CARBONATED BEVR	246.9210745	23.60007322
Dairy	CHEESE	342.2024046	32.6012709
Other	CHINESE/ORIENTL	22.49334327	2.142101565
Supplies	CLEANING SYSTEM	16.47354164	1.557646759
Other	COCOA	21.70019442	2.065545086
Other	COFFEE	326.9678335	31.17600273
Other	COFFEE/TEA/COCO	16.52958859	1.576072405
Other	CONDIMENTS	36.3726731	3.467676361
Supplies	CONTAINERS PANS	652.2807818	62.09800178
Convenience Products	CONVENIENCE PRD	1141.614201	108.609017
Other	COOKIE/CRK/CONE	300.3320067	28.5331711
Supplies	COOKING AREA	78.82456991	7.453214283
Dairy	CREAM	29.65904187	2.818660716
Supplies	CUPS	2297.363254	218.5734004
Supplies	CUTLERY PLASTIC	1594.626502	152.4945344
Dairy	DAIRY SPECLTIES	91.05581363	8.619964048
Other	DESSERTS/TOP FZ	2.666089521	0.252389808
Other	DIET KITS	237.7370564	22.73485464
Other	DIETARY FOODS	207.1822403	19.73765306
Supplies	DINING RM SUPPL	323.1301055	30.83601564
Supplies	DINING ROOM	5.80741073	0.549116559
Supplies	DINNERWARE	281.8081626	26.9505192
Supplies	DISNFCTNT CLNRS	4.518306533	0.427226014
Drinks	DISP DRNK MX FF	22.13147917	2.106434286
Drinks	DISP JCE BSE FF	5.589717483	0.533397877
Drinks	DISP JUICE	74.62858125	7.121420172
Drinks	DISP JUICE CONC	0.104922864	0.009973194
Supplies	DISPENSERS	11.87352032	1.135467741
Other	DOILIES	3.212498998	0.305639291
Supplies	DRAIN CLNR/MANT	2.04902169	0.19374413

Poultry	EGGS	347.7890815	32.96529588
Other	ENTREE PREP CAN	30.03715754	2.860533622
Supplies	EQUIPMENT	460.9899819	43.86234043
Supplies	EQUIPMENT CHRGS	-0.305388687	-0.029054883
Supplies	EXTRACTS/FD COL	0.996965621	0.094949107
Supplies	FILTERS	10.36434517	0.986070692
Meat	FISH DRIED, CAN	61.40477767	5.858255251
Supplies	FLATWARE	122.0459826	11.67128808
Supplies	FLOOR CARE	22.54778689	2.131993711
Supplies	FOOD WRAPS	129.6893969	12.33873546
Other	FOODS MISC FZ	1.662077139	0.157984806
Supplies	FOUNTAIN ITEMS	9.042715949	0.864332079
Meat	FRESH FINFISH	1.379452965	0.131605192
Meat	FRESH OTHER	0.310933403	0.029664259
Meat	FROZEN FINFISH	111.1719397	10.60623659
Meat	FROZEN SURIMI	3.334296317	0.318104871
Meat	FRSH SHELLFISH	0.079954304	0.007627952
Fruit	FRUIT FRESH	280.7114543	26.6905973
Fruit	FRUITS CANNED	667.163889	63.66400509
Fruit	FRUITS FROZEN	24.80234219	2.357527895
Meat	FRZN PREPRD SFD	1.304367567	0.124441753
Meat	FRZN SFD OTHER	1.942953906	0.18536538
Meat	FRZN SHELLFISH	12.19110149	1.163078624
Other	GEL/PUDD/TOPPNG	363.45619	34.59310488
Supplies	GLASSWARE	96.00639234	9.181115502
Other	GRAVIES & BASES	44.4248306	4.230936247
Supplies	HAND/BODY CARE	1.260985412	0.119231789
Other	ICE	0.305832326	0.029230657
Supplies	IMPORT SPECLTY	40.0618129	3.813603354
Supplies	INDUSTRIAL SUPP	0.673474638	0.064121292
Other	JAM/JELL/P-BTTR	2.209035321	0.210550873
Supplies	JANITORIAL MANT	0.381514098	0.036073858
Drinks	JUICE & DRNK FZ	31.42653189	2.987174558
Drinks	JUICE/DRINK REF	0.732535221	0.069902054
Drinks	JUICES/DRINKS	2447.082008	233.736085
Supplies	KITCHEN SUPPLIE	238.9835106	22.83397757
Supplies	LABELS	2.30113392	0.218931411
Supplies	LAUNDRY	13.73813258	1.299001645
Supplies	LIDS	620.9429526	59.07692541
Supplies	LINERS TRASH	71.72813888	6.82426283
Supplies	MAINT SUPPLIES	23.59651989	2.244988593
Supplies	MAINTENANCE SUP	18.43460459	1.75657237
Supplies	MATCHES	0.076969759	0.007322954
Meat	MEAT PRE-FAB FR	1.080822959	0.102632768
Meat	MEAT SPCLTY FR	0.695258592	0.066020354
Meat	MEAT SPCLTY FZ	5.905512623	0.560775568
Meat	MEATS CANNED	5.762569713	0.545948225

Supplies	MEDICAL	5.66636438	0.537243056
Other	MEXICAN FOODS	86.77385533	8.276068246
Dairy	MILK	82.46266424	7.83687731
Dairy	MILK & NONDAIRY	29.11652556	2.773844938
Other	MISC	-3.198235031	-0.302404259
Drinks	MISC BEVERAGES	0.618170689	0.058941856
Supplies	NAPKINS	281.7330575	26.80453018
Other	NUTRITIONAL	151.5723459	14.42638261
Supplies	OFFICE SUPPLIES	7.583318414	0.721481956
Fruit	OLIVES	32.87653663	3.137238136
Other	PASTA PRODUCTS	35.96335117	3.417278297
Other	PICKLE,REL,PROD	33.97590513	3.242145195
Supplies	PICKS-STIRRERS	14.07352761	1.338964775
Supplies	PLACEMAT COVERS	37.35192466	3.55368695
Supplies	PLANTS/FLOWERS	0.286213452	0.027227797
Supplies	PLATES BOWLS	844.4313741	80.33976245
Meat	PORK FRESH	120.5710388	11.44918268
Meat	PORK FROZEN	180.1700615	17.10858567
Other	PORTION PAKS/PC	388.8520418	37.05756277
Supplies	POT AND PAN	172.1451079	16.27708694
Vegetables	POTATO-CAN/DEHY	67.1689427	6.409585382
Vegetables	POTATOES FROZEN	151.7024184	14.41971409
Poultry	POULTRY FRESH	249.8127568	23.66647169
Poultry	POULTRY FROZEN	1607.569686	152.2960755
Other	PROD PREP FRESH	25.56532365	2.430801265
Other	REFRG/MANUFACTR	114.607431	10.91191004
Supplies	RESTROOM	1.102682535	0.104263547
Grains	RICE AND GRAINS	86.78552	8.228886093
Other	SALAD DRES/MAYO	72.40829467	6.896028063
Other	SALT/SEASN/SPCE	114.6354298	10.91830551
Supplies	SANITIZER	21.99834389	2.080041427
Other	SAUCES/SAUC MIX	95.96136916	9.138917182
Other	SHORTENING, OIL	68.29027515	6.460996092
Other	SNACKS	145.4952813	13.82697339
Other	SOUP,CHOWDR,BAS	426.1584682	40.62809164
Supplies	STRAWS	81.31693286	7.736547065
Other	SUGAR	22.56989574	2.135808926
Other	SYRUPS	2.620160439	0.249320964
Supplies	TBL COVER SKIRT	40.47538726	3.850855259
Other	TEA	116.9903656	11.15489532
Supplies	TISSUES	0.082412584	0.007840788
Supplies	TOWELS	23.70789241	2.255584649
Supplies	TRAYS CARRIERS	644.0535206	61.27568022
Vegetables	VEG/FRUIT DRIED	38.64474476	3.687668454
Vegetables	VEGETABLE CAN	91.46834746	8.72835211
Vegetables	VEGETABLE FRESH	237.1790304	22.59727557
Vegetables	VEGETABLES FRZN	430.6900174	40.93821955

Supplies	WAREWASH	238.5313042	22.55419758
Supplies	WASHANTIMICROBL	1.885795576	0.178310374
Other	WINE/LIQ COOKNG	3.0923969	0.293873743
Supplies	WIPERS	88.1174601	8.383553749
Other	YOGURT	146.3133407	13.89868194
	Grand Total	23932.1551	2278.447206

Categories	Item Major Description	Ozone Depletion	Eutrophication
Drinks	ALCOHOLIC BEV	3.35845E-06	1.71032E-07
Supplies	APPAREL DISP	0.033636223	0.000576951
Other	BABY/STRND FOOD	0.005873923	0.000340258
Supplies	BAGS	0.013383433	0.000386689
Other	BAKERY PRODUCT	0.10254125	0.006872206
Other	BAKING NEEDS	0.008041173	0.000359007
Supplies	BAR MAINT	5.98886E-05	5.02061E-07
Supplies	BAR SUPPLIES	0.001486737	2.57046E-05
Other	BATTER/BRD/STUF	0.00560832	0.000322057
Meat	BEEF FRESH	0.109578742	0.006010648
Meat	BEEF FROZEN	0.051271225	0.002812346
Supplies	BOXS CTN CIR SQ	0.002804268	8.68579E-05
Other	BREAD AND ROLLS	0.000106702	7.15163E-06
Dairy	BUTTER	0.002044981	7.83791E-05
Other	CANDY AND NUTS	0.003929099	8.19782E-05
Other	CAPP&OTHER MIX	0.003679986	7.66664E-05
Drinks	CARBONATED BEVR	0.064915368	0.001092034
Dairy	CHEESE	0.081051022	0.004527981
Other	CHINESE/ORIENTL	0.008400371	0.000359237
Supplies	CLEANING SYSTEM	0.006809608	5.70865E-05
Other	COCOA	0.007922639	0.000261186
Other	COFFEE	0.095048789	0.003295025
Other	COFFEE/TEA/COCO	0.00480723	0.000166633
Other	CONDIMENTS	0.010334166	0.000473461
Supplies	CONTAINERS PANS	0.087473625	0.00228006
Convenience Products	CONVENIENCE PRD	0.298261915	0.017419768
Other	COOKIE/CRK/CONE	0.236743797	0.004891401
Supplies	COOKING AREA	0.032583424	0.000273154
Dairy	CREAM	0.006036982	0.000231383
Supplies	CUPS	0.265801013	0.008224826
Supplies	CUTLERY PLASTIC	0.426127082	0.003752062
Dairy	DAIRY SPECLTIES	0.033294391	0.001387241
Other	DESSERTS/TOP FZ	0.000975027	4.06261E-05
Other	DIET KITS	0.063529734	0.000559381
Other	DIETARY FOODS	0.066410643	0.003464214
Supplies	DINING RM SUPPL	0.050295222	0.000945784
Supplies	DINING ROOM	0.002400588	2.01247E-05
Supplies	DINNERWARE	0.006972904	0.000347702
Supplies	DISNFCTNT CLNRS	0.001867716	1.56575E-05
Drinks	DISP DRNK MX FF	0.007609146	0.000440774
Drinks	DISP JCE BSE FF	0.001322534	5.48012E-05
Drinks	DISP JUICE	0.01765722	0.000731653
Drinks	DISP JUICE CONC	2.81635E-05	1.76712E-06
Supplies	DISPENSERS	0.003172924	2.79377E-05
Other	DOILIES	0.000371368	1.15026E-05
Supplies	DRAIN CLNR/MANT	0.000846997	7.10057E-06

Poultry	EGGS	0.088533165	0.003137222
Other	ENTREE PREP CAN	0.007404737	0.000318328
Supplies	EQUIPMENT	0.096453955	0.001975868
Supplies	EQUIPMENT CHRGS	-3.53032E-05	-1.09346E-06
Supplies	EXTRACTS/FD COL	0.000337069	1.66161E-05
Supplies	FILTERS	0.001198129	3.71102E-05
Meat	FISH DRIED, CAN	0.010861291	0.00128283
Supplies	FLATWARE	0.032613968	0.000287167
Supplies	FLOOR CARE	0.009320496	7.81359E-05
Supplies	FOOD WRAPS	0.014992227	0.000464361
Other	FOODS MISC FZ	0.000446136	2.79929E-05
Supplies	FOUNTAIN ITEMS	0.003932506	8.19272E-05
Meat	FRESH FINFISH	0.000243998	2.88187E-05
Meat	FRESH OTHER	5.4998E-05	6.49582E-06
Meat	FROZEN FINFISH	0.019664117	0.002322534
Meat	FROZEN SURIMI	0.000589771	6.9658E-05
Meat	FRSH SHELLFISH	1.41423E-05	1.67035E-06
Fruit	FRUIT FRESH	0.069257498	0.001610639
Fruit	FRUITS CANNED	0.157851848	0.006540822
Fruit	FRUITS FROZEN	0.006657471	0.000417724
Meat	FRZN PREPRD SFD	0.000230717	2.725E-05
Meat	FRZN SFD OTHER	0.00034367	4.0591E-05
Meat	FRZN SHELLFISH	0.002156365	0.000254689
Other	GEL/PUDD/TOPPNG	0.124961877	0.007238645
Supplies	GLASSWARE	0.02565549	0.000225897
Other	GRAVIES & BASES	0.015019824	0.000740414
Supplies	HAND/BODY CARE	0.000521249	4.36975E-06
Other	ICE	8.04031E-05	1.35258E-06
Supplies	IMPORT SPECLTY	0.011214005	0.000572169
Supplies	INDUSTRIAL SUPP	0.000384311	6.57026E-06
Other	JAM/JELL/P-BTTR	0.00062958	3.17417E-05
Supplies	JANITORIAL MANT	0.000157705	1.32208E-06
Drinks	JUICE & DRNK FZ	0.008435543	0.000529289
Drinks	JUICE/DRINK REF	0.000173319	7.18172E-06
Drinks	JUICES/DRINKS	0.619778184	0.016164203
Supplies	KITCHEN SUPPLIE	0.077435508	0.000669701
Supplies	LABELS	0.000266013	8.23935E-06
Supplies	LAUNDRY	0.005678882	4.76074E-05
Supplies	LIDS	0.071781641	0.002223325
Supplies	LINERS TRASH	0.008291846	0.000256827
Supplies	MAINT SUPPLIES	0.002727782	8.44888E-05
Supplies	MAINTENANCE SUP	0.007550435	7.6448E-05
Supplies	MATCHES	8.89778E-06	2.75595E-07
Meat	MEAT PRE-FAB FR	0.000215256	1.18073E-05
Meat	MEAT SPCLTY FR	0.000138467	7.59526E-06
Meat	MEAT SPCLTY FZ	0.00117614	6.4514E-05
Meat	MEATS CANNED	0.001447518	4.4118E-05

Supplies	MEDICAL	0.001669188	2.87303E-05
Other	MEXICAN FOODS	0.023841102	0.000982559
Dairy	MILK	0.016784954	0.000643326
Dairy	MILK & NONDAIRY	0.006706439	0.00027966
Other	MISC	-0.001320463	-1.10486E-05
Drinks	MISC BEVERAGES	0.000179701	6.22963E-06
Supplies	NAPKINS	0.032679233	0.001014452
Other	NUTRITIONAL	0.052112924	0.003018736
Supplies	OFFICE SUPPLIES	0.000876639	2.71525E-05
Fruit	OLIVES	0.007778632	0.000322319
Other	PASTA PRODUCTS	0.027606183	0.000576994
Other	PICKLE,REL,PROD	0.008038744	0.000333097
Supplies	PICKS-STIRRERS	0.001626914	5.03911E-05
Supplies	PLACEMAT COVERS	0.004317921	0.000133741
Supplies	PLANTS/FLOWERS	5.50273E-05	2.14392E-06
Supplies	PLATES BOWLS	0.097617131	0.003023539
Meat	PORK FRESH	0.024012888	0.001317163
Meat	PORK FROZEN	0.035882609	0.001968244
Other	PORTION PAKS/PC	0.110612428	0.005068705
Supplies	POT AND PAN	0.071158993	0.000596542
Vegetables	POTATO-CAN/DEHY	0.01589226	0.000658519
Vegetables	POTATOES FROZEN	0.040720123	0.002554988
Poultry	POULTRY FRESH	0.062964502	0.001899161
Poultry	POULTRY FROZEN	0.405182769	0.01222129
Other	PROD PREP FRESH	0.00630751	0.000146686
Other	REFRG/MANUFACTR	0.033588529	0.001164309
Supplies	RESTROOM	0.000455812	3.82118E-06
Grains	RICE AND GRAINS	0.018211469	0.000719465
Other	SALAD DRES/MAYO	0.0244809	0.001206805
Other	SALT/SEASN/SPCE	0.035993594	0.001681699
Supplies	SANITIZER	0.009093375	7.62319E-05
Other	SAUCES/SAUC MIX	0.030056439	0.001202739
Other	SHORTENING, OIL	0.017461046	0.000736063
Other	SNACKS	0.031999191	0.001160983
Other	SOUP,CHOWDR,BAS	0.104079166	0.004896782
Supplies	STRAWS	0.009400321	0.00029116
Other	SUGAR	0.004392799	0.000181771
Other	SYRUPS	0.000884175	5.08574E-05
Supplies	TBL COVER SKIRT	0.004678996	0.000144925
Other	TEA	0.034008827	0.001178973
Supplies	TISSUES	9.52698E-06	2.95083E-07
Supplies	TOWELS	0.002740657	8.48876E-05
Supplies	TRAYS CARRIERS	0.074453246	0.002306074
Vegetables	VEG/FRUIT DRIED	0.009143397	0.00037887
Vegetables	VEGETABLE CAN	0.021641531	0.000896749
Vegetables	VEGETABLE FRESH	0.058690504	0.002074935
Vegetables	VEGETABLES FRZN	0.115606268	0.007253727

Supplies	WAREWASH	0.098600811	0.000826594
Supplies	WASHANTIMICROBL	0.000779524	6.53494E-06
Other	WINE/LIQ COOKNG	0.000414881	2.11282E-05
Supplies	WIPERS	0.010186469	0.00031551
Other	YOGURT	0.032540278	0.001267963
	Grand Total	5.576869846	0.188437767

Appendix C

CEDA CMU Comparison

Item Major Description	Sum of CEDA Emissions Subtotals (kg CO2e)	Percent of Total Emissions (CEDA)	Sum of CMU Emissions Subtotals (kg CO2e)	Percent of Total Emissions (CMU)	Percent Difference in Subtotals
CONVENIENCE PRD	1548556	8.8	1464143	8.3	-5.5
BEEF FRESH	1479857	8.4	1891042	10.8	27.8
POULTRY FROZEN	1447573	8.2	1400748	8.0	-3.2
JUICES/DRINKS	1103924	6.3	989181	5.6	-10.4
BEEF FROZEN	692416	3.9	884807	5.0	27.8
CHEESE	673821	3.8	678172	3.9	0.6
VEGETABLES FRZN	660899	3.7	630167	3.6	-4.6
EGGS	501806	2.8	484422	2.8	-3.5
FRUITS CANNED	495697	2.8	440415	2.5	-11.2
PORK FROZEN	484593	2.7	619240	3.5	27.8
GEL/PUDD/TOPPNG	463569	2.6	441938	2.5	-4.7
PORTION PAKS/PC	420783	2.4	402622	2.3	-4.3
CUPS	417810	2.4	371887	2.1	-11.0
SOUP,CHOWDR,BAS	397464	2.3	363328	2.1	-8.6
FRUIT FRESH	359904	2.0	315225	1.8	-12.4
COOKIE/CRK/CONE	359594	2.0	345659	2.0	-3.9
VEGETABLE FRESH	326689	1.8	242312	1.4	-25.8
PORK FRESH	324293	1.8	414400	2.4	27.8
COFFEE	268783	1.5	231412	1.3	-13.9
BAKERY PRODUCT	262736	1.5	245600	1.4	-6.5
POTATOES FROZEN	232789	1.3	221965	1.3	-4.6
SNACKS	228333	1.3	230182	1.3	0.8
YOGURT	227768	1.3	229498	1.3	0.8
POULTRY FRESH	224950	1.3	217673	1.2	-3.2
DIETARY FOODS	213175	1.2	199752	1.1	-6.3
RICE AND GRAINS	212018	1.2	136249	0.8	-35.7
CUTLERY PLASTIC	205016	1.2	187871	1.1	-8.4
NUTRITIONAL	193323	1.1	184302	1.0	-4.7
FROZEN FINFISH	163552	0.9	195093	1.1	19.3
PLATES BOWLS	153588	0.9	136707	0.8	-11.0
REFRG/MANUFACTR	151202	0.9	122425	0.7	-19.0
MILK	132082	0.7	133344	0.8	1.0
TRAYS CARRIERS	117142	0.7	104267	0.6	-11.0
SALT/SEASN/SPCE	116977	0.7	103177	0.6	-11.8
CONTAINERS PANS	116405	0.7	103515	0.6	-11.1
LIDS	112939	0.6	100526	0.6	-11.0
DAIRY SPECLTIES	110615	0.6	109282	0.6	-1.2
SAUCES/SAUC MIX	97308	0.6	100178	0.6	2.9
TEA	96172	0.5	82800	0.5	-13.9

FISH DRIED, CAN	90337	0.5	107758	0.6	19.3
EQUIPMENT	84168	0.5	68022	0.4	-19.2
SHORTENING, OIL	81702	0.5	104276	0.6	27.6
MEXICAN FOODS	68279	0.4	61716	0.4	-9.6
VEGETABLE CAN	67960	0.4	60381	0.3	-11.2
SALAD DRES/MAYO	64625	0.4	60915	0.3	-5.7
CARBONATED BEVR	62581	0.4	57028	0.3	-8.9
DISP JUICE	55448	0.3	49265	0.3	-11.2
NAPKINS	51755	0.3	46066	0.3	-11.0
POTATO-CAN/DEHY	49906	0.3	44340	0.3	-11.2
DINING RM SUPPL	48726	0.3	52398	0.3	7.5
JUICE & DRNK FZ	48224	0.3	45982	0.3	-4.6
CREAM	47505	0.3	47959	0.3	1.0
WAREWASH	46865	0.3	47942	0.3	2.3
MILK & NONDAIRY	46408	0.3	46573	0.3	0.4
PASTA PRODUCTS	42448	0.2	40730	0.2	-4.0
IMPORT SPECLTY	42155	0.2	44661	0.3	5.9
GRAVIES & BASES	39650	0.2	37373	0.2	-5.7
KITCHEN SUPPLIE	38693	0.2	36069	0.2	-6.8
FRUITS FROZEN	38059	0.2	36290	0.2	-4.6
ENTREE PREP CAN	37059	0.2	40350	0.2	8.9
SUGAR	34663	0.2	34385	0.2	-0.8
POT AND PAN	33822	0.2	34599	0.2	2.3
PROD PREP FRESH	32778	0.2	28709	0.2	-12.4
DIET KITS	30565	0.2	28009	0.2	-8.4
CONDIMENTS	29571	0.2	27095	0.2	-8.4
VEG/FRUIT DRIED	28713	0.2	25511	0.1	-11.2
DISP DRNK MX FF	28228	0.2	26910	0.2	-4.7
APPAREL DISP	26631	0.2	22155	0.1	-16.8
PICKLE,REL,PROD	25244	0.1	22429	0.1	-11.2
OLIVES	24427	0.1	21703	0.1	-11.2
FOOD WRAPS	23588	0.1	20996	0.1	-11.0
BABY/STRND FOOD	21790	0.1	20774	0.1	-4.7
COCOA	21562	0.1	20285	0.1	-5.9
CHINESE/ORIENTL	20440	0.1	19230	0.1	-5.9
BAGS	19681	0.1	17511	0.1	-11.0
FRZN SHELLFISH	17935	0.1	21394	0.1	19.3
BAKING NEEDS	17325	0.1	16385	0.1	-5.4
BUTTER	16092	0.1	16246	0.1	1.0
WIPERS	16027	0.1	14266	0.1	-11.0
MEAT SPCLTY FZ	15884	0.1	20297	0.1	27.8
FLATWARE	15691	0.1	14379	0.1	-8.4
COOKING AREA	15487	0.1	15843	0.1	2.3

STRAWS	14790	0.1	13165	0.1	-11.0
COFFEE/TEA/COCO	13593	0.1	11705	0.1	-13.9
BATTER/BRD/STUF	13141	0.1	12330	0.1	-6.2
LINERS TRASH	13046	0.1	11612	0.1	-11.0
GLASSWARE	12343	0.1	11311	0.1	-8.4
DINNERWARE	12283	0.1	13645	0.1	11.1
TBL COVER SKIRT	7362	0.0	6553	0.0	-11.0
PLACEMAT COVERS	6794	0.0	6047	0.0	-11.0
CANDY AND NUTS	6319	0.0	6031	0.0	-4.6
MEATS CANNED	5355	0.0	5260	0.0	-1.8
MAINTENANCE SUP	4908	0.0	4383	0.0	-10.7
FROZEN SURIMI	4905	0.0	5851	0.0	19.3
FOUNTAIN ITEMS	4571	0.0	4045	0.0	-11.5
FLOOR CARE	4430	0.0	4532	0.0	2.3
BOXS CTN CIR SQ	4412	0.0	3927	0.0	-11.0
SANITIZER	4322	0.0	4421	0.0	2.3
TOWELS	4312	0.0	3838	0.0	-11.0
MAINT SUPPLIES	4292	0.0	3820	0.0	-11.0
CAPP&OTHER MIX	4277	0.0	3785	0.0	-11.5
DISP JCE BSE FF	4153	0.0	3690	0.0	-11.2
SYRUPS	3371	0.0	3220	0.0	-4.5
DESSERTS/TOP FZ	3238	0.0	3199	0.0	-1.2
CLEANING SYSTEM	3237	0.0	3311	0.0	2.3
MEAT PRE-FAB FR	2907	0.0	3715	0.0	27.8
FRZN SFD OTHER	2858	0.0	3410	0.0	19.3
LAUNDRY	2699	0.0	2761	0.0	2.3
PICKS-STIRRERS	2560	0.0	2278	0.0	-11.0
FOODS MISC FZ	2550	0.0	2432	0.0	-4.6
JAM/JELL/P-BTTR	2172	0.0	2013	0.0	-7.4
FRESH FINFISH	2029	0.0	2421	0.0	19.3
FRZN PREPRD SFD	1919	0.0	2289	0.0	19.3
FILTERS	1885	0.0	1678	0.0	-11.0
MEAT SPCLTY FR	1870	0.0	2390	0.0	27.8
DISPENSERS	1527	0.0	1399	0.0	-8.4
OFFICE SUPPLIES	1379	0.0	1228	0.0	-11.0
BAR SUPPLIES	1374	0.0	1239	0.0	-9.8
MEDICAL	1346	0.0	1235	0.0	-8.2
WINE/LIQ COOKNG	1291	0.0	1170	0.0	-9.4
DINING ROOM	1141	0.0	1167	0.0	2.3
EXTRACTS/FD COL	890	0.0	839	0.0	-5.7
DISNFCTNT CLNRS	888	0.0	908	0.0	2.3
DOILIES	584	0.0	520	0.0	-11.0
JUICE/DRINK REF	544	0.0	484	0.0	-11.2

MISC BEVERAGES	508	0.0	438	0.0	-13.9
PLANTS/FLOWERS	494	0.0	347	0.0	-29.7
FRESH OTHER	457	0.0	546	0.0	19.3
LABELS	419	0.0	373	0.0	-11.0
DRAIN CLNR/MANT	403	0.0	412	0.0	2.3
WASHANTIMICROBL	371	0.0	379	0.0	2.3
INDUSTRIAL SUPP	307	0.0	264	0.0	-14.2
BREAD AND ROLLS	273	0.0	255	0.0	-6.5
HAND/BODY CARE	248	0.0	253	0.0	2.3
RESTROOM	217	0.0	222	0.0	2.3
DISP JUICE CONC	161	0.0	154	0.0	-4.6
FRSH SHELLFISH	118	0.0	140	0.0	19.3
ICE	78	0.0	71	0.0	-8.9
JANITORIAL MANT	75	0.0	77	0.0	2.3
BAR MAINT	28	0.0	29	0.0	2.3
TISSUES	15	0.0	13	0.0	-11.0
MATCHES	14	0.0	12	0.0	-11.0
ALCOHOLIC BEV	10	0.0	9	0.0	-9.4
EQUIPMENT CHRGS	-56	0.0	-49	0.0	-11.0
MISC	-627	0.0	-642	0.0	2.4

Appendix D

Literature Emissions Data

Appendix D
Literature Emissions Results (Process-Based LCA)

Item Major Description	Item Intermediate Description	Emissions Factor	Functional Unit	Emissions Result	Unit	Source
BAKERY PRODUCT	BREAD/ROLLS	0.75	kg	117.4267176	kg CO2e	ADAS (2009)
BAKERY PRODUCT	BISCUITS	2.50	kg	53.5499745	kg CO2e	ADAS (2009)
BAKERY PRODUCT, COOKIE/CRK/CONE	COOKIES	2.50	kg	484.2685406	kg CO2e	ADAS (2009)
BEEF FRESH	BEEF PRE-COOKED	6.9	kg	7749848.6	kg CO2	Carlsson-Kanyama A, González AD (2009).
BEEF FRESH	BEEF PRE-COOKED	6.6	kg	7412898.661	kg NO2	Carlsson-Kanyama A, González AD (2009).
BEEF FRESH	BEEF PRE-COOKED	17	kg	19093829.88	kg CH4	Carlsson-Kanyama A, González AD (2009).
BEEF FRESH		1.3	kg	146011.6403	kg Enteric CH4	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).
BEEF FRESH		.02	kg	22463.32928	kg Manure CH4	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).
BEEF FRESH		1.3	kg	1460116.403	kg Total CH4	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).
BEEF FRESH		2.22	kg	2493429.55	kg N2O	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).
BEEF FRESH		2.1	kg	2358649.574	kg CO2	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).
BEEF FRESH		5.66	kg	6357122.185	Total kg GHG CO2 equiv	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).
BKFST FD/CEREAL	BKFST/CERL-MISC	0.37	kg	13723.70077	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
BUTTER		4.8	500 g	43228.04	kgCO2e	Bell, S., Davis, J., Flysjo, A., Nilsoon, K., Unger, N., and Sim, S. (2010)

BUTTER		3.7	500 g	33321.61	kgCO2e	Bell, S., Davis, J., Flysjo, A., Nilsoon, K., Unger, N., and Sim, S. (2010)
BUTTER		4.5	500 g	40526.29	kgCO2e	Bell, S., Davis, J., Flysjo, A., Nilsoon, K., Unger, N., and Sim, S. (2010)
BUTTER		3.6	500 g	32421.03	kgCO2e	Bell, S., Davis, J., Flysjo, A., Nilsoon, K., Unger, N., and Sim, S. (2010)
CANDY AND NUTS	NUTS	1.06	kg	6164.008016	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
CHEESE	CHEESE MISC	5.0	kg	1695.247138	kg CO2	Carlsson-Kanyama A, González AD (2009).
CHEESE	CHEESE MISC	1.3	kg	440.7642558	kg NO2	Carlsson-Kanyama A, González AD (2009).
CHEESE	CHEESE MISC	4.5	kg	1525.722424	kg CH4	Carlsson-Kanyama A, González AD (2009).
CHEESE		8.8	kg	387577.12	kg CO2e	Berlin, J. (2002)
COCOA	TOTAL	0.74	kg	6813.719756	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
COCOA	OTHER BRANDS, SYSCO BRAND	210.00	kg	59154.93495	kg CO2e	ADAS (2009)
COFFEE	TOTAL	8.1	kg	122102.4382	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
COFFEE	OTHER COFFEES, SYSCO BRAND	130	kg	1659278.626	kg CO2e	ADAS (2009)
COFFEE	OTHER COFFEES, SYSCO BRAND	10.3	kg	9447.781172	kg CO2e	ADAS (2009)
CONDIMENTS, PORTION PAKS/PC	KETCHUP	1376	kg	281973.76	kg CO2e	Andersson, K., Ohlsson, T., and Olsson, P. (1998)

CONDIMENTS, PORTION PAKS/PC	KETCHUP	910	kg	186479.74	g CH4	Andersson, K., Ohlsson, T., and Olsson, P. (1998)
CONDIMENTS, PORTION PAKS/PC	KETCHUP	181.6	kg	37213.98	gN2O	Andersson, K., Ohlsson, T., and Olsson, P. (1998)
EGGS	HARD COOKED EGG	1.7	kg	291010.9695	kg CO2	Carlsson-Kanyama A, González AD (2009).
EGGS	HARD COOKED EGG	.74	kg	126675.3632	kg NO2	Carlsson-Kanyama A, González AD (2009).
EGGS	HARD COOKED EGG	.04	kg	6847.316929	kg CH4	Carlsson-Kanyama A, González AD (2009).
EGGS	SHELL EGGS	6	20 eggs	1058.25	kg CO2e	Williams et al. (2006), Williams et al. (2007)
EGGS	SHELL EGGS	1.8	12 eggs	529.12	kg CO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
FRESH FINFISH	FRSH FLTS/PRTNS	1.5	kg	84987.60928	kg CO2	Carlsson-Kanyama A, González AD (2009).
FRESH FINFISH	FRSH FLTS/PRTNS	8.5	kg	0	kg CO2	Carlsson-Kanyama A, González AD (2009).
FRUIT FRESH	APPLES	.80	kg	603504.3528	kg CO2	Carlsson-Kanyama A, González AD (2009).
FRUIT FRESH	APPLES	.02	kg	15087.60882	kg NO2	Carlsson-Kanyama A, González AD (2009).
FRUIT FRESH	ORANGES	1.1	kg	20594.47497	kg CO2	Carlsson-Kanyama A, González AD (2009).
FRUIT FRESH	ORANGES	.10	kg	1872.224997	kg NO2	Carlsson-Kanyama A, González AD (2009).
FRUIT FRESH	MANGOES	11	kg	347065.5453	kg CO2	Carlsson-Kanyama A, González AD (2009).
FRUIT FRESH	MANGOES	.23	kg	7256.825039	kg NO2	Carlsson-Kanyama A, González AD (2009).
FRUIT FRESH	APPLES	0.88	kg	5663.369861	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)

FRUIT FRESH	AVOCADO	0.88	kg	730.802554	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
FRUIT FRESH	BANANAS	1.33	kg	4921.183952	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
FRUIT FRESH	PEACHES	0.88	kg	25.51337041	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
FRUIT FRESH	PEARS	0.88	kg	1552.240231	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
FRUITS CANNED	CHERRIES	0.32	kg	81.26716848	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
FRUITS CANNED	CRANBERRIES	1.39	kg	2799.610327	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
FRUITS CANNED	PINEAPPLE	1.78	kg	14671.65273	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
MILK	BUTTERMILK, FLVR MILK FRSH, FLVR UHT/ESL ML, LO FAT MILK FRSH, REG/WHL MILK FRS, SKIM MILK FRESH	.38	kg	15018.53887	kg Enteric CH4	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).
MILK	BUTTERMILK, FLVR MILK FRSH, FLVR UHT/ESL ML, LO FAT MILK FRSH, REG/WHL MILK FRS, SKIM	.2	kg	7904.494144	kg Manure CH4	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).

	MILK FRESH					
MILK	BUTTERMILK, FLVR MILK FRSH, FLVR UHT/ESL ML, LO FAT MILK FRSH, REG/WHL MILK FRS, SKIM MILK FRESH	.57	kg	22527.80831	kg Total CH4	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).
MILK	BUTTERMILK, FLVR MILK FRSH, FLVR UHT/ESL ML, LO FAT MILK FRSH, REG/WHL MILK FRS, SKIM MILK FRESH	.37	kg	14623.31417	kg N2O	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).
MILK	BUTTERMILK, FLVR MILK FRSH, FLVR UHT/ESL ML, LO FAT MILK FRSH, REG/WHL MILK FRS, SKIM MILK FRESH	.14	kg	5533.145901	kg CO2	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).
MILK	BUTTERMILK, FLVR MILK FRSH, FLVR UHT/ESL ML, LO FAT MILK FRSH, REG/WHL MILK FRS, SKIM MILK FRESH	1.09	kg	43079.49309	Total kg GHG CO2 equiv	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).
MILK	BUTTERMILK, FLVR MILK FRSH, FLVR UHT/ESL ML, LO FAT MILK FRSH, REG/WHL MILK FRS, SKIM MILK FRESH	.45	kg	17785.11182	kg CO2	Carlsson-Kanyama A, González AD (2009).
MILK	BUTTERMILK, FLVR MILK FRSH, FLVR UHT/ESL ML, LO FAT MILK	.14	kg	5533.145901	kg NO2	Carlsson-Kanyama A, González AD (2009).

	FRSH, REG/WHL MILK FRS, SKIM MILK FRESH					
MILK	BUTTERMILK, FLVR MILK FRSH, FLVR UHT/ESL ML, LO FAT MILK FRSH, REG/WHL MILK FRS, SKIM MILK FRESH	.45	kg	17785.11182	kg CH4	Carlsson-Kanyama A, González AD (2009).
MILK	MILK MISC	0.00050059	kg	150.7954889	kg CO2	Carlsson-Kanyama A, González AD (2009).
MILK		1.05	L	3742.75	kgCO2e	Hospido, A., Feijoo, G., and Moreira. M.T. (2003)
MILK	BUTTERMILK, FLVR MILK FRSH, FLVR UHT/ESL ML, LO FAT MILK FRSH, REG/WHL MILK FRS, SKIM MILK FRESH	610	1000 L	2174.35781	kgCO2e	Eide, M.H. (2002)
MILK	BUTTERMILK, FLVR MILK FRSH, FLVR UHT/ESL ML, LO FAT MILK FRSH, REG/WHL MILK FRS, SKIM MILK FRESH	530	1001 L	1889.19613	kgCO2e	Eide, M.H. (2002)
MILK	BUTTERMILK, FLVR MILK FRSH, FLVR UHT/ESL ML, LO FAT MILK FRSH, REG/WHL MILK FRS, SKIM MILK FRESH	520	1002 L	1853.55092	kgCO2e	Eide, M.H. (2002)
MILK	BUTTERMILK, FLVR MILK FRSH, FLVR UHT/ESL ML, LO FAT MILK FRSH,	1100	1000 L	3920.97	kgCO2e	Williams et al. (2006), Williams et al. (2007)

	REG/WHL MILK FRS, SKIM MILK FRESH					
PASTA PRODUCTS	MISC.	.96	kg	583392.8551	kg CO2	Carlsson-Kanyama A, González AD (2009).
PASTA PRODUCTS	MISC.	.12	kg	72924.10689	kg NO2	Carlsson-Kanyama A, González AD (2009).
PORK FRESH	HAM	3.9	kg	118593.6135	kg CO2	Carlsson-Kanyama A, González AD (2009).
PORK FRESH	HAM	1.6	kg	48653.79016	kg NO2	Carlsson-Kanyama A, González AD (2009).
PORK FRESH	HAM	3.8	kg	115552.7516	kg CH4	Carlsson-Kanyama A, González AD (2009).
PORTION PAKS/PC	HONEY	1	kg	1557.315958	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
Poultry Fresh	CHICKEN FRESH	5.49	kg	4781901.384	kg CO2	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).
Poultry Fresh	CHICKEN FRESH	7.52	kg	6550072.57	kg CH4	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).
Poultry Fresh	CHICKEN FRESH	3.8	kg	3309877.097	kg NO2	Phetteplace, H. W., Johnson, D.E. & Seidl, A.F. (2001).
Poultry Fresh	CHICKEN FRESH	3.1	kg	2700162.895	kg CO2	Carlsson-Kanyama A, González AD (2009).
Poultry Fresh	CHICKEN FRESH	1.2	kg	1045224.346	kg NO2	Carlsson-Kanyama A, González AD (2009).
Poultry Fresh	CHICKEN FRESH	.01	kg	8710.202886	kg CH4	Carlsson-Kanyama A, González AD (2009).
Poultry Fresh	TURKEY FRESH	3.76	kg	915425.5638	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
RICE AND GRAINS	RICE	.59	kg	190698.6627	kg CO2	Carlsson-Kanyama A, González AD (2009).
RICE AND GRAINS	RICE	.21	kg	67875.79518	kg NO2	Carlsson-Kanyama A, González AD (2009).

RICE AND GRAINS	RICE	.52	kg	168073.3976	kg CH4	Carlsson-Kanyama A, González AD (2009).
SUGAR	GRANULATED	1.04	kg	200381.1697	kg CO2	Carlsson-Kanyama A, González AD (2009).
SUGAR	GRANULATED	.03	kg	5780.226049	kg NO2	Carlsson-Kanyama A, González AD (2009).
TEA	TOTAL	0.87	kg	420471.5936	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
TEA	OTHER BRANDS, SNGL STRNG TEA, SYSCO BRANDS	4.10	kg product	23172.62913	kg CO2e	ADAS (2009)
TEA	OTHER BRANDS, SNGL STRNG TEA, SYSCO BRANDS	0.87	kg product	817.9317365	kg CO2e	ADAS (2009)
VEGETABLE FRESH	CARROTS	.38	kg	31014.42541	kg CO2	Carlsson-Kanyama A, González AD (2009).
VEGETABLE FRESH	CARROTS	.04	kg	3264.676359	kg NO2	Carlsson-Kanyama A, González AD (2009).
VEGETABLE FRESH	POTATOES	.4	kg	66076.99373	kg CO2	Carlsson-Kanyama A, González AD (2009).
VEGETABLE FRESH	POTATOES	.06	kg	9911.54906	kg NO2	Carlsson-Kanyama A, González AD (2009).
VEGETABLE FRESH	VEG MISC FRS	1.2	kg	37629.59906	kg CO2	Carlsson-Kanyama A, González AD (2009).
VEGETABLE FRESH	VEG MISC FRS	.12	kg	3762.959906	kg NO2	Carlsson-Kanyama A, González AD (2009).
VEGETABLE FRESH	ASPARAGUS	2.39	kg	326.5048477	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
VEGETABLE FRESH	CABBAGE	0.64	kg	1453.678564	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)

VEGETABLE FRESH	BROCCOLI	2.39	kg	4107.403344	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
VEGETABLE FRESH	CAULIFLOWER	2.39	kg	1581.130406	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
VEGETABLE FRESH	EGGPLANT	1.3	kg	22.88878644	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
VEGETABLE FRESH	ONIONS	0.37	kg	862.4228193	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
VEGETABLE FRESH	TOMATOES	3.79	kg	38124.54897	kgCO2e	World Wildlife Fund - UK & Food Climate and Research Network (2010)
VEGETABLE FRESH	POTATOES	0.24	kg crop production	5.761685495	kg CO2e	Williams et al. (2006), Williams et al. (2007)
VEGETABLES FROZEN	MISC	2.2	kg	107503.9136	kg CO2	Carlsson-Kanyama A, González AD (2009).
VEGETABLES FROZEN	MISC	.05	kg	2443.270763	kg NO2	Carlsson-Kanyama A, González AD (2009).
YOGURT	BULK FRESH, PORTION PAK FRS	1.8	kg product	475.2482132	kg CO2e	ADAS (2009)
	SUGAR	160	tonne	6095.59	kgCO2e	Ramjeawon, T. (2000)